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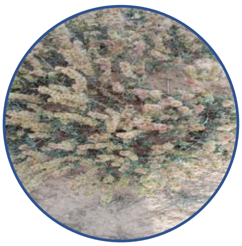
Ornamental Plants of Algeria: Ecology, Cultivation, and Ornamental Potential of Forest and Medicinal Plants



Editors
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PREFACE

It is with great pleasure and deep gratitude that we present this collective work devoted to the ornamental and medicinal plants of Algeria, a country with exceptionally rich plant biodiversity. The result of a rich and multidisciplinary collaboration between renowned researchers and young scientists, this book is part of a context in which the promotion of plant heritage, both for its traditional therapeutic properties and its contemporary uses, is essential in the fields of health, the environment and culture.

This recent interest in research into the benefits of ornamental and medicinal plants has greatly encouraged us in the preparation of this collective book, which confirms the strategic place these plants occupy in Algeria. Our main goal is to explore in depth their multifaceted dimensions: biological, ecological, cultural and economic. We draw on rigorous studies of taxonomy, phytogeography, pharmacological properties, and the socio-cultural impact of these plants on the daily lives of local populations.

Readers are invited on a scientific, historical and heritage journey into the heart of Algerian flora, where each plant reveals its secrets, including medicinal properties, ornamental functions and ecological roles. This journey reveals not only the therapeutic and ecological properties of these species, but also the ancestral traditions and knowledge associated with them, highlighting the multidimensional richness of this plant heritage.

In order to better preserve this natural heritage and promote the sustainable management of these natural resources, this book raises awareness among a wide audience of the importance of promoting and conserving ornamental plants in Algeria. To this end, we have emphasized the need to combine traditional knowledge and scientific advances to ensure their sustainability in the face of environmental and social challenges.

The chapters devoted to the inventory of ornamental species in several Algerian provinces, as well as their crucial role in urban planning and the fight against environmental degradation, highlight current and future strategies for rational and sustainable use, which must be implemented, as well as local dynamics of plant heritage management through studies on phytoremediation, soil decontamination, ecosystem restoration and the evaluation of the antibacterial activities of essential oils show the growing importance of plants in environmental protection and public health strategies.

This book is intended to be a valuable source of information for researchers, practitioners, students, decision-makers and anyone interested in plant biodiversity, its uses and its preservation. It also invites in-depth reflection on the need to combine ancestral knowledge and scientific innovation for harmonious sustainable development, as well as celebrating the diversity of ornamental and medicinal plants that shape Algeria's cultural and natural identity.

We warmly thank all the authors for their dedication and scientific rigor, and hope that this book will help stimulate new research and contributions by paving the way for other alternatives while strengthening national and international recognition of this unique heritage.

We wish you an enriching and inspiring read.

Assoc. Prof. Dr. Zohra ARABI
Prof. Dr. Arzu ÇIĞ

PART I

Medicinal and Aromatic Plants: General Aspects

CHAPTER I

Ornamental Plants and Their Medicinal Potential in Algeria

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1. INTRODUCTION

For centuries, medicinal plants have played a vital role in human health and well-being, serving as a primary source of treatment for various ailments. Before the advent of modern medicine, the use of plants for therapeutic purposes was deeply rooted in cultural traditions and ancestral knowledge. Even today, despite the remarkable advancements in pharmaceutical sciences, medicinal plants continue to be an essential component of healthcare systems worldwide. According to the World Health Organization (WHO), in recent years, an important increase has been observed regarding the use of medicinal plants owing to their abundance, cultural importance and low prices (Thomford et al., 2015).

Algeria, with its diverse ecosystems and rich biodiversity, is home to an impressive variety of plant species, many of which possess both ornamental and medicinal properties. The country's unique geographic features, ranging from the Mediterranean coastline to the vast Sahara Desert, create a wide range of habitats that support the growth of numerous endemic and native plant species. This diversity has made Algeria an important reservoir of medicinal plants, many of which are also valued for their aesthetic appeal.

Ethnomedicinal studies have revealed that approximately 28% of higher plant species are used for therapeutic purposes. Furthermore, an estimated 74% of pharmacological principles in modern medicine are derived from plants, highlighting their indispensable role in drug discovery and development (Ncube et al., 2008). The dual function of certain plants as both medicinal and ornamental has further increased their cultural and scientific significance. These plants not only contribute to public health but also enhance the beauty of gardens and landscapes, making them an integral part of Algerian culture and heritage.

The increasing global interest in natural remedies has further amplified the importance of studying and preserving Algeria's ornamental medicinal plants. Researchers have been exploring their pharmacological potential to identify bioactive compounds that could lead to the development of new drugs. Additionally, these plants hold great potential for sustainable economic development through their use in herbal medicine, cosmetics, and horticulture.

2. LOCALIZATION AND CLIMATE OF ALGERIA

2.1. Localization

Algeria is the largest country on the African continent; it is located in North Africa. Algeria is approximately between 18° and 37° N latitude and 9° and 12° E longitude. Its Capital is Algiers (located on the Mediterranean coast) (Meddi & Hubert, 2003).

It has a total area of 2,381,741 km^2. With more than 1,200 kilometers of Mediterranean coastline, where mountains often fall steeply into the sea, the country has borders with Morocco (1,350 km), Mauritania (450 km), Mali (1,100 km), Niger (1,180 km), Libya (1,000 km), Tunisia (1140 km), to which must be added 60 kilometers of borders with present-day Western Sahara. Algeria is divided into two main blocs: Northern Algeria (381,000 km^2) and Saharan Algeria (2,000,000 km^2). The first, a narrow northern strip, concentrates nine-tenths of the population and encompasses 90% of the country's fertile land (Stora & Ellyas ,1999).

2.2. Climate

Algeria has a diverse climate that varies significantly across its deferent regions: references

- **Mediterranean Climate** in coastal areas (mild, wet winters and hot, dry summers). Average temperatures range from 10°C in winter to over 30°C in summer. Dominance of aromatic plants (*Rosmarinus officinalis, Lavandula stoechas, Pelargonium graveolens*) (Stambouli-Meziane et al., 2009).
- **Semi-Arid Climate** in Inland regions such as the Tell Atlas, less rainfall than coastal areas (winter is cold, and summer is hot, Average rainfall between 200-400 mm in the year. Characterized by hardy shrubs such as *Nerium oleander*, *Bougainvillea*, and *Hibiscus*.
- **Desert Climate**: Sahara Desert (southern Algeria), extremely low rainfall (less than 100 mm annually), very high temperatures with significant seasonal temperature variations (summer temperatures often exceeding 40°C). Characterized by succulent plants such as *Aloe vera* and decorative xerophytic plants (Merchela et al., 2023).

3. HISTORICAL CONTEXT OF MEDICINAL PLANTS IN ALGERIA

In Africa, up to 80% of the population uses traditional medicine for primary health care (Assefa et al., 2010). Algeria, the biggest African country with a large variety of soils (littoral, steppe, mountains, and desert) and climates, possesses a rich flora (more than 3,000 species and 1,000 genders) (Bouabdelli et al., 2012). In Algeria, many patients use medicinal plants as a treatment for many ailments and serious diseases, such as cancer, diabetes and arterial hypertension, for several considerations: Historical, cultural and economic (Azzi et al., 2012).

The use of plants for medicinal purposes in Algeria dates back centuries, influenced by indigenous knowledge, Arab-Andalusian traditions, and Berber (Amazigh) heritage. The region's biodiversity allowed for the cultivation and utilization of numerous plant species, many of which were both ornamental and medicinal. These plants were often grown in gardens and courtyards, serving dual purposes: aesthetic beauty and therapeutic value.

During the Islamic Golden Age (8th–13th centuries), knowledge about medicinal plants was expanded through translations of Greek and Roman texts into Arabic, as well as original contributions by scholars such as Ibn Sina (Avicenna). Algeria's strategic location facilitated the exchange of botanical knowledge between North Africa, the Middle East, and Europe.

Ornamental medicinal plants have historically been integral to Algerian traditional medicine practices. Healers and herbalists often relied on these plants to prepare remedies for various ailments. The knowledge was passed down orally through generations, ensuring the preservation of indigenous practices despite colonial influences during French rule (1830–1962).

4. DISTRIBUTION OF ORNAMENTAL MEDICINAL PLANTS IN ALGERIA

Owing to its diversified climate allowing an important development of medicinal plants, in coastal, mountainous and also Saharan regions, Algeria is considered one of the richest countries in flora. In fact, the Algerian flora consists of 4000 taxa with 131 families and 917 genera. The national endemic flora counts 464 Taxa (387 species, 53 subspecies and 24 varieties) (Radford et al., 2011).

Several ethnobotanical studies carried out to document the popular knowledge related to the use of medicinal plants in Algeria (Azzi et al., 2012; Boudjelal et al., 2013; Ramdane et al., 2015).

5. PARTS USED

According to our results, roots, rhizomes or tubers represented the most used part for medical care (37, 6%). Leaves occupied the second position (33,6%), followed by other aerial parts such as stem and bourgeons (16%), fruits (8%), flowers (1,6%), and seeds (3,2%) (Zatoutet al., 2021). Although a majority of recent ethnobotanical studies reported that aerial parts (leaves) are the most used part of the medicinal species (Tugume et al., 2016).

The part of medicinal plants most used is the leaves, then leaves (28,8%), roots (22,2%), flowers (16%), stems (15%), seeds (8%), rhizomes and barks (3%), bulbs (2.4%), pollen (1,6%), latex, tuber and sapwood (1%) (Benchohra et al., 2025).

The frequent use of underground parts of the plants that are responsible for their multiplication and regeneration would be responsible for their disappearance. Indeed, during our collection of medicinal plants in Tlemcen Park, we found that these species are becoming increasingly rare (Zatout et al., 2021).

6. MODES OF PREPARATION

According to Zatout et al. (2021) the most common methods of preparation were: decoction (40,4%), infusion (28,5%), raw (17,4%), poultice (6,3%), dry (2,3%), juice (3,1%), maceration (0,7%), and fumigation (0,7%). The findings corroborate those previously reported in Algeria (Madani et al., 2017). Infusion (24%), poultices (16%), raw (8,2%), powder (4,8%), powder with olive oil or honey (3,2%), maceration (3,2%), juice (2,6%) and essential oil (2%) (Benchohra et al., 2025).

According to Zatout et al. (2021), oral administration (82,7%) was the most frequent route prescribed by local populations in Tlemcen. Similar findings were reported in most of the ethnobotanical investigations carried out in Algeria and its neighboring countries (Telli et al., 2016; Skalli et al., 2019).

Moreover, several studies showed that 46% of medicinal plants are administered with other plants. The use of herbal mixtures in popular therapy may be explained by the search of a synergistic effect or the reduction of toxic effects of certain species**.** On the other hand, the results published by Zatout et al. (2021) revealed that 64 species (ornamentals plants were the most frequently used species) are mixed with honey, milk, olive oil or sugar. Bees honey was found to be the most added adjuvant.

Benchohra et al. (2025) mentioned that the ways of administration at the beginning place (Tiaret) in one of the towns of the highlands of Algeria were as follows. local (11%), wound (2%), fumigation (2%), wash (1,8%), plaster (1.8%), rinse (1,2%), ear drop (0,8%) and nasal (0,2%). In Algeria, the majority of the medicinal plants administered orally. In this result, the oral ingestion mode represents 81%.

They found that honey was the adjuvant most added (53%) to medicinal plants used to treat several diseases. Similar findings were reported in different regions in Algeria-Tlemcen (northwest of Algeria) (Bouasla & Bouasla, 2017), Constantine and Mila (north-east of Algeria) (Ouelbani et al., 2016).

7. TAXONOMIC AFFILIATION OF ORNAMENTAL MEDICINAL PLANTS IN ALGERIA

For Algerian, its application in traditional medicine and in food is a well-known fact since many centuries (Reguieg, 2011). Due to its geographical position, Algeria possesses a wide variety of biotopes – it contains more than 4125 species belonging to 123 plant families. (Quezel & Santa, 1962-1963), and is endowed, according to Mokkadem (1999) there are more than 600 species of medicinal and aromatic plants growing in the different bioclimatic zones ranging from moist in the north (named the Tell) to semi-arid in the Hauts Plateau (high steppic plains) and Saharan in the South.

However, despite the rich medical tradition in Algeria, the study of medicinal flora in the country, as well as in other Maghreb countries, is insufficient. Unfortunately, these varied plants are under significant human and climate pressure, resulting in the permanent loss of several species, particularly those known for their medicinal properties (Ouadeh, 2022).

7.1. Some Ornamental Plants with Medicinal Potential in Algeria

Table 1 presents a selection of ornamental plants cultivated in Algeria that also have medicinal properties. For each species, it provides essential information: scientific name, family, ornamental uses, main chemical constituents and therapeutic properties, as well as the parts traditionally used. It highlights the dual value of these plants, which are both decorative and beneficial to health, illustrating the richness of Algeria's plant heritage and its importance in traditional medicine.

Table 1: Ornamental and medicinal plant species used in Algeria

Scientific name	Botanicalfamily	Vernacular name	Ornamental use	Chemical constituents	Medicinalproperties	Used parts
Rosmarinusofficinalis	Lamiaceae	اكليل الجبل Iklil el jabal	Massifs, borders, dry gardens	Essential oils (1,8-cineole, camphor, borneol), flavonoids	Calming, cholesterol, colon, cough, depurative, hair loss, high blood pressure, influenza, obesity, prostate, rheumatism, stomach	Leaves, flowering tops
Lavandulastoechas	Lamiaceae	الخزامة Khezama	Aromaticbeds, rock gardens	Linalool, linalylacetate, tannins	Antimicrobial, colon, dental gingiva, influenza, kidney, mouth infections, uterine fibroids, vomiting.	Flowers, seeds
Lavanduladentata	Lamiaceae	الخزامة Khezama	Aromaticbeds, rock gardens.	Linalool, linalylacetate, tannins	Calming, antispasmodic, respiratory antiseptic, relaxing	Flowers
Neriumoleander	Apocynaceae	الدفلة Defla	Hedges, alignments, roundabout.	Cardiotonic glucosides (oleandrin)	Strictly pharmacological use (cardiotonic), toxic	Leaves, bark
Pelargoniumgraveolens	Geraniaceae	العطرشة Al-'atrasheh	Pots, floweringbeds.	Geraniol, citronellol, linalool.	Antibacterial, anti-inflammatory, antifungal, healing, calming. Hormonal regulation, haemorrhoids, dysentery, skin inflammation and antioxidant properties	Leaves, essential oil
Aloe vera	Asphodelaceae	الصبار Al-sabbar	Dry gardens, indoor plant	Aloin, acemannan, polysaccharides	Moisturising, anti-ageing, purifying, strengthening the immune system,	Leaf gel

					regulating scalp sebum and combating dandruff, regulating blood sugar and cholesterol levels, Healing, anti-inflammatory, mild digestive	
Bougainvilleaglabra	Nyctaginaceae	الجهنمية الجرداء Al-jahannamiya al-jarada	Climbing, facades, pergolas	Betalains, flavonoids	Antitussive, anti-inflammatory, antibacterial, relieve coughs, asthma and bronchitis, aid digestion and help treat diarrhoea	Leaves, bracts
Hibiscus rosa-sinensis	Malvaceae	ورد الصين Ward al-Sin	Cultivating in urban and coastal areas, gardens and green spaces	Anthocyanins, organicacids	Antioxidant, anti-inflammatory antihypertensive, cholesterol-lowering and diuretic, soothe coughs and sore throats. Treat abscesses, boils, burns, cracks and eczema	Flowers
Asparagus officinalis	Asparagaceae	السكوم Sekoum	Used by florists to make bouquets and can be planted in gardens for its aesthetic appeal	Minerals (potassium, phosphorus, iron, copper, magnesium, calcium, zinc) and fibre, polyphenols, flavonoids and saponins	Rheumatism, diuretic and detoxifying, renal support, antioxidant, source of nutrients, anti-obesity, sexual stimulant	Aerial parts
Phoenix dactylifera	Arécacées	نخيل التمر Nakhil al-tamr	in gardens, public squares and urban alignments. Planted in towns along roadsides for its aesthetic appeal	sugars (mainly in the pulp), minerals (particularly potassium), lipids, proteins, amino acids (glutamic acid, gamma-aminobutyric acid and glycine)	Energizing, Nutritious and energising, digestive, tonic, antitussive, anti-inflammatory and antioxidant, antibacterial, improves male fertility, relieves sore throats and fevers	Fruits, seeds
Jasminum officinal	Oleaceae	ياسمين Yāsamīn	Pergolas, floweringhedge.	Jasmonates, benzylacetate, linalool	Relaxant, mildsedative, antispasmodic	Flowers
Jasminum sambac	Oleaceae	الياسمين العربي Yasmin el-Arabi	Gardens, patios	Indole, linalool, benzylacetate.	Mild antidepressant, calming, relaxing and sedative properties, anti-inflammatory and analgesic, antiseptic, emotional regulator, aphrodisiac, skin care, antioxidant	Flowers
Myrtuscommunis .	Myrtaceae	الريحان Rayehan	Pots and terraces, gardens, planting in	Myrtenol, eugenol, 1,8-cineole	Respiratory, antiseptic, anti-inflammatory,	Leaves

			the Mediterranean massif, Hedges, Mediterranean beds		colon, diabetes, dysuria, hair loss, stomach	
Citrus limon	Rutaceae	ليم lim	Used for its ornamental qualities thanks to its evergreen foliage, fragrant flowers and decorative fruits. Planted in containers on terraces or in the ground in Mediterranean gardens	Limonene, citral, flavonoids	Antiviral and antibacterial, digestive, cardiovascular, healing and, Antiseptic, antioxidant, purifying	Fruits, leaves, peel
Mentha x piperita .	Lamiaceae	النعناع Naâ'naâ	Gardens and parks	Menthol, menthone, flavonoids and phenolic acids	Calming, diarrhea, high blood pressure, inflammation, influenza, pregnancy, rheumatism, stomach, uterine fibroids	Leaves
Menthapulegium	Lamiaceae	فليو Flio	Home gardens, gardens and parks	Menthol, menthone, and phenolic compounds	Hair loss, heart, influenza, vomiting	Aerial parts
Salvia officinalis	Lamiaceae	الميرامية Miramiya	Home gardens and public garden	Terpenes, diterpenes, triterpenes, flavonoids and phenolic acids	Analgesic, anorexia, anguish, calming, cholesterol, colon, depurative, hair loss, high blood pressure, inflammation, obesity, pregnancy, renal lithiasis	Leaves
Laurusnobilis	Lauraceae	الرند Rand	Hedges, beds	Essential oils ,volatilecompounds cineol (1,8-cineole) and linalool, alpha-terpinyl acetate, pinene, eugenol and methyl eugenol, flavonoids, tannins and coumarins	Diabetes, high blood pressure, low blood pressure, stomach, strengthening	Leaves
Callistemon citrinus	Myrtaceae	فرشة الزجاجة Farshat al-zujajah	Urban gardens	1,8-cineole, monoterpenes, limonenemonoterpenols, steroids, glycosides, flavonoids	Antibacterial, antiviral and antifungal, clears the respiratory tract in cases of colds, coughs or bronchitis. Anti-inflammatory and antispasmodic, digestive, healing	Leaves, flowers
Eucalyptus globulus	Myrtaceae	الكاليتوس Al-kalitos	Cities and forests.	1,8-cineole (eucalyptol). It is also rich in monoterpenes	Respiratory tract conditions: asthmatic bronchitis,	Leaves

				such as α-pinene and limonene, sesquiterpenes such as aromadendrene and globulol. Compounds such as camphor, p-cymene and α-phellandrene	rhinopharyngitis, laryngitis, sinusitis, viral conditions: flu, colds	
Artemisia herba-alba	Asteraceae	الشيح Chih	Rockeries, dry gardens	Essential oil, chrysanthenone camphor, α-thujone, α-pinene and β-thujone, myrtenyl acetate, limonene and camphene, flavonoids such as hispidulin and cirsimaritine	Calming, colon, diabetes, diarrhea, hair loss, heart, high blood pressure, influenza, intestinal parasitosis, low blood pressure	Aerial parts
Punicagranatum	Lythraceae	Romman الرمان	Beds and hedges	Polyphenols, flavonoids, tannins	Cardiovascular: regulates blood pressure and high cholesterol. protects against skin ageing, wrinkles, inflammation (eczema) and bacterial or fungal infections. Diarrhoea and dysentery. vomiting. Antimicrobial properties. Antioxidant,digestive	Fruits, bark, seeds
Opuntia ficus-indica	Cactaceae	التين الشوكي	Hedges, dry gardens.	Fibers, flavonoids, polysaccharides	Hypoglycemic, digestive, antioxidant, Diarrhea, hair loss, kidney	Fruits, stems
Berberis vulgaris	Berberidaceae	غريس Ghriss	Hedges Soil stabilisation Landscaping, planting in parks and gardens Decorative aspects	isoquinoline alkaloids, flavonoids (quercetin), phenolic acids, organic acids (malic and ascorbic), alkaloids	Cancer, diabetes, intestinal parasitosis.	Aerial parts, roots
Lantana camara	Verbenaceae	أم كلثوم Oum keltoum	Gardens, streets.	sesquiterpenes and monoterpenes. β-caryophyllene, sabinene, α-humulene and 1,8-cineole. germacrene D, tetradecane and fatty acids such as palmitic acid	Antipyretic and anti-inflammatory effects, antidiarrhoeal effects, antibacterial effects, healing, relieves coughs through steam inhalation	Leaves, flowers
Euphorbiatirucall	Euphorbiaceae	قرن الغزال	Dry garden.	Diterpene esters (such as tigliane, ingenane and daphnane types) which are irritants and potentially carcinogenic. terpenoids from sterols, tannins, fatty acids, flavonoids and phoric acids	Very limited traditional use,irritant	Latex, stems

Cestrumnocturnum	Solanaceae	مسك الليل *misk al-layl*	Planted as an ornamental plant for its intense night-time fragrance and growth in gardens, balconies and green spaces	Alkaloids, flavonoids	Mildantispasmodic, relaxin	Leaves, flower
Calendula officinalis	Asteraceae	زهرة القطيفة Zahrat katifa	Borders, massifs, pot.	Flavonoids, triterpenoids, carotenoids.	Anti-inflammatory, healing, antiseptic.	Flowers
Rosa gallica	Rosaceae	الورد الغالي Al-Ward al-Ghali	Massifs, garden	Essential oils, flavonoids, tannins.	Antioxidant, astringent	Flowers, petals
Neriumindicum	Apocynaceae	حبق الفيل Hbakel Fil	Hedges, urbangardens.	Cardiotonic glycoside, phenols and flavonoids.	Strict pharmacological use, toxic.	Leaves, bark
Plumbago auriculata	Plumbaginaceae	الياسمين الأزرق Al-Yasmin al-Azraq	Climbingwalls, massif	Plumbagin, flavonoids	Anti-inflammatory, antimicrobial, headaches, digestive and respiratory problems.	Leaves, roots
Atriplexhalimus	Amaranthaceae	القطف Guettaf	used as an ornamental plant or for hedges	Proteins, mineralsalts, flavonoids, alkaloids and tannins	Cancer, cysts, high blood pressure, thyroid disorders, ulcer, uterinefibroids	Leaves

Sources: Preethi et al., 2006; Hamman, 2008; Fonseca et al., 2010; Benabdelkader et al., 2011; Lakhmili et al., 2014; Hamidpour et al., 2014; Atailia & Djahoudi, 2015; Bouasla, & Bouasla, 2017; Abarca-Vargas, & Petricevich, 2018; Benhammou et al., 2019; Ez Zoubi et al., 2020; Belhouala & Benarba, 2021; Djahafi et al., 2021; Bendif, 2021; Souilah et al., 2022; Batiha et al., 2023; Makhlouf et al., 2023; Ayouaz et al., 2023; Abo-Elghiet et al., 2023

The photographs of the plants provide a visual illustration of the species presented in the Table 2, making their identification easier and highlighting their ornamental characteristics. They offer an essential complement to the botanical and medicinal information by showing the shape of the leaves, flowers, and the overall appearance of each plant in its natural environment. These images enhance the understanding of the studied species and strengthen the accuracy of their classification and description.

Table 2: Some ornamental plants with medicinal potential in Algeria

 *Rosmarinus officinalis*	 *Lavandula stoechas*
 *Lavandula dentata*	 *Nerium oleander*
	
Pelargonium graveolens	*Aloe vera*

	
Bougainvillea glabra	*Hibiscus rosa-sinensis*
 *Asparagus officinalis*	 *Phoenix dactylifera*
 *Jasminum officinal*	 *Jasminum sambac*

Myrtus communis

Citrus limon

Mentha x piperita

Mentha pulegium

Laurus nobilis

Callistemon citrinus

 *Eucalyptus globulus*	 *Artemisia herba-alba*
 *Salvia officinalis*	 *Punica granatum*
 *Opuntia ficus-indica*	 *Berberis vulgaris*

 *Lantana camara*	 *Euphorbia tirucall*
 *Cestrum nocturnum*	 *Calendula officinalis*
 *Calendula officinalis*	 *Nerium indicum*

	
Plumbago auriculata	*Atriplex halimus*

8. CONCLUSION

In conclusion, ornamental medicinal plants in Algeria represent a fascinating intersection of beauty and utility. They are not only a testament to the country’s rich natural heritage but also a valuable resource for traditional medicine and modern pharmacology. By safeguarding these plants and continuing to explore their potential, Algeria can contribute to global efforts in promoting sustainable healthcare solutions and biodiversity conservation. The present overview reports an important ethnobotanical knowledge possessed by local populations living in Algeria. Ornamentals medicinal plants are traditionally used to treat different diseases and health problems. Ornamental medicinal plants in Algeria is a testament to the country's rich cultural heritage and ecological diversity. From ancient times to the modern era, these plants have been a source of beauty, inspiration, and identity for generations of Algerians. Conservation efforts are therefore crucial to ensure the sustainable use of these valuable resources. Local communities, researchers, and policymakers must work together to promote awareness about the importance of preserving these plants while encouraging their responsible use.

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CHAPTER II

Identifying and Promoting Medicinal Plants: Case of the Biskra Province Algeria

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1. INTRODUCTION

Medicinal plants represent an invaluable heritage for humanity, particularly for vulnerable communities in developing countries, who depend on them for their primary healthcare and livelihoods. These communities use a wide variety of plant species, both woody and herbaceous, for medicinal purposes. According to the World Health Organization, over 80% of African populations use medicinal plants and traditional pharmacopoeia to treat various health problems. Africa abounds in exceptional plant diversity, with more than 200,000 medicinal species recorded in the continent's tropical zones (Sofowora, 1993). The use of plants by man, whether for food, medicine or poison, is rooted in a very ancient tradition (Sévenet & Tortora, 1994). Indeed, the therapeutic use of plants goes back to ancient times, and many herbal remedies have been developed thanks to the observations, experience and inspiration of healers, who have become revered figures in many cultures and societies (Bremness, 2005). This practice originates in the most ancient civilizations and has been preserved over the centuries (Eddouks et al., 2007; Petrovska, 2012).

In Algeria, herbal medicine is an integral part of the local cultural heritage. The population has precious traditional knowledge, passed down empirically through the generations (Bouasla & Bouasla, 2017). The country's geographical and climatic diversity has favored the development of a rich flora, used since time immemorial to treat a multitude of pathologies. This knowledge, passed down orally from generation to generation, has survived the ages. However, in the face of industrialization and social change, this heritage is now being passed down less and less. Hence the urgency and importance of documenting these traditional uses of medicinal plants. It is also important to emphasize that, although much work has been published in recent years on the diversity of ethno pharmacological research in Algeria (Benarba et al., 2015; Boudjelal et al., 2013; Bouzabata et al., 2020), much remains to be explored.

Plants from the Biskra region in southern Algeria are particularly well known for their exceptional ability to resist and adapt to diverse environmental conditions. This study aims to draw up an inventory of the plants used by the Biskra region's population as part of traditional treatments and thus make a significant contribution to this field.

2. MATERIALS AND METHOD

The study area is located in the northeastern part of the Algerian Desert (Figure 1). It lies within one of the country's most important agricultural regions, along the African platform's northern edge. Geographically, the area is defined by the coordinates 4° 55' 12" to 6° 46' 12" E and 34° 16' 48" to 35° 23' 24" N. Extending southeastward towards the Chott Melghir region, it covers a total area of 10,250 km².

The Biskra region is part of a vast sedimentary basin which, in terms of climate, relief and vegetation, represents one of the most morphologically distinct transition zones between the mountainous regions, which cover just 13% of the total area. The majority of these mountains are located in the north of the wilaya, where the maximum altitude varies between 1,500 and 1,700 m, while the average altitude is around 300 m. To the south of the south-Atlantic flexure, the plains begin to develop and extend eastwards, particularly around El-Outaya and Sidi Okba. The southeastern part of the wilaya is marked by depressions made up of clay soils, crossed by wadis from the north. The most notable depression is that of Chott Melghir, located at -33 m below sea level (Brinis, 2011).

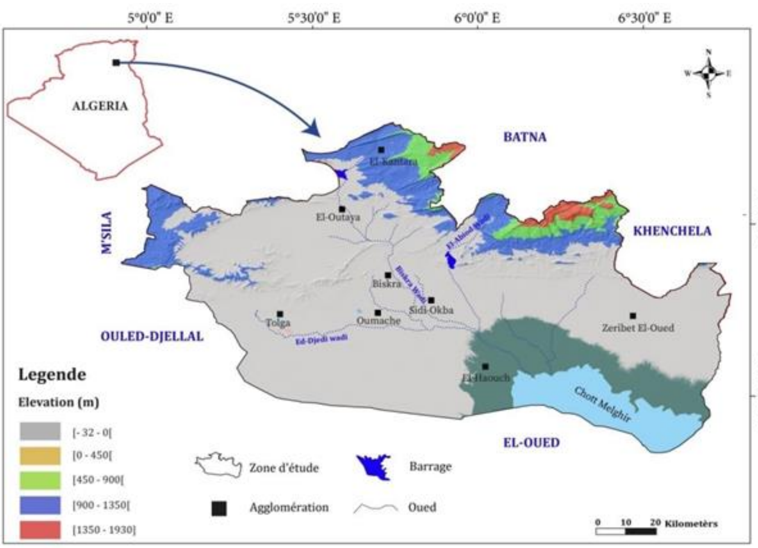

Figure 1: Location of the study area (Reghais, 2023)

The Biskra region is crisscrossed by several wadis forming a temporary hydrographic network, with numerous tributaries draining run-off water from the southwestern Aurès. The main wadis include Oued El-Hai, Oued Abiod and Oued Abdi, which join to form Oued Biskra. Similarly, Oued El-Arab and Oued Kattane, after their confluence, form Oued Zeribet El-Oued (Brinis, 2011; Sedrati, 2011).

The identification and valorization of medicinal plants was carried out for six months; information was gathered on the traditional uses of wild and locally cultivated plants. Ethno botanical surveys were carried out in the five selected towns: El-Kantra; Ourellal; Tolga; Oueld Djellal; and Biskra,

All surveys described information on the informant, botanical characteristics of the plant (scientific name, common name, etc.) ethno botanical characteristics of plants, disease and more information on the control and prevention against disease.

3. RESULTS AND DISCUSSION

This study, carried out over six months at: Tolga, Biskra, Ourellal, El-Kantra and Ouled Djellal stations, enabled us to identify 37 species of spontaneous medicinal plants. We were able to list 27 families of medicinal plants and identify 37 species of spontaneous medicinal plants at the five stations (Figure 2, Table 1):

- 26 species in the Biskra region
- 14 species in the El-Kantra region
- 20 species in the Ouled Djellal region
- 21 species in the Ourellal region
- 20 species in Tolga

Despite the dominance of three families in our inventory (Lamiaceae, Apiaceae and Asteraceae, with six, three and three species respectively), there is a good biodiversity of medicinal plants in the Biskra region, with 37 species representing 27 families.

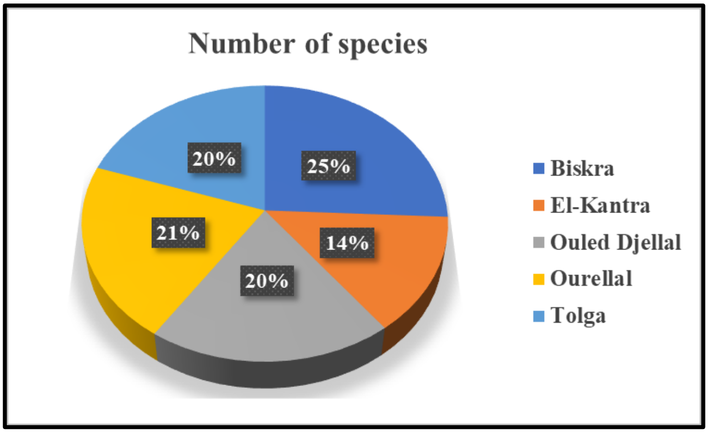

Figure 2: Distribution of medicinal plant areas in the five study stations

The most frequent species in the five sampling stations are: *Malva silvestre; Mentha piperita; Nerium oleander; Punica granatum; Phoenix dactylifera;* and *Rumex acetosa oseille.*

We can see that, for each species and station, dominance varies.

- In Biskra, the most abundant species is *Atriplex halimus*;
- In El-Kantara, the most abundant species is *Opuntia ficus-indica*;
- in Ouled-Djellal, the most abundant species is *Astragalus aramatus*;
- In Ourellal, the most abundant species is *Hordeum vulgare*;
- In Tolga, the most abundant species is *Malva silvestre*;

Table 1: Medicinal plant species inventoried in the study regions

Family	Species	Sampling stations				
		Biskra	El-Kantra	Ouled Djellal	Ourellal	Tolga
Agavaceae	*Agave americana*	+	+	-	-	-
Alliaceae	*Allium sativum*	+	-	-	+	+
Apocynaceae	*Nerium oleander*	+	+	+	+	+
Apiaceae	*Apium graveolens*	+	-	-	+	+
	Coriandrum sativum	+	-	-	+	+
	Foeniculum vulgare	-	+	+	+	+
Arecacea	*Phoenix dactylifera*	+	+	+	+	+
Asteraceae	*Chamaemelum nobile*	-	+	-	-	+
	Silybum mariamum	+	-	-	-	-
	Scorzonera undulata	+	-	+	-	-

Cactacées	*Opuntia ficus- indica*	-	+	-	-	-
Chenopodiaceae	*Atriplex halimus*	+	-	+	+	-
Composée	*Artemisia herba alba*	-	-	+	+	+
Cucurbitaceae	*Citrullus colocynthis*	+	-	+	+	-
Cupressaceae	*Juniperus communis*	+	-	-	+	+
Euphorbiaceae	*Ricinus communis*	+	-	-	+	+
Fabaceae	*Astragalus aramatus*	+	-	+	+	-
Lamiaceae	*Marrubium vulgare*	-	-	+	-	-
	Mentha piperita	+	+	+	+	+
	Rosmarinus officinalis	+	-	-	-	+
	Melissa officinalis	+	-	-	-	-
	Teucrium polium	+	+	-	-	+
	Thymus communs	-	+	-	-	-
Lauraceae	*Laurus nobilis*	-	+	-	-	-
Liliaceae	*Aliium cepa*	+	-	+	+	+
Lythraceae	*Lawsonia inermis*	-	-	+	-	-
Malvaceae	*Althaea officinalis*	+	-	-	-	-
	Malva sivestre	+	+	+	+	+
Moraceae	*Ficus carica*	+	-	+	+	+
Orobanchaées	*Cistanche violacea*	-	-	+	-	-
Papavéraceae	*Papaver rhoeas*	+	+	+	-	-
Poaceae	*Hordeumn vulgare*	-	-	+	+	+
Polygonaceae	*Rumex acetosa oseille*	+	+	+	+	+
Punicaceae	*Punica granatum*	+	+	+	+	+
Rhamnacées	*Zizyphus lotus*	+	-	-	+	-
Tamaricaceae	*Tamarix gallica*	+	-	+	+	-
Zygophyllaceae	*Zygophyllum*	+	-	-	-	-

(+) Presence of the species (-) Absence of the species

Dominated by the Lamiaceae family, the species identified are traditionally used for:

Chamaemelum nobile relieves inflammation and menstrual pain thanks to its active compounds, notably α-bisabolol (Morillas-Cruz et al., 2022). Its aqueous extracts can significantly lower blood pressure in hypertensive models (Zeggwagh et al., 2009; Hebi et al., 2016) . In addition, this plant has antibacterial properties, particularly against *Pseudomonas aeruginosa*, by inhibiting the formation of biofilms (Kazemian et al., 2015). *Marrubium* *vulgare* has potential in the treatment of Alzheimer's disease thanks to its rich phenylethanoid glycosides, which inhibit the main enzymes associated with the disease, such as acetylcholinesterase (Emam et al., 2024), *Mentha piperita* is known for its antimicrobial, antiviral and antioxidant properties, making it the subject of extensive research, with more than 3,266 scientific articles published on its benefits (Da Silva et al., 2024). If we consider the number of species used according to the pathologies, we can see that three of the species inventoried are used in the therapy of eye disease, which is very common in the Biskra region. After a bibliographical search in ancient, modern and traditional medicine, we found that there are plants that are used in several therapies such as: *Ricinus communis* or castor oil to soften the heart (Adeoye et al., 2023); Fresh leaves of Ricinus communis are traditionally used to treat eye redness and irritation, demonstrating its anti-inflammatory properties (Akbar, 2020).

This study has shown that the Biskra region is rich in medicinal plants, despite being subject to particularly harsh climatic conditions. To adapt to the desert climate, some plants shorten their development cycle, which means that they are still poorly understood. Part of this flora loses its aerial parts during the dry period to limit losses through evaporation and survives in the form of seeds or reserve organs (Ozenda, 1991). Sometimes these plants spend the dry season as bulbs, fleshy rhizomes or seeds, as is the case for therophytes.

According to Ozenda (2000), reducing the evaporative surface is an adaptation strategy achieved by reducing the size and number of leaves. Many species have reduced leaves, sometimes transformed into spines, as in the case of *Astragalus armatus*. The majority of Chenopodiaceae have tiny leaves or leaves modified into spines (Ozenda, 1977), enabling them to build up reserves by accumulating water in their tissues (succulent leaves). In the end, only some of the medicinal plants were inventoried in this study.

4. CONCLUSION

Medicinal plants, which are rich in active ingredients, represent a precious resource that requires greater conservation. This study focused on the identification and inventory of local medicinal plants in the Biskra region, known for its biodiversity despite an arid to semi-arid climate.

In five stations studied (Biskra, Ourellal, El Kantra, Tolga, Ouled Djellal), 37 species divided into 27 families were identified. These included

Malva sylvestris, Mentha piperita, Nerium oleander, Punica granatum, Phoenix dactylifera and *Rumex acetosa*. The majority of these species belong to the Spermatophytes and are used to treat cardiovascular diseases (hypercholesterolaemia, hypertension, atherosclerosis) and their associated factors (diabetes, obesity).

This study highlights the richness of Biskra's medicinal flora and calls for further research into medicinal plants in Desertn biotopes. Traditional medicine, which is rooted in local knowledge, should be promoted for its potential contribution to health and sustainable development.

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CHAPTER III

The *Lavandula* Genus: Therapeutic Properties, Composition, and Applications

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1. INTRODUCTION

The *Lavandula* genus is native to the regions bordering the Mediterranean Sea, extending across southern Europe, northern and eastern Africa, the Middle East, southwestern Asia, and southeastern India. It includes several hundred hybrids, about thirty species, and numerous subspecies (Koulivand et al., 2013). Among the various species of the *Lavandula* genus, narrow-leaved lavender (*Lavandula angustifolia*, formerly *L. officinalis* Chaix or *L. vera*), also known as garden lavender, stands out as the most valuable due to its exceptional biological properties (Salehi et al., 2018). These plants are cultivated worldwide, both for their ornamental and medicinal value (Lis-Balchin, 2002; Salehi et al., 2018). They are primarily exploited for the extraction of their essential oils as well as for the production of extracts. These essential oils have multiple applications, notably in perfumery, cosmetics, the food industry, and aromatherapy products (Batiha et al., 2023).

Lavender oils are produced in the glandular trichomes found on the surface of leaves and flowers (Guitton, 2010). Their chemical composition has generated significant interest due to the diversity of compounds they contain and their economic potential. Essential oils from the *Lavandula* genus contain similar components, but in varying proportions. The quality and composition of these oils depend on their origin, growing conditions, variety, and many other factors. The main components of lavender oils include monoterpenes (linalool, linalyl acetate, 1,8-cineole, β-ocimene, terpinen-4-ol, and camphor), sesquiterpenes (β-caryophyllene and nerolidol), as well as other terpenic compounds such as perillyl alcohol (Heral et al., 2021).

The benefits of lavender are largely attributed to its high content of essential oils. Indeed, lavender essential oil has remarkable antioxidant capabilities and the ability to chelate iron ions. It also exhibits antimicrobial properties (Stanojević et al., 2011), as well as anxiolytic, anti-inflammatory, antinociceptive, and anticancer effects (Salehi et al., 2018). Lavender is also used in aromatherapy and massage (Koulivand et al., 2013). In this context, the aim of this chapter is to describe the botanical characteristics, phytochemical composition, and biological properties of the *Lavandula* genus, in order to demonstrate how these elements combine to make it both an ornamental and therapeutic plant.

2. BOTANICAL DESCRIPTION OF *Lavandula*

Lavender is a perennial plant in the Lamiaceae family, which includes herbaceous to semi-woody dicotyledonous plants, with 7,534 species across 236 genera (World Checklist of Selected Plant Families, Kew Royal Botanic Garden website). It is characterized by the presence of a woody stem, often branched, that can reach up to 1 meter in height. The zygomorphic leaves, which are bilabiate, are covered with fine hairs that give them a silvery appearance. The flowers, arranged in spikes, are purple to blue, although some varieties display pink or white tones. They emit an intense fragrance, primarily due to the presence of compounds such as linalool and linalyl acetate (Heral et al., 2021). Lavender prefers well-drained soils and sunny conditions, and it is mainly cultivated in Mediterranean regions (Lis-Balchin, 2002). In terms of classification, the *Lavandula* genus comprises 39 species, divided into three subgenera: *Lavandula*, *Fabricia*, and *Sabaudia,* which include the following sections: *Stoechas, Lavandula, Dentata / Pterostoechas, Subnudae, Chaetostachys, Hasikenses,* and *Sabaudia* (Moja et al., 2016) (Figure 1a). Figure 1b illustrates the characteristic inflorescences of the eight sections. The *Lavandula* genus has a wide distribution range, covering the entire northern part of Africa, as well as France, Spain, Portugal, Italy, Türkiye, and India (Lis-Balchin, 2002) (Figure 1c). The subgenus *Lavandula*, on the other hand, is limited to the northern region of this area, extending along the Mediterranean perimeter to Jordan (Guitton, 2010) (Figure 1c).

In Algeria, the *Lavandula* genus includes seven native species: *Lavandula stoechas, L. multifida, L. coronopifolia, L. pubescens, L. dentata, L. antineae,* and *L. sahariensis* (Quezel & Santa, 1963). These species are rare, with some confined to high mountain areas or the Sahara desert, while others are particularly abundant and cover vast territories. The Algiers-Moroccan region forms a notable center of diversity, hosting many species, including three endemic to Algeria and four to Morocco, representing three of the six sections of the *Lavandula* genus (Upson & Jury, 1997).

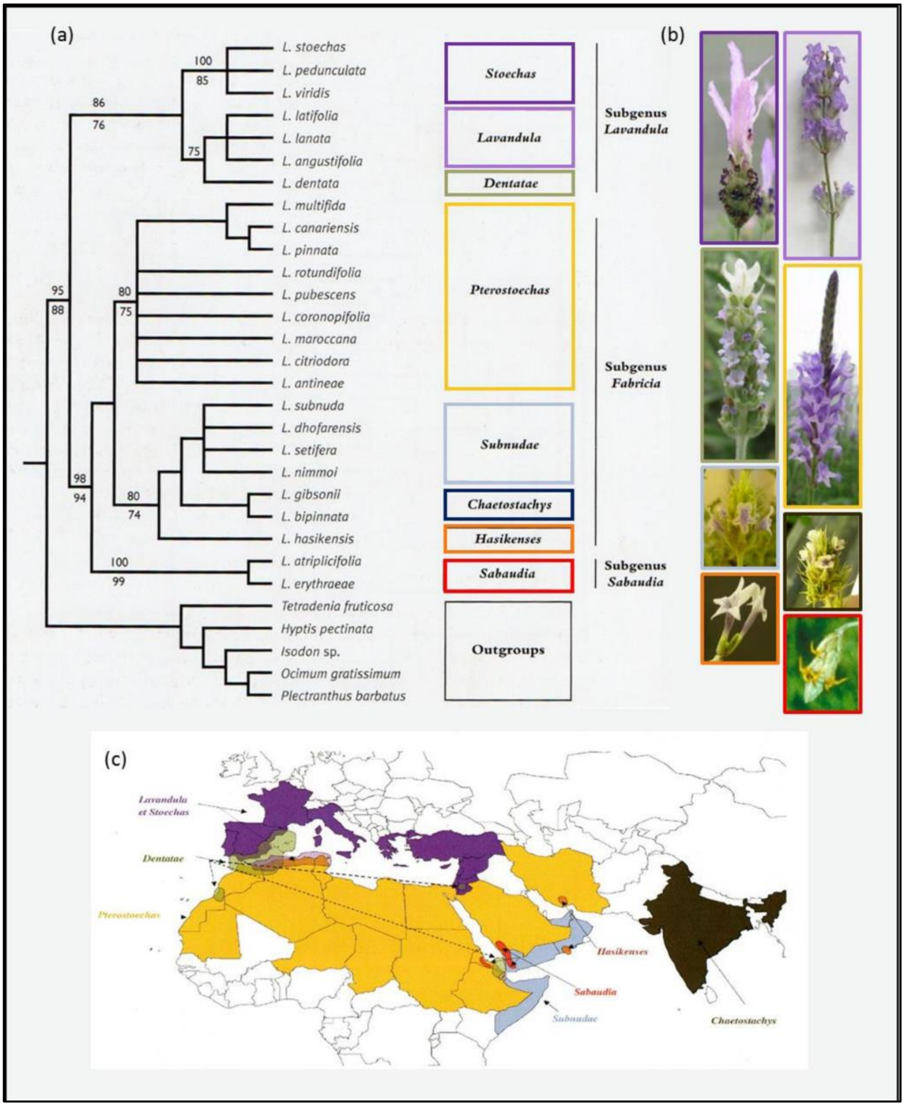

Figure 1: Classification and geographical distribution of the *Lavandula* genus' sections. (a) Phylogenetic tree of the *Lavandula* genus based on morphological traits (adapted from Upson &Andrews (2004)). (b) Illustrative inflorescences of the eight sections of the *Lavandula* genus (adapted from Guitton (2010)). (c) Geographical distribution of the eight sections of the *Lavandula* genus (Guitton 2010)

3. CHEMICAL COMPOSITION OF LAVENDER

Lavender (*L. angustifolia*) contains a variety of compounds, including essential oil, anthocyanins, phytosterols, sugars, minerals, as well as acids such as coumaric acid, glycolic acid, valeric acid, and ursolic acid, in addition to herniarine, coumarin, and tannins (Batiha et al., 2023).

The macronutrient composition varies depending on the lavender variety (Colceru-Mihul et al., 2009). The amount of calcium is strongly influenced by climatic conditions. For instance, the average calcium content in lavender grown in Romania is 2,13 g per kg of dry matter (d.m.) (Adnan et al., 2010), while in Pakistan, this value reaches 10,50 g of Ca per kg of d.m. The calcium concentration in the Munstead variety is 13,8 g per kg of d.m., compared to 8,10 g per kg of d.m. in the Blue River variety (Góra et al., 2005). Potassium concentrations range from 17,7 g per kg of d.m. for the Munstead variety to 23,9 g per kg of d.m. for the Lavender Lady variety. Zinc levels vary between 23,0 and 106,27 mg per kg of d.m. (Góra et al., 2005). A study by Kvaternjak et al. (2020) confirmed a relatively higher concentration of potassium (2,96%) and magnesium (0,26%) in the leaves of true lavender (*L. angustifolia* Mill.).

Copper content ranges from 7,2 to 11,1 mg per kg of d.m, while manganese content varies from 9,6 to 18,0 mg per kg of d.m. for the Munstead and Lavender Lady varieties, respectively. The highest iron concentration was observed in the Ellagance Purple variety (489 mg per kg of d.m.), while the lowest was found in the Munstead variety (137 mg per kg of d.m.) (Adaszyńska et al., 2011; Batiha et al., 2023). The *Lavandula* genus is distinguished by its rich content of phenolic compounds. To date, about nineteen flavones and eight anthocyanins have been identified in these plants (Harborne & Williams, 2002). The family is also characterized by various glycosides of hypolaetine and scutellareine, as well as triterpenes, including ursolic acid (Lis-Balchin, 2002). The flavonoids present in the leaves are primarily flavone glycosides, and their distribution among different taxa holds some taxonomic importance. The main flavones found in Lavandula species are analogues of luteolin, apigenin, hypolaetine, scutellarine, and isoscutellarine (El-Garf et al., 1999; Lis-Balchin, 2002; Héral et al., 2021).

A study conducted by El-Garf et al. (1999), who examined the dried aerial parts of *L. coronopifolia* and *L. pubescens*, identified four flavone glycosides (40-methyl ether 8-O-glucuronide of hypolaetine, 8-O-glucuronide of hypolaetine, 8-O-glucuronide of isoscutellarine, and 7-O-glucoside of luteolin) as well as one flavone aglycone (xanthomicrol). Furthermore, a chemical analysis of *L. dentata* and *L. stoechas* using HPLC-DAD-MS led to the probable identification of nine flavones, including C- and di-C-hexosides of apigenin, 7-O-glucoside of apigenin, genkwanine (7-methyl ether of apigenin), 8-O-glucuronide of isoscutellarine, 7-O-glucoside of luteolin, 7-O-glucuronide of luteolin, and 7,40-di-glucuronide of luteolin (Algieri et al., 2016). A study by Contreras et al. (2018) on the phytochemical characterization of the aerial parts of *L. dentata* and *L. stoechas* confirmed the diversity of flavones, with the identification of six O-glycoside derivatives, five C-glycoside derivatives, and ten O-glucuronide derivatives in hydromethanolic extracts. Among these compounds, apigenin glucuronide hexoside, hypolaetine di-glucuronide, and 7,30-dimethyl ether of luteolin were tentatively identified for the first time in *Lavandula*.

All species of the *Lavandula* genus are particularly aromatic plants, producing complex mixtures of essential oils, volatile terpenes, mainly mono- and sesquiterpenes, which are synthesized and stored in specialized glandular trichomes located on the surface of the flowers and leaves (Perrin & Colson, 1986; Guitton, 2010). The composition of *Lavandula* essential oils varies not only between species but also within the same species. This variation is due to various factors such as genotype, cultivation and climatic conditions, location, extraction methods, and drying processes (Smigielski et al., 2011).

Essential oils are primarily extracted through steam distillation or hydrodistillation. The yield is approximately 3%, with the oils being yellow in color and having an intense floral and herbaceous fragrance characteristic of lavender (Prusinowska & Śmigielski, 2014). The essential oil contains hundreds of chemical compounds, with the main ones being oxygenated monoterpenes, while monoterpene esters are present in smaller quantities (Šoškić et al., 2016). Dominant compounds reported in the literature from different countries include linalool (27.3–42.2%), linalyl acetate (27.2–46.6%), (Z)-β-ocimene (0.2–11.6%), terpinen-4-ol (0.70–4.6%), lavandulyl acetate (0.50–4.8%), β-caryophyllene (1.8–5.1%), (E)-β-ocimene (0.30–3.8%), α-terpineol (0.30–2,0%), and 1,8-cineole (0,10–1,2%) (Cavanagh & Wilkinson, 2002) (Table1).

Some species, such as *L. stoechas*, produce more than 100 different terpenes, while others, such as *L. canariensis*, exhibit a much more limited terpene diversity. *L. stoechas* has been the subject of numerous studies due to its wide geographical distribution and its traditional use dating back centuries. A study conducted by Skoula et al. (1996) on four wild populations of *L. stoechas* in Crete revealed that the main components of the essential oils were, either separately or in combination, fenchone, camphor, 1,8-cineole, α-pinene, and myrtenyl acetate. Generally, essential oils distilled from *L. stoechas* populations contain more oxygenated compounds than hydrocarbon compounds (Lis-Balchin, 2002). The terpene compounds characteristic of lavender species serve as valuable chemotaxonomic markers for differentiating species and even subspecies. For example, *L. stoechas* subsp. luisieri is the only lavender taxon to produce the irregular monoterpenes, namely cis- and trans-α-necrodol, as well as trans-α-necrodol acetate (Lavoine-Hanneguelle &Casabianca, 2004; Baldovini et al., 2005).

The essential oil characterization study identified 20 compounds representing 91,84% of the total. The essential oil of *L. officinalis* is primarily composed of: linalyl acetate (32,98%), linalool (28,92%), β-caryophyllene (4,62%), lavandulyl acetate (4,52%), Z-β-ocimene (4,44%), terpinene-4-ol (4,32%), E-β-ocimene (3,09%), and β-farnesene (2,73%), making up approximately 85,62% of the total components. Laib & Barbat (2011) also identified the essential oils of *L. officinalis* in Algeria, finding linalyl acetate (15,26%), linalool (10,68%), 1,8-cineole (10,25%), γ-terpinene (11,2%), and camphor (11,25%). Kulevanova et al. (2000) reported a predominance of monoterpene compounds, as well as the presence of sesquiterpene hydrocarbons and their oxygenated derivatives in the chemical composition of the essential oil from *L. officinalis* flowers collected from the Kozjak Mountain (Macedonia).

In a comparative study of the chemical composition of commercially produced *L. officinalis* essential oil in France and locally grown oil in Poland, GC/MS analysis showed that the self-produced oil had a lower linalool content than the commercial oil (23,2% versus 40,2%), a comparable content of linalyl acetate (40,6% versus 44%), while the proportion of lavandulyl acetate was significantly higher (23,2% versus 5,5%) (Miastkowska et al., 2021).

As mentioned previously, several factors can influence the chemical composition of essential oil. Seasonal variations have affected the composition of essential oils from *L. angustifolia* cultivated in Belgrade, demonstrating that the composition of lavender essential oils depends on both the part of the plant and its stage of development (Lakušic et al., 2014). The study reported by Chrysargyris et al. (2016) shows that water stress affects both the chemical composition and the yield of the essential oil, but certain compounds, such as 1,8-cineole, considered an antioxidant, increased from 74,4% to 76,4% under severe water deficit conditions.

Table 1: The chemical composition of the essential oil as a percentage of the total oil composition (Wells et al., 2018)

Constituents	***L. angustifolia***	***L. latifolia***	***L. stoechas***	***L. luisieri***	***L. x intermedia***
Linalool	6.97–44.4	27–61.1	0.08–2.7	0.2–3.1	21.1–32.3
Linalyl acetate	7.2–50.5	0.05–1.1	nd	nd	3.04–46.0
Borneol	0–6.2	0.16–5.9	0.8–1.4	nd	0–15.7
Alpha terpineol	0.6–3.5	0.1–2.95	0.09–0.66	nd	0–3.6
Lavandulyl acetate	2–3.5	nd	0–0.22	3.3–4.3	0–3.1
Oct-1-en-3-yl acetate	3.4	nd	nd	nd	nd
Cis-linalool oxide (furanoid)	3.2	0–0.6	0.05–0.1	0.7–1	nd
Cryptone	2.7	nd	nd	nd	nd
Terpineo-4-ol	2.3–30.2	0.3–7.1	0.2–0.5	0	0–2.8
1,8-Cineole	0–6.03	6.6–34.9	8–52.7	2.4–43.2	5.2–26.1
Trans-linalool oxide (furanoid)	2.1	nd	0.01–0.05	nd	nd
Geranyl acetate	1.8	nd	0.01–0.02	0.2–0.4	nd
β-Myrcene	0.4–2.8	0.2–0.8	0.8	0-0.1	nd
β-Caryophyllene	1.5–4.3	0.5–1.9	0.2	nd	0–1.9
Octan-3-one	1.5	0.1–0.2	0.13–16.3	nd	nd
Gamma-cadinene	1.2	0.1–0.2	0–0.8	1.53	nd
α-Cadinol	1.2	0–0.1	nd	0.5–2.4	nd
Cuminol	1	nd	nd	nd	Nd
Camphor	0–1.7	1.1–46.7	7.9–51.6	1.0–2.7	2.5–11.1
α-Limonene	0.8–5.9	0.2–3.4	0.06–1.3	0.3–0.8	nd
Lavandulol	0–7.01	0.5–0.6	0	0.9–1.7	0–4.95
Neryl acetate	0.8	nd	nd	nd	nd
Camphene	0.4–0.6	0.2–5.3	0–4.4	0.1–0.2	0.1–1.2
p-Cymene	0.6	0–0.2	0.3	0.3–0.4	nd
Trans-pinocarveol	0.6	nd	0.03–0.1	nd	nd
Nerol	0.6	0.09–0.79	nd	nd	nd
Carotol	0.6	nd	nd	nd	nd
Hexyl acetate	0.4	nd	nd	nd	nd

β-Ocimene	0.4–21.2	0–1.3	nd	0–0.4	0–14.97
Cis-*p*-Menth-2-en-1-ol	0.4	nd	nd	nd	nd
Verbenone	0.4	0.08–0.7	0.2–1.5	1.7–2.1	nd
Cumin aldehyde	0.4	nd	0–0.01	nd	nd
β-Cyclocitral	0.3	nd	nd	nd	d
Daucol	0.3	nd	nd	nd	nd
α-Pinene	0.3–0.5	0.6–1.9	0.2–2.1	2–3.4	0.2–0.6
Oct-1-en-3-ol	0.2	0–0.1	0–0.02	nd	nd
Cis-Verbenol	0.2	nd	nd	0–1.2	nd
Hexyl butanoate	0.2	nd	nd	nd	nd
Trans-carveol	0.2	0.0.1	nd	nd	nd
Gernial	0.2	nd	nd	nd	nd
(Z)-b-Farnesene	0.2	0–0.3	nd	nd	nd
ọ-Cymene	0.1	nd	nd	nd	nd
Allo-ocimene	0.1	nd	nd	nd	nd
Myrenol	0.1	0.2–0.3	0–0.9	nd	nd
Geraniol	nd	0.06–0.8	nd	nd	nd
α-Thajene	0.3	0–0.1	nd	nd	nd
β-Pinene	0.4	0.04–2.6	0.1–0.4	0.2–1.8	nd
Sabinene	0.5	0.02–1.2	0–0.7	0.1–0.2	nd
Gamma-4-carene	0.2	nd	nd	nd	nd
Para-mentha-1(7),8-diene	4	nd	0–0.46	nd	nd
Fenchone	nd	nd	2.9–68.2	2.9–6.6	nd

nd: not detected

Another study showed the post-harvest effect on the composition of essential oil during the period between harvest and chemical analysis of two varieties of *L. angustifolia* grown in the Czech Republic (Dušková et al., 2016).

Other species of *Lavandula* have been studied in the literature for their chemical compositions and biological properties. These studies revealed that the essential oil of *L. multifida*, hydrodistilled in Algeria at three stages of development, mainly contained carvacrol (ranging from 27,5% to 57,0%), β-bisabolene (ranging from 25,2% to 38,4%), and caryophyllene oxide (ranging from 3,5% to 7,5%) (Khadir et al., 2016). Additionally, essential oils from *Lavandula* species in Tunisia showed that the dominant compounds were (E)-β-ocimene (26,9%), carvacrol (18,5%), β-bisabolene (13,1%), and myrcene (7,5%) for *L. coronopifolia,* while for *L. multifida,* the main components were carvacrol (65,1%) and β-bisabolene (24,7%), and for *L. stoechas*, the major components were fenchone (34,3%) and camphor (27,4%) (Messaoud et al., 2012).

A study conducted by Kane et al. (2004) on the composition of the essential oil of three *Lavandula* species from Tunisia confirmed that the essential oil of *L. dentata* was mainly rich in linalool (47,3%), linalyl acetate (28,7%), bicyclogermacrene (3,4%), camphor (2,3%), and δ-terpineol (1,5%). In contrast, for *L. stoechas*, the main compounds were linalyl acetate (64,3%), linalool (20,3%), and β-thujone (9,0%). The essential oil of *L. multifida*, on the other hand, was characterized by a strong presence of linalool (50,1%), camphene (10,1%), linalyl acetate (7,3%), α-thujene (3,8%), bornyl acetate (3,0%), β-caryophyllene (2.,1%), nerol (2,0%), and terpinolene (2,1%) (Msaada et al., 2012).

4. BIOLOGICAL PROPERTIES

Lavandula extracts and their essential oils have been used for centuries in traditional medicine (Cavanagh & Wilkinson, 2006). Currently, numerous studies focus on the bioactive compounds of *Lavandula* species, aiming to explore their potential for the development of new therapeutic approaches. This plant is particularly used to treat various conditions such as gastrointestinal diseases, parasitic disorders, and certain problems of the central nervous system, including epilepsy and migraines. It is also well known for its anxiolytic properties (Salehi et al., 2018; Samuelson et al., 2020). Several studies have demonstrated the multiple biological properties of lavender, including the following activities:

4.1. Antioxidant Activity

Antioxidants are essential molecules that help protect our bodies against oxidative stress (Williamson, 2017). The antioxidant activity of lavender is primarily attributed to its richness in polyphenols and flavonoids (Saxena et al., 2012; Cardia et al., 2021). Moreover, *Lavandula* essential oils, in particular, exhibit significant antioxidant capacity due to their composition rich in thymol, linalool, limonene, fenchone, camphor, camphene, β-caryophyllene, 1,8-cineole, and trans-α-necrodyl acetate (Williamson, 2017).

Several studies have shown that *Lavandula* species possess strong antioxidant activity, particularly in terms of free radical scavenging (Haddouchi et al., 2020). In this regard, Dobros et al. (2022) used DPPH and FRAP methods to study the antioxidant properties of extracts from cultivars of *L. angustifolia* and *L. x intermedia*. Furthermore, extracts from three lavender species native to Algeria exhibited powerful antioxidant activity, both in the DPPH free radical scavenging test and in iron reduction in the FRAP test (Haddouchi et al., 2020). Additionally, research has shown that these species are effective in inhibiting lipid peroxidation, as demonstrated in a rat model of heart attack (Ziaee et al., 2015). In this context, Economou et al. (1991) observed the inhibitory effect of lavender essential oil on fat oxidation reactions and lipid peroxidation, using a linoleic acid-based model system. Finally, a supplementary study highlighted the hepatoprotective properties of *L. officinalis*, thanks to its ability to reduce oxidative stress and increase antioxidant enzyme levels (Cardia et al., 2021).

4.2. Antimicrobial Activity

Lavender essential oil possesses strong antimicrobial effects. Several studies have demonstrated the antimicrobial activity of linalool against various bacteria found in the oral cavity, skin, and respiratory tract, including *Haemophilus influenzae*, *Streptococcus pyogenes*, *Staphylococcus aureus*, *S. epidermidis*, and *Escherichia coli* (Soković et al., 2007; Boughendjioua, 2017). Additionally, a study conducted by Boughendjioua (2017) revealed the antibacterial activity of essential oil from dried flowering tops of *L. officinalis* against *Streptococcus β-hemolyticus* group A, *Staphylococcus aureus*, and *Staphylococcus epidermidis*.

Furthermore, lavender essential oil exerts an inhibitory effect on the growth of various bacterial strains such as *S. enteritidis*, *K. pneumoniae*, *E. coli*, *S. aureus*, *P. aeruginosa*, *C. albicans*, and *A. niger* (Stanojević et al., 2011). Similarly, the essential oil of *L. dentata* inhibits the growth of several bacteria, including *Salmonella*, *Enterobacter*, *Klebsiella*, *E. coli*, *S. aureus*, and *L. monocytogenes*. Bacteriostatic and bactericidal effects have also been observed in vitro against both methicillin-sensitive and methicillin-resistant *Staphylococcus aureus*, as well as vancomycin-resistant *Enterococcus* (Roller et al., 2008).

It has also been observed that lavender essential oil is active against yeasts and molds, such as *Candida* sp., *A. niger*, and *P. expansum*, with a minimum inhibitory concentration (MIC) 2,5 to 3 times lower than that observed for bacteria. Additionally, a study showed that *L. angustifolia* oil inhibited the germination of conidia and the growth of germ tubes, even at doses up to 1000 mg/mL (Daferera et al., 2000).

4.3. Anti-Inflammatory Property

Species of the genus *Lavandula* are commonly used as remedies to treat various inflammatory diseases (Hajhashemi et al., 2003). For example, the essential oil of *L. stoechas* has shown anti-inflammatory properties in vitro, attributed to its volatile composition. A study by Giovannini et al. (2016) demonstrated that the essential oil of *L. angustifolia* stimulates the innate macrophage response to a bacterium responsible for major nosocomial infections, suggesting its potential as an adjunctive anti-inflammatory drug and immune system regulator. Further research has also highlighted the anti-inflammatory effects of lavender essential oil. For instance, But et al. (2023) revealed that pre-treatment with intraperitoneal injection of lavender oil, administered for three days, was effective in the treatment of experimentally induced thrombosis. Additionally, Pandur et al. (2021) reported that lavender essential oil, extracted during early flowering, powerfully inhibits the synthesis of four pro-inflammatory cytokines: IL-6, IL-8, IL-1β, and TNFα in THP-1 cells. Lavender essential oil has also shown its potential in the alternative treatment of bronchial asthma, by reducing allergic inflammation in the airways and mucosal cell hyperplasia in a murine asthma model (Ueno-Iio et al., 2014). In addition to these findings, the polar fractions of *L. dentata* and *L. stoechas* also demonstrated anti-inflammatory properties (Algieri et al., 2016). Husseini et al. (1996) observed that *L. officinalis* modulated pain and inflammation induced by formalin, by inhibiting cyclooxygenase enzymes.

4.4. Anxiolytic Activity

Lavender (*L. angustifolia*) has anxiolytic properties, as demonstrated by a study conducted on pigs. The results revealed a significant reduction in the incidence and severity of motion sickness, assessed by cortisol concentration in saliva, in animals when the floor of the vehicle was covered with lavender (Bradshaw et al., 1998). In a clinical study conducted on 122 critically ill patients, it was observed that aromatherapy using essential oils reduced anxiety compared to patients receiving a massage without aromatherapy or those resting. No differences were noted in terms of blood pressure and respiratory status between the two patient groups (Dunn et al., 1995). These data support the effectiveness of the lavender scent in reducing anxiety and pain, making it a commonly used method, particularly by many women during childbirth. Considered a safe method, it helps reduce cortisol levels and anxiety (Mirzaei et al., 2009).

In vitro studies have also confirmed that this essential oil possesses analgesic activity (Hajhashemi et al., 2003). Furthermore, a study conducted by Rahmati et al. (2017) showed that extracts of *L. officinalis* not only improved memory deficits induced by scopolamine but also reduced anxiety and depressive behaviors in a dose-dependent manner. Exposure to the scent of lavender appears to induce an anxiolytic effect comparable to that of diazepam in gerbils. After two weeks of prolonged exposure to this scent, increased exploratory behavior was observed in females, suggesting further anxiety reduction in this group (Bradley et al., 2006). A study on the anxiolytic effect of *L. stoechas* essential oil revealed that inhaling this oil in patients who had suffered a myocardial infarction resulted in a significant reduction in anxiety (Najafi et al., 2014).

5. THERAPEUTIC BENEFITS

5.1. Anticancer Potential

Lavender, primarily known for its soothing and relaxing properties, is also attracting growing interest in the field of oncology research due to its potentially antitumor effects. In fact, studies have highlighted the antitumor properties of essential oils and their active components. For example, a study conducted by Aboalhaija et al. (2022) demonstrated the antiproliferative efficacy of the ethanolic extract of *L. angustifolia* from Jordan against breast cancer, both in vitro and in vivo. Other research has also revealed that lavender essential oil is capable of inhibiting the growth of human prostate cancer xenograft tumors in nude mice, with this effect being mainly attributed to linalool, rather than linalyl acetate (Zhao et al., 2017).

Moreover, it has been proven that *L. officinalis* essential oil exhibits anticancer and antimutagenic properties (Fahmy et al., 2022). Some studies also suggest that lavender oil can induce apoptosis while inhibiting the migration and invasion of cancer cells, which are key characteristics in the metastasis process by blocking these processes, lavender could therefore help limit the spread of cancer to other parts of the body (Boukhatem et al., 2020).

5.2. Healing Effect of Lavender Essential Oil

Lavender essential oil (*L. angustifolia*) is widely recognized for its healing and regenerative properties (Samuelson et al., 2020), making it a popular natural remedy for wound treatment. Several studies have demonstrated that topical application of this essential oil promotes the healing of skin wounds by accelerating tissue regeneration. The mechanisms through which lavender oil may promote wound healing include accelerating granulation, remodeling tissues through collagen replacement, and wound contraction via the induction of transforming growth factor-β (TGF-β). This leads to an increase in the production of fibroblasts and type I collagen, which may contribute to improving wound healing (Mori et al., 2016). A study by Inan et al. (2013) showed that lavender essential oil stimulates collagen production, a key protein in the healing process. Furthermore, it exerts an anti-inflammatory effect that reduces local inflammation, a critical factor for rapid and effective healing. Additionally, lavender oil has antibacterial properties, which help prevent wound infections and create an environment conducive to healing (Rahmati et al., 2017). Active compounds in lavender, such as linalool and linalyl acetate, also play a crucial role in stimulating tissue repair. This action was highlighted by Li et al. (2016), who confirmed that these substances promote the healing process. These properties make lavender essential oil a promising agent in the management of wounds, minor burns, and superficial cuts.

A study conducted by Hartman & Coetzee (2002) examined the impact of a blend of lavender and chamomile essential oils (total concentration of 6%) on the healing of chronic wounds. This blend was chosen due to the supposed regenerative effects of lavender oil on the skin, as well as its antibacterial and analgesic properties.

Additionally, a clinical study by Kaur et al. (2016) compared the effectiveness of lavender essential oil and betadine in healing episiotomy wounds in postnatal mothers. Using the REEDA scale to assess healing, the researchers found that lavender essential oil promoted wound healing in the first three days, while both treatments were found to be equivalent by the fifth day. Finally, a study conducted by Ben Djemaa et al. (2016) evaluated the effectiveness of 4% *Lavandula aspic* essential oil on the healing of excisional wounds in rats. The results showed that after 14 days, the wounds of the group treated with 4% lavender essential oil had nearly fully closed, while those treated with Cytolnat centella cream were completely closed.

6. CONCLUSION

A thorough study of the *Lavandula* genus highlights the botanical and phytochemical richness of this plant, particularly the presence of active compounds such as linalool and linalyl acetate, which endow lavender with its numerous virtues. Biologically, its antioxidant, anti-inflammatory, and antimicrobial effects open up many possibilities for its use in various health fields. The therapeutic properties of lavender, ranging from anxiolysis to muscle pain management and skin healing, further solidify its status as a natural agent with multiple applications, both in medicine and in the cosmetic industry. Thus, this genus represents a valuable resource, whose rational exploitation could contribute to new therapeutic approaches and well-being strategies.

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CHAPTER IV

Taxonomic and Ecological Insights on *Lavandula stoechas* (Lamiaceae), an Ornamental Plant from Algeria

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1. INTRODUCTION

The Lamiaceae is a very large family with a cosmopolitan and eclectic distribution throughout the world, due to its ecology being widely adapted to various climate types of the biosphere. It is an aromatic, medicinal, culinary, and also nutritional family. In the present chapter, emphasis is placed on its ornamental aspect, the ease of cultivation and biological cycle favor its use in gardening, as well as its daily use as a flowering plant for decoration. Moreover, many species of Lamiaceae have significant ecological and pastoral importance, with some being used as natural forage in Algerian steppe ecosystems (*Artemisia herba-alba*, *Artemisia campestris*), along with genera such as *Salvia* (sage), *Teucrium*, and *Marrubium*, etc.

The choice of the species focused on *Lavandula stoechas* (Figure 1). In the present chapter, taxonomic and ecological aspects are also highlighted (Linnaeus, 1753a; 1753b), emphasizing the diversity, distribution, and adaptive strategies of this species in various Mediterranean ecosystems. This plant deserves particular attention, as it meets all the criteria defined by KEW, being both a wild species and, at present, widely cultivated and used as an ornamental plant in most Algerian gardens. Online participatory platforms are of great interest for studying the distribution and occurrence of species in general, and plants in particular. Among the most well-known are iNaturalist (URL-1) and GBIF (URL-2), which provide valuable global databases. For synonymy and nomenclature, the Plants of the World Online (POWO) website (URL-3) is also an important resource. In addition, The African Plant Database is also of great interest for taxonomy, as it helps validate the status and accepted names of plant species (URL-15). The North Africa project within the Tela Botanica network (URL-4) has greatly contributed to plant identification and to the knowledge of the botanical heritage of the North African region, including Algeria.

Figure 1: Morphological and botanical aspects of butterfly lavender (*Lavandula stoechas* L.); A: *Lavandula stoechas* peduncles topped with an enlarged crown of purple floral bracts; B: Potted plants of *Lavandula stoechas* L. with flowering tops; C: Elongated, opposite, linear and narrow leaves of *Lavandula stoechas;* D: Illustration of the flowering aerial part of *Lavandula stoechas* (Boukhatem et al., 2020)

In Algeria, several key floristic reference works are available for studying the flora, including the two volumes of *The New Flora of Algeria* by Quézel & Santa (1962–1963), the 16 volumes of *Flora of North Africa* by Maire (1952–1987), as well as *Analytical and Synoptic Flora of Algeria and Tunisia* by Battandier & Trabut (1902-1905) and *Flora of Algeria* by the same authors (Battandier & Trabut, 1888, 1895), and also other works by Battandier on the flora of Algeria (1910, 1919). These works were later updated by Dobignard & Chatelain (2010, 2011a, 2011b, 2012, 2013) in the five volumes of *Synonymic Index of the Flora of North Africa*.

2. THE LAMIACEAE FAMILY WORLDWIDE

The Lamiaceae is one of the earliest plant families recognized by botanists. It was first described and named by Jussieu in 1789 (Brahmi et al., 2017). This family comprises about 260 genera and more than 6,500 species

(Spichiger et al., 2004). According to Meyer et al. (2008), it includes nearly 6,970 species distributed among 240 genera.

These are dicotyledonous angiosperms belonging to the order Lamiales. Also known as Labiatae (from the Latin *labia*, meaning “lip”), the family owes its name to the characteristic shape of its flowers, which are generally bilabiate (Naghibi et al., 2010).

It is widely distributed in tropical as well as other regions of the world (Figure 2). The greatest diversity is observed in the following areas: the Mediterranean Basin, Central Asia, the American continent, the Pacific islands, Equatorial Africa, and China, with a marked decrease in the Great African Sahara and in the deserts of Asia and the Arabian-Persian Gulf (Crété, 1965).

The Lamiaceae are primarily plants with a Mediterranean affinity, which in the Sahara are found mainly in the pre-Saharan region and in the upper zone of the Hoggar. However, three species, namely *Marrubium deserti* Jury, *Salvia argentea* L., and *Teucrium polium* L., have a wider distribution, particularly the first two (Ozenda, 2004).

The Lamiaceae include annual, biennial, and perennial herbaceous plants, as well as shrubby forms. They are generally flowering plants, herbaceous or tree-like, often highly aromatic (Sarri et al., 2015).

About 40% of the species in the Lamiaceae family contain compounds with aromatic properties. This family, also known as Labiatae, is characterized by the presence of glandular hairs that secrete essential oils of significant economic importance (Cantino & Sanders, 1986). Some species are cultivated as culinary herbs (*Mentha*, *Ocimum*, *Salvia*, etc.), while others are used in cosmetics, perfumery, essential oil production, and horticulture (Venkateshappa & Sreenath, 2013). The Lamiaceae family, widely distributed in the plant kingdom, holds great economic importance due to the richness of its phytochemical compounds. These plants contain various active metabolites such as menthone, menthol, coumaric acid, and carvone, as well as a high content of polyphenolic compounds known for their remarkable biological properties. Several studies have highlighted their antioxidant, anti-inflammatory, antifungal, antitumor, antidiabetic, antispasmodic, and analgesic activities (Lamoudi et al., 2023). From a medicinal perspective, many species of this family are thus considered promising sources of natural therapeutic molecules (Topcu & Kusman, 2014).

This family holds an important place in the Algerian flora (Quézel & Santa, 1962; 1963), with a large number of species represented. I have already conducted five studies in the ethnobotanical and phytotherapeutic fields, focusing on several species belonging to this family, including *Ballota hirsuta* Benth., *Marrubium vulgare* L., *Teucrium polium* L., *Thymus ciliatus* Desf., *Salvia officinalis* L., *Mentha pulegium* L., *Phlomis crinita* Cav., *Ajuga iva* (L.) Schreber, *Sideritis incana* L., *Salvia argentea* L., and *Rosmarinus officinalis* L. (Saidi et al., 2015; Saidi et al., 2022; Saidi &Taibi, 2025).

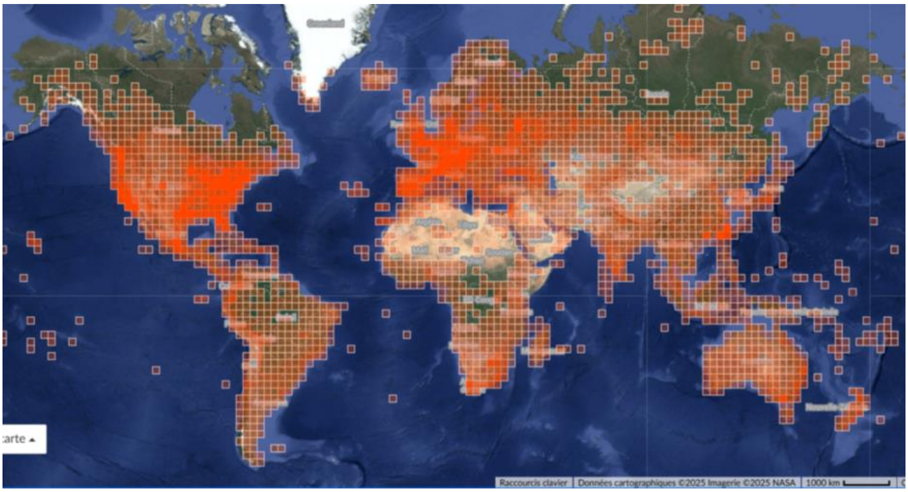

Figure 2: Global distribution of species belonging to the Lamiaceae family on Inaturalist plateform (URL-5)

2.1. Global Distribution of *Lavandula stoechas*

The distribution of *Lavandula stoechas* is mainly concentrated in the western Mediterranean region, including southern Europe (Spain, France, Portugal, Italy) and North Africa (Morocco, Algeria, Tunisia). Some isolated occurrences are also observed in the Atlantic islands, as well as in Australia, South Africa, and the west coast of the United States, where the species has been introduced for ornamental purposes. This distribution reflects the species' strong Mediterranean affinity, characterized by adaptation to hot and dry climates, poor and calcareous soils, and marked seasonal precipitation (Figure 3, 4, 5, 6).

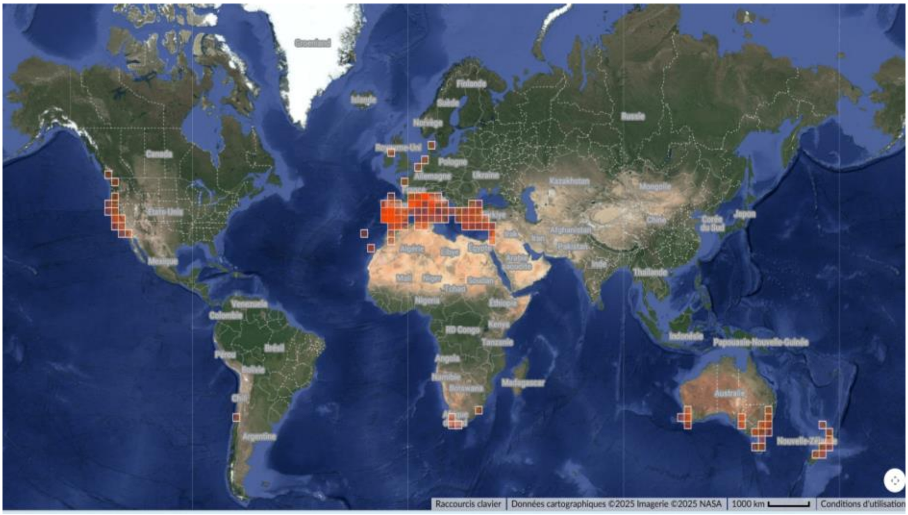

Figure 3: Global distribution of *Lavandula stoechas* (French: Toupet Lavender) worldwide on the iNaturalist platform (URL-6)

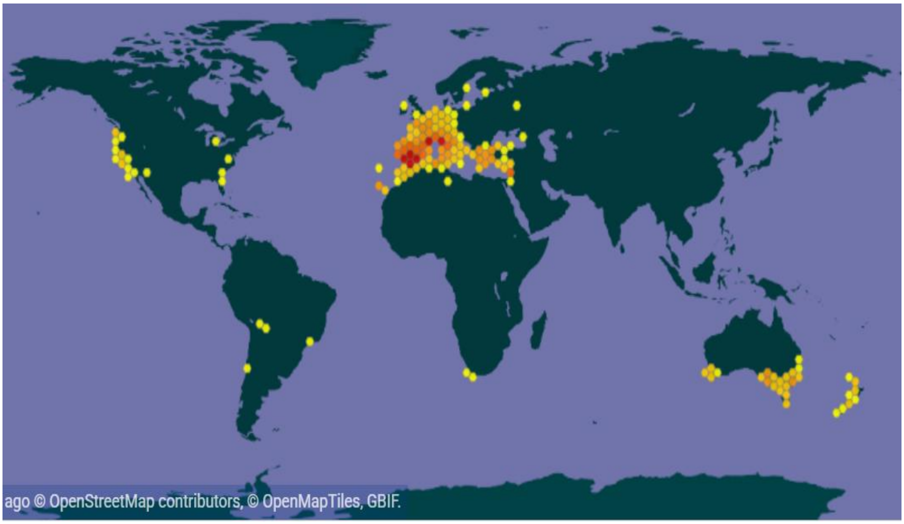

Figure 4: Global distribution of *Lavandula stoechas* (French: Toupet Lavender) worldwide on the GBIF platform (URL-7)

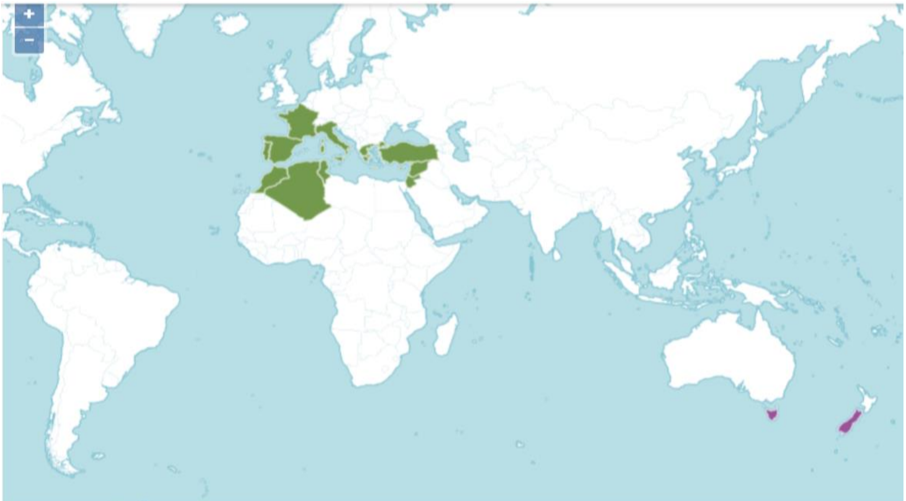

Figure 5: Global distribution of *Lavandula stoechas* (French: Toupet Lavender) worldwide on the POWO platform (URL-8)

Figure 6: Global distribution of *Lavandula stoechas* (French: Toupet Lavender) in Africa according to the African Plant Database (URL-15)

Lavandula stoechas L., first described by Linnaeus in 1753a (Sp. Pl.: 573), is an accepted species belonging to the Lamiaceae family. It is a typically Mediterranean subshrub, mainly developing in the subtropical biome. Its natural distribution includes Algeria, Morocco, Tunisia, France, Spain, Portugal, Italy, Greece, Cyprus, Lebanon-Syria, Türkiye and various Mediterranean islands (Balearic Islands, Corsica, Sardinia, Sicily, Crete, eastern Aegean Islands, Palestine) (Dobignard & Chatelain, 2013). The species has also been introduced in some temperate regions such as the Canary Islands, Tasmania, and southern New Zealand. Taxonomically, *Lavandula stoechas* has a recognized homotypic synonym: *Stoechas officinarum* Mill. (1768), and includes three accepted infraspecific taxa: *L. stoechas* var. *iuliae*, *L. stoechas* subsp. *luisieri*, and *L. stoechas* subsp. *stoechas*.

2.2. The Distribution of *Lavandula stoechas* in Algeria

The distribution map of *Lavandula stoechas* in Algeria, based on observations from iNaturalist, shows a marked concentration of occurrences in the northern strip of the country, particularly in the coastal and subcoastal regions of the Tell (areas of Algiers, Tizi Ouzou, Béjaïa, Skikda, and Annaba). These areas are characterized by a humid to subhumid Mediterranean climate, favorable for the species' development. In contrast, the absence of observations in the High Plains, the steppe regions (Djelfa, Laghouat), and the Sahara reflects the ecological requirements of this species, which prefers well-drained siliceous or calcareous soils and habitats such as maquis, garrigue, and open forests typical of northern Algeria.

It is also worth noting two personal observations made in the city of Sfisef (Sidi Bel Abbes province), specifically in the Ghatarnia forest (first observation on Inaturalist plateform (URL-9), as well as another in western Algeria in Oran (second observation on Inaturalist plateform (URL-10)), confirming the presence of the species in the western region of the country (Figure 7).

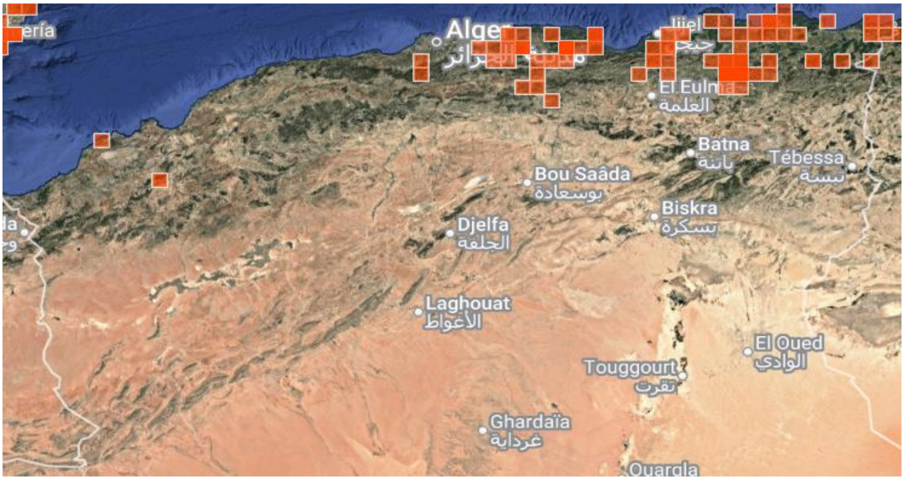

Figure 7: Distribution of *Lavandula stoechas* (French: Toupet Lavender) in Algeria on the iNaturalist platform (URL-11)

2.2.1. *Lavandula stoechas* in the ancient flora of Algeria

Several historical floras have documented *Lavandula stoechas* in Algeria (Table 1), reflecting the recognition of this species over time. **Desfontaines** (*Flora Atlantica*, 1798–1799) and **Battandier & Trabut** (*Flora of Algeria*, 1888–1895; *Analytical and Synoptic Flora of Algeria and Tunisia*, 1902–1905) explicitly treated *L. stoechas*, providing early records of its presence. Quézel & Santa (*The New Flora of Algeria*, 1962–1963) also included the species, confirming its established distribution in the country.

In contrast, some authors did not treat this species: Pomel (*Flora Atlantica*, 1860–1875), Battandier (*Flora of Algeria – Supplement to the Phanerogams*, 1910–1919), and Maire (*Flora of North Africa*, 1952–1987) did not mention *L. stoechas*. These omissions indicate that, although the species is present in Algeria, its documentation was incomplete in certain historical floras, highlighting the importance of consulting multiple sources to obtain comprehensive taxonomic and distributional information.

Table 1: Analysis of the presence of *Lavandula stoechas* in historical floras of Algeria

Flora	**All pages**	**Author**	**Year**	**Name**	**Page in the book**
Flora Atlantica	970	Desfonaines	1798-1799	*Lavandula stoechas* L.	504
The Atlantic Flora, new generic sections	426	Pomel	1860-1875	Untreated	
Flora of Algeria	1157	Battandier & Trabut	1888-1895	*Lavandula stoechas* L.	665
Analytical and Synoptic Flora of Algeria and Tunisia	472	Battandier & Trabut	1902-1905	*Lavandula stoechas* L.	257
Flora of Algeria – Supplement to the Phanerogams	192	Battandier	1910-1919	Untreated	
Flora of North Africa	5551	Maire	1952-1987	Untreated	
The New Flora of Algeria	1172	Quèzel & Santa	1962-1963	*Lavandula stoechas* L.	799
Synonymic Index of the Flora of North Africa	2236	Dobignard & Chatelain	2010-2013	*Lavandula stoechas* L.	277

According to **Battandier & Trabut (1888–1895)** in Flore de l'Algérie (p. 666): *Lavandula stoechas* L. (French lavender) is an aromatic subshrub 6–10 cm tall or more, belonging to the tribe Ocyomoideae (Lamiaceae). Its floral leaves are bract-like, with each flower bearing 3 to 5 bracts forming a terminal tuft. The calyx is enlarged with scarious appendages, the corolla is tubular and widened at the throat, and the stamens are kidney-shaped. The leaves are entire, toothed or crenate, often rolled at the edges, and tomentose and grayish on both surfaces. The stems are quadrangular and branched, and the flowers are grouped in dense spikes topped with violet bracts. A common species of Mediterranean maquis and scrublands, especially on the slopes of the Algerian Tell, within the Mediterranean region and extending to Morocco.

According to **Battandier & Trabut (1902–1905)** in Analytical and Synoptic Flora of Algeria and Tunisia (p. 257): *Lavandula stoechas* L., commonly known as French lavender, is a woody plant of scrublands. Its leaves are entire, often rolled at the margins, and its floral spikes are subglobose (almost spherical). It grows mainly in the regions of Algeria and Tunisia that are typical of dry Mediterranean zones.

According to **Desfontaines (1798–1799)** in Flora Atlantica (p. 506): *Lavandula stoechas* L. (French lavender) is a shrubby plant reaching up to 60 cm in height, with linear-lanceolate, grayish (incanous) leaves whose margins are revolute (rolled under). The floral spikes are dense, ending in ovate violet bracts, often lighter at the base. The flowers are bluish-violet with a bilabiate corolla and a tubular, appendaged calyx. Variety distinguished by a bare upper branch and longer bracts. It grows on uncultivated hills and slopes typical of the Mediterranean Basin (Algeria, Morocco, Spain).

According to **Quézel & Santa (1962–1963)** (p. 799): *Lavandula stoechas* L. (French lavender) is an aromatic subshrub belonging to the Lamiaceae family. It bears dense terminal spikes with bracteolate flowers and a tubular calyx with five unequal teeth. The leaves are entire, grayish on both sides, with revolute margins, and the flowering stems bear leaves up to the spikes. The flowers and bracts are violet to bluish-violet, forming a decorative apical tuft. It is a typical species of Mediterranean garrigues and forests on siliceous soils, common throughout the Algerian Tell and more broadly across the Mediterranean Basin ("Helhal," "Amezzir").

2.3. Comparative Analysis of Historical and Recent Distributions of *Lavandula stoechas* in Algeria

A comparison between the historical herbarium data and recent participatory observations (iNaturalist, Pl@ntNet, and Tela Botanica) reveals a notable shift in the recorded distribution of *Lavandula stoechas* across Algeria. Historically (Figure 8), the species was confined almost exclusively to the Tellian zone of northern Algeria, particularly along the humid and subhumid coastal regions where Mediterranean climatic conditions prevail.

Figure 8: Geographical distribution of historical specimens of *Lavandula stoechas* in Algeria on GBIF plateform (URL-12)

These early records, dating from the 19th and early 20th centuries, corresponded closely to the ecological optimum of the species—acidic or siliceous soils, mild winters, and moderate summer drought. In contrast, recent citizen-science data (2013–2025) indicate a significant expansion of reported occurrences toward the interior regions, including the High Plateaus and even certain Saharan localities, such as Oued Souf (Figure 9). This apparent range extension may reflect several factors: improved sampling effort and accessibility through digital platforms, the ornamental or spontaneous introduction of the species outside its natural range, and possible ecological plasticity enabling its establishment under drier or more continental conditions. Overall, while the historical map portrays *Lavandula stoechas* as a strictly Mediterranean species limited to the northern Tell, the contemporary data suggest a broader, though partially anthropogenic, distribution extending into the steppe and Saharan fringes of Algeria. This comparison underscores the value of integrating historical herbarium collections with modern participatory observations to better understand both the biogeographical dynamics and ecological adaptability of Mediterranean taxa.

Figure 9: Geographical distribution of recent observations of *Lavandula stoechas* in Algeria (2013-2025) on GBIF plateform (URL-13)

2.4. *Lavandula stoechas* in the New Synonymic Index of Dobignard & Chatelain (2010; 2011a; 2011b; 2012; 2013)

Lavandula stoechas L., first described in *Species Plantarum* (Linnaeus, 1753a), is a widely studied species mentioned in several Mediterranean floras, including *Flora of Algeria* (Battandier & Trabut, 1888; 1895), *Analytical and Synoptic Flora of Algeria and Tunisia (*Battandier & Trabut, 1902-1905). *Flora of North Africa* (Maire, 1952; 1953; 1955; 1957; 1958; 1959; 1961; 1962; 1963a; 1963b; 1964; 1965; 1967; 1977; 1980; 1987), *Flore d'Algérie* (Quézel & Santa, 1962; 1963), and *Flore de Tunisie* (Pottier-Alapetite, 1981). This species, belonging to the tribe Mentheae (family Lamiaceae), is an aromatic subshrub characteristic of Mediterranean bioclimates. Its natural range extends across the western Mediterranean basin, notably in Algeria, Morocco, Tunisia, and southern Europe. It has also been introduced to the Canary Islands, Macaronesia, New Zealand, and Tasmania. Several infraspecific taxa have been described, such as *L. stoechas* subsp. *stoechas*, subsp. *luisieri*, and subsp. *pedunculata*. Major floristic references (Ball, 1878; Braun-Blanquet, 1922; Quézel & Santa, 1963; Romo, 1998) confirm the species' high morphological and ecological variability, often linked to local adaptations to siliceous substrates and xeric conditions.

2.5. Taxonomic Summary of *Lavandula stoechas* L.

The species *Lavandula stoechas* L., originally described by Linnaeus in 1753a (Sp. Pl. 2: 573), has undergone numerous subdivisions and reclassifications throughout the history of Mediterranean taxonomy. Several forms, varieties, and subspecies have been proposed, but most were later included within the type species. Among them are *f. brevebracteolata* Sennen (nom. nud.), described in Morocco, *var. platyloba* Briq., and *subsp. linneana* Rozeira (nom. superfl.), all now considered morphological variants of *L. stoechas*. Other taxa originally assigned to this species were later reclassified under *Lavandula pedunculata* (Mill.) Cav., such as *subsp. atlantica* Braun-Blanq., and subsp. *pedunculata* (Mill.) Samp. ex Rozeira.

This taxonomic complexity reflects the high morphological variability of the genus *Lavandula* in the Mediterranean Basin, where species exhibit fine ecological adaptations to climatic and edaphic conditions. According to Dobignard & Chatelain (2013), *L. stoechas* is now regarded as a well-defined species, widely distributed across the western Mediterranean regions, encompassing most of the formerly described forms under various synonymous names.

2.5.1. Classification and Synonymy of *Lavandula stoechas* L. synonyms (basionym unknown)

- *Lavandula approximata* Gand.
- *Lavandula corsica* Gand.
- *Lavandula debeauxii* Gand.
- *Lavandula incana* Salisb.
- *Lavandula olbiensis* Gand.
- *Stoechas officinarum* Mill.

Recognized infraspecific taxa

- *Lavandula stoechas* subsp. *stoechas*
- *Lavandula stoechas* subsp. *luisieri*
- *Lavandula stoechas* subsp. *cariensis*

Taxonomic classification

- **Kingdom:** Plantae
- **Division:** Magnoliophyta

- **Class:** Magnoliopsida
- **Order:** Lamiales
- **Family:** Lamiaceae
- **Subfamily:** Nepetoideae
- **Genus:** *Lavandula*
- **Species:** *Lavandula stoechas* L., 1753.

2.6. Morpho-Ecological Description of *Lavandula stoechas* L.

Lavandula stoechas L. is a chamaephytic subshrub (30–60 cm tall), woody, with whitish, densely tomentose, quadrangular stems (Figure 10). The leaves are linear to linear-oblong, whitish on both surfaces, clustered at the nodes, and attenuate at the base. The inflorescences are short, oval or oblong, quadrangular spike-like heads topped with a tuft of large sterile violet bracts. The fertile bracts are broad, obovate, and membranous, shorter than the very hairy calyx. The flowers, dark purple to pinkish-blue, are hermaphroditic and insect-pollinated (entomogamy). The fruit is an achene with oval, triquetrous carpels. The species flowers from April to June and mainly grows on arid, siliceous hillsides of the Mediterranean region (Provence, Languedoc, Roussillon, Corsica, North Africa). Its dispersal is barochorous, and it belongs to parvochamaephytic plant formations characteristic of Mediterranean bioclimates (URL-14).

Figure 10: *Lavandula stoechas* observed in Algeria (iNaturalist, Project "Flora of Algeria", 2025)

3. ECOLOGY OF *Lavandula stoechas* L.

3.1. Ecology and Environmental Requirements of *Lavandula stoechas* L.

Lavandula stoechas L. is a typically Mediterranean species, characterized by its thermophilic, heliophilic, and xerophilic nature. It thrives in dry, warm, and sunny environments with high temperatures and moderately mild winters. The species is sensitive to excessive continentality, showing a preference for coastal or sub-coastal areas with maritime influence. Edaphically, *L. stoechas* grows on acidic to neutral soils, generally siliceous, schistose, or decalcified, with a light or stony texture, well-drained, and poor in organic matter. It avoids calcareous or humid substrates and is intolerant to salinity. This species primarily colonizes arid maquis and garrigue formations of Mediterranean regions, between 0 and 800 m of altitude, notably on siliceous slopes in southern France, Corsica, and western Algeria (Oran and Sfisef regions).

4. INTERNATIONAL HERBARIA PRESERVING ALGERIAN SPECIMENS OF *Lavandula stoechas*

The *Lavandula stoechas* specimens (98 in total) studied originate mainly from Algeria, where the species is widely distributed across Mediterranean regions. These specimens, collected between 1831 and 1954, are now preserved in several major international herbaria (Table 2), highlighting the long-standing botanical interest in Algerian flora.

Table 2: Global collections preserving *Lavandula stoechas* specimens from Algeria

Dataset	Country (Ville)	Specimen number	Old specimen	New specimen
The vascular plants collection (P) at the Herbarium of the Muséum national d'Histoire Naturelle (MNHN - Paris)	France – Paris	45	March 1837	August 1945
Meise Botanic Garden Herbarium (BR)	Belgium-Meise	10	March 1837	March 1934
Edinburgh (E) Herbarium Specimens	United Kingdom - Edinburgh	10	June 1911	
Naturalis Biodiversity Center (NL) - Botany	Netherlands-Leiden	09	January 1831	3 May 1954
Royal Botanic Gardens, Kew - Herbarium Specimens	United Kingdom -London	09	April 1857	April 1937
NMNH Extant Specimen Records (USNM, US)	United States-Washington D.C.	04	February 1865	June 1935

The New York Botanical Garden Herbarium (NY)	United States- New York	03	1831	June 1935
Natural History Museum (London) Collection Specimens	United Kingdom - London	02	April 1976	April 1976
Vascular Plant Herbarium, Oslo (O) UiO	Norway- Oslo	02	March 1901	June 1906
Herbarium Horti Botanici Pisani (PI), Sistema Museale di Ateneo, Università di Pisa	Italy- Pisa	01	April 1906	

The National Museum of Natural History in Paris holds the largest collection (45 specimens, dated 1837–1945), followed by the Meise Herbarium (Belgium) and the Edinburgh Herbarium (United Kingdom). Additional samples collected in Algeria are preserved in Leiden (Netherlands), Kew (London), Washington D.C., New York, Oslo, and Pisa. Together, these collections illustrate the scientific and heritage value of Algerian *Lavandula stoechas* specimens, which have contributed to the understanding of Mediterranean plant diversity since the 19th century.

4.1. Observations of *Lavandula stoechas* on Online Citizen Science Platforms

Observations of *Lavandula stoechas* from online participatory platforms total 157 records, collected between 2013 and 2025, mainly distributed across iNaturalist, Pl@ntNet, and Tela Botanica (Table 3). The iNaturalist platform shows the highest number of records (82), reflecting continuous monitoring of the species.

Table 3: Occurrences of *Lavandula stoechas* reported through online biodiversity databases

Platforms	Number of Observations	Old Observation	Recent Observation
iNaturalist Research-grade Observations	82	30 January 2025	2 November 2013
Pl@ntNet automatically identified occurrences	54		
Pl@ntNet observations	12		
Carnet en Ligne: Online Notebook (Tela botanica)	09		

Pl@ntNet includes 66 occurrences (54 automatically identified and 12 manually verified), while Tela Botanica, through its “North Africa” project, contributes 9 records. These data confirm the current and active presence of *Lavandula stoechas* in Algeria and highlight the essential role of citizen science tools in the spatio-temporal monitoring of plant species.

5. CULINARY USES

Lavandula stoechas (French lavender) possesses aromatic essential oils that make it a valuable culinary herb. Its composition includes fenchone (39,2%), camphor (18%), polyphenols, and flavonoids. The flowers and leaves are edible and can be incorporated into salads, or infused in milk, cream, or water to flavor sauces, broths, marinades, desserts (sorbets, syrups, custards, fruit salads), and even liqueurs. In Portugal, it is commonly added to soups and purees; in Spain, it is used to season fish and meat; while in Catalonia, it flavors Ratafia, a traditional walnut liqueur. Historically, the Romans also used its leaves in salads (Pied, 2023).

6. MEDICINAL INTEREST

Lavandula stoechas (French lavender) is one of the five main plant species used by the blue tit (*Cyanistes caeruleus*) to protect its nest from parasites. Historically, under the name Stoechas arabica, its flowers were among the numerous ingredients of theriac, a traditional remedy widely used in Western maritime pharmacopoeia during the 18th century (Cécile et al., 2002).

The medicinal properties of *Lavandula stoechas* are primarily attributed to its essential oil and various bioactive compounds, which exhibit antimicrobial, anti-inflammatory, and antioxidant activities. Traditionally, it has been used to relieve headaches, muscle pain, respiratory ailments, and digestive disorders, while also providing calming and relaxing effects (Delcourt, 1990; Lamoudi et al., 2023).

The aerial parts of the plant, particularly the flowers and leaves, are used to extract an essential oil of high economic value, widely employed in the perfume, cosmetic, food, and pharmaceutical industries. This oil is also incorporated into various body care products such as soaps, creams, and lotions (Pied, 2023).

7. CULTIVATION AND GARDENING

Lavandula stoechas is highly valued in Mediterranean gardens for its ornamental appeal and pleasant fragrance. Well-suited for cultivation in pots, borders, or garden beds, it thrives in sunny, well-drained, and slightly acidic soils. The species produces violet-blue flowers from April to June and shows moderate hardiness, tolerating temperatures from –3°C to –7°C up to 50°C. Regular pruning after flowering encourages vigorous growth and abundant blooming. Watering should remain minimal, even during dry summers, as the plant is highly sensitive to excess moisture. In some regions where *Lavandula stoechas* is endemic, it is a protected species, and the preservation of its wild populations depends on limiting overharvesting and safeguarding its natural habitats (URL-16).

8. CONCLUSION

Lavandula stoechas thus represents a characteristic element of Mediterranean flora, whose wide yet ecologically coherent distribution highlights its remarkable adaptability to arid and calcareous environments.

Lavandula stoechas stands out as a well-defined Mediterranean taxon with broad biogeographical and taxonomic significance, reflecting both its ecological adaptability and its evolutionary diversification across the Mediterranean basin.

In Algeria, *Lavandula stoechas* is primarily confined to the northern coastal and subcoastal regions, reflecting its strict ecological preference for Mediterranean climates and well-drained habitats. These observations in Sfisef and Oran confirm that *Lavandula stoechas* also occurs in western Algeria, extending its known national range beyond the northern coastal areas.

Historical records demonstrate that *Lavandula stoechas* has long been recognized in Algeria, though inconsistencies in its documentation across floras highlight the need to consult multiple sources for a complete understanding of its distribution.

The comparison of historical and recent data shows that while *Lavandula stoechas* was historically confined to northern Algeria, modern observations reveal an expanded distribution toward interior and even Saharan regions, highlighting both the species' ecological adaptability and the role of human-mediated spread.

Lavandula stoechas is a well-defined Mediterranean species with a complex taxonomic history, reflecting its high morphological and ecological variability. Despite numerous synonyms and infraspecific taxa described over time, it is now recognized as a distinct species widely distributed across the western Mediterranean basin.

Lavandula stoechas is a woody chamaephytic subshrub (30–60 cm) with densely tomentose, quadrangular stems and linear-oblong, whitish leaves clustered at the nodes. Its short, spike-like inflorescences bear sterile violet bracts and dark purple to pinkish-blue hermaphroditic flowers, flowering from April to June. Adapted to arid, siliceous Mediterranean hillsides, the species is insect-pollinated and barochorously dispersed, forming part of parvochamaephytic plant communities typical of Mediterranean bioclimates.

Lavandula stoechas is a thermophilic, heliophilic, and xerophilic Mediterranean species, favoring dry, sunny, and warm habitats on well-drained, siliceous or schistose soils, typically in maquis and garrigue formations up to 800 m altitude.

Historical Algerian specimens preserved in major international herbaria underscore the long-standing botanical interest in this species and its contribution to understanding Mediterranean plant diversity.

Citizen science platforms, with 157 records between 2013 and 2025, confirm the active presence of *Lavandula stoechas* in Algeria and demonstrate the crucial role of participatory observations in monitoring the species' distribution over time.

In summary, *Lavandula stoechas* is a multifaceted Mediterranean species valued for its culinary, medicinal, and ornamental uses. Its aromatic and bioactive compounds support traditional remedies, high-value essential oils, and diverse culinary applications, while its cultivation in gardens requires sunny, well-drained conditions and careful management to preserve both plant health and wild populations.

In conclusion, *Lavandula stoechas* is a quintessential Mediterranean species distinguished by its ecological adaptability, taxonomic diversity, and broad geographic distribution across northern Africa and southern Europe. Valued for its aromatic, medicinal, and culinary properties, it provides ecological services, supports traditional uses, and contributes economically through essential oil production. Its cultivation and conservation require careful management, particularly in endemic regions, while modern participatory observations and historical herbarium records together enhance our understanding of its distribution, ecology, and cultural significance.

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PART II

Culture, Uses, and Perceptions of Ornamental Plants

CHAPTER V

The Culture of Ornamental Plant Care in Algerian Society: A Field Study in Sidi Aïssa

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1. INTRODUCTION

In recent decades, there has been a significant rise in interest in ornamental plants in contemporary civilizations, indicating changes in individuals' environmental and aesthetic values. This phenomena in Algeria is seen in both urban and rural settings, indicating significant cultural and social changes. The exploration of decorative plants in Algerian culture is fundamentally intertwined with the region's historical and natural context. Algeria, characterized by its different habitats, possesses a wealth of indigenous flora that has historically played a crucial role in local customs and traditions. The valuation and utilization of these plants exemplify Algeria's extensive cultural legacy, which integrates the influences of several civilizations that have traversed the region, significantly impacting gardening preferences and practices throughout history. This paper examines the sociological dynamics through a field study conducted in Sidi Aissa, M'sila province, Algeria.

2. RESEARCH PROBLEM

Recent transformations towards modernity and globalization have significantly influenced how Algerians interact with their environment. As urbanization advances, traditional gardening practices have evolved to include contemporary styles and modern trends that have gained popularity through various media platforms. These transformations present both challenges and opportunities for the culture of ornamental plants, as communities strive to balance preserving cultural practices with adopting modern aesthetics.

Additionally, growing environmental awareness has become an important aspect of ornamental plant culture. Increasing recognition of biodiversity loss and environmental sustainability has spurred interest in incorporating native plant species into gardens, practices that not only enhance local ecosystems but also deepen individuals' connections to their natural surroundings.

This research paper seeks to address the following core problem:

What are the main factors influencing interest in ornamental plants within Algerian society? How are these factors reflected in an urban environment like Sidi Aissa?

This problem raises several dimensions, including:

- **Social dimension**: What role do social interactions, collective norms, and class differences play in the spread of ornamental plants?
- **Cultural dimension**: How do Algerian cultural heritage and external influences (via globalization) shape residents' preferences?
- **Economic dimension**: Are ornamental plants accessible to all social groups? How do they impact consumption habits?
- **Technological dimension**: What is the impact of digital platforms and social media on the spread of this phenomenon?
- **Environmental dimension**: To what extent does interest in ornamental plants reflect increased environmental awareness among the residents of Sidi Aissa?

These dimensions form the core of the study, helping to understand the interconnected factors influencing the popularity of ornamental plants and what they reveal about current social and cultural changes.

2.1. The Importance of the Study

This study is significant for enhancing the understanding and appreciation of ornamental plants in the Algerian cultural context, particularly amidst the ongoing rapid urbanization and the adoption of advanced agricultural methods in Algeria. Ornamental plants enhance aesthetic appeal, promote environmental awareness, and strengthen community bonds. This study examines local enthusiasm for these plants to underscore their potential as symbols of identity and continuity within evolving cultural landscapes.

Recognizing ornamental plants as vital components of Algerian heritage is essential for fostering initiatives that aim to preserve biodiversity. The study emphasizes its role in enhancing environmental awareness, a critical concern in light of the significant global decline in biodiversity. This study explores the role of education in agricultural practices as a means to bridge the generational gap and instill sustainability values in younger generations.

This study's results may assist decision-makers in acknowledging the significance of incorporating ornamental plant culture into urban planning and community development strategies. This study elucidates community interactions with plants, establishing a foundation for the development of green spaces that enhance individual well-being and promote social interactions among residents.

2.2. Study Objectives

This study aims to achieve the following objectives:

1. To study the factors influencing the increasing interest in ornamental plants within Algerian society.
2. To examine the impact of media and social networks on this phenomenon.
3. To analyse the relationship between the urban environment and the interest in ornamental plants.
4. To study the cultural and social influences on the interest in and acquisition of ornamental plants.
5. To compare the growing interest in ornamental plants across different social groups.
6. To analyse the role of caring for ornamental plants in shaping individual and collective identities.
7. To explore the implications of these practices on community cohesion and environmental awareness.

2.3. Previous Studies

The previous studies highlight several key themes:

2.3.1. Urban ecology and ornamental plants

Ornamental plants play a crucial role in promoting sustainability within urban environments by providing essential ecosystem services such as improving air quality, reducing the urban heat island effect, and supporting local biodiversity when native species are incorporated. In addition to their ecological functions, ornamental plants and green spaces contribute significantly to residents' physical and psychological well-being, as exposure to greenery is associated with reduced stress levels and improved overall quality of life (Tzoulas et al., 2007; WHO Regional Office for Europe, 2016).

Private gardens and household green areas that include ornamental plants represent vital components of the urban green infrastructure and can enhance habitat conservation when managed using environmentally responsible practices (Goddard et al., 2010; Francini, 2022). Therefore, integrating ornamental plants thoughtfully into urban planning strategies can maximise environmental, social, and health benefits while fostering sustainable urban development (Nguyen et al., 2021).

2.3.2. Cultural symbolism of plants

The cultural symbolism of plants reflects how societies attribute meanings that go beyond their biological functions. As Goody (1993) explains, plants often embody moral, spiritual, or aesthetic values within different cultural contexts. In Algeria, this symbolic dimension can be observed in traditional practices related to agriculture and hospitality, where plants such as olive trees, mint, and jasmine convey meanings of prosperity, purity, and social belonging. According to Kandeler & Ullrich (2009), the symbolic attribution of plants in Mediterranean cultures encompasses themes of identity, ritual and nature-society interaction.

2.3.3. The impact of social media

Recent research indicates that social media platforms have become key drivers of interest and consumer behaviour in the ornamental plant sector. For example, a survey of green-industry firms found that nearly 89 % of ornamental horticulture businesses reported using social media in 2017, and many cited plant-related imagery and content as central to engaging online communities and influencing consumption patterns (Peterson et al., 2018). In this way, social media acts as a catalyst for spreading trends, including enthusiasm for ornamental plants.

2.3.4. Heritage and modern consumption

The integration of heritage practices with modern consumption patterns can be understood through the lens of modernity theory. According to Giddens (1991), the advent of late modernity brings about a “disembedding” of social relations from local, traditional contexts and a reflexive re-ordering of life, whereby traditions are never simply preserved unchanged but are reinterpreted and merged within new forms of social practice. In many societies, including

Algeria, this can be seen in how traditional plant-related rituals and symbolism are adapted into contemporary consumption and lifestyle choices, creating a hybrid cultural form where heritage informs modern aesthetics.

2.3.5. Ecological practices and environmental awareness

Research in environmental sociology shows that ecological practices and environmental awareness emerge when human societies recognize the interplay between social behaviours and natural systems. According to Gifford (2011), individuals develop environmental concern when they understand how environmental degradation is connected to social structures and daily actions. This dynamic interaction between natural and social systems underpins the adoption of ecological practices in urban settings and the growing interest in ornamental plants as part of sustainable living. These studies provide a conceptual framework for analysing the Algerian specificities and their sociological impacts.

2.4. Theoretical Approach to the Study

These theories provide a rich framework for understanding the interest in ornamental plants, particularly in societal contexts experiencing rapid change, such as Algeria. They help explore the social, cultural, and economic aspects of the phenomenon.

This study is based on four main theoretical frameworks:

2.4.1. Modernity theory

This theory focuses on how societies interact with rapid social changes, particularly those resulting from globalisation. It posits that the interest in plants reflects a fusion of local traditions and modern influences. In the Algerian context, this interest can be viewed as a symbol of "cultural hybridity," where modern environmental values merge with traditional agricultural heritage. Giddens argues that "ornamental plants are not merely aesthetic reflections but represent a blend of the old and the new in changing societies" (Giddens, 1991).

2.4.2. Urban ecology theory

This theory examines the interaction between the natural environment and social structures in urban areas. It suggests that the growing interest in plants may be a response to increasing population density and the decline of public green spaces. In a city like M'sila, the creation of private green spaces (e.g., home gardens) may reflect an attempt to reconnect with nature. Park & Burgess (1925) assert that "in urban environments, plants serve as tools to recreate balance between humans and nature"

2.4.3. Habitus and cultural capital theory

This theory examines aesthetic practices as social indicators. Habitus, which reflects individuals' acquired tastes and dispositions, plays a crucial role in how ornamental plants are perceived and adopted among different social classes. Cultural capital influences access to and appreciation of these plants. The theory explains how individuals' choices, including interest in plants, reflect cultural trends and social tastes associated with their class. For instance, the acquisition of ornamental plants among the upper classes may express "social distinction" that reflects accumulated cultural capital. Bourdieu states, "Plants are not merely decorative; they are symbols of refined taste and indicators of social status" (Bourdieu, 1979).

2.4.4. Symbolic interactionism

Symbolic interactionism interprets the interest in ornamental plants as cultural and social symbols carrying meanings shaped through social interactions. Plants serve as a means of expressing individual and collective identity, reflecting values such as aesthetic taste, environmental connection, or traditional ties. They also foster community bonds and embody cultural belonging, making them part of a shared cultural identity. This theory emphasises that the meanings of plants are dynamic and constructed through social dialogue. According to Blumer, plants "are not just living organisms but cultural symbols that reflect collective identity and social bonds" (Blumer, 1969). For example, flowers may symbolise love, while medicinal plants represent health and healing.

2.5. Environmental and Social Culture Associated with Ornamental Plants in Algerian Society

Ornamental plants play a central role in building an environmental culture in Algeria, symbolising a blend of reconnecting with roots and cultural heritage while adopting modern practices of sustainable consumption.

Ornamental plants go beyond merely decorating spaces, they reflect evolving social and environmental practices, and ornamental plants contribute to fostering a culture of sustainability by raising awareness about the importance of green spaces and ecological balance. Additionally, according to Goody (1993), these plants are used to express aesthetic values and modern aspirations while preserving cultural traditions associated with respect for nature. This fusion of heritage and modernity underscores the tensions and harmonies within a society undergoing continuous transformation.

Social media also plays a pivotal role in disseminating practices related to ornamental plants. As Smith & Duggan (2013) have shown, users create a community dynamic by sharing inspiring content, encouraging environmentally responsible behaviours. Finally, Bourdieu's (1979) theory of habitus highlights that these practices are also influenced by individuals' social positions. Adopting ornamental plants may be seen as a means of social distinction, reflecting sophisticated tastes and an increasing sensitivity to environmental aesthetics.

2.5.1. Ornamental plants in Algerian cultural heritage

2.5.1.1. Ornamental plants

Ornamental plants are a variety of plants cultivated for aesthetic purposes and to enhance the surrounding environment, whether in homes, public gardens, or indoor and outdoor spaces. They are characterised by the beauty of their foliage, flowers, or unique forms, adding a natural touch to any setting. Their significance lies in the following aspects:

- **Aesthetic**: They enhance the visual appeal and beauty of the environment.
- **Environmental**: They contribute to air purification by reducing harmful gases such as carbon dioxide and increasing oxygen levels.
- **Psychological**: They reduce stress and anxiety while promoting a sense of relaxation and well-being.

- **Social and economic**: They improve public spaces and support commercial projects centred on the production and distribution of these plants.

2.5.1.2. Types of ornamental plants

- **Indoor plants**: These include potted plants grown in closed spaces, such as flowering plants, climbing plants, and shade plants.
- **Outdoor plants**: These include trees, shrubs, aromatic plants, and flowers used in gardens and open spaces.
- **Ground-planted ornamental plants**: Examples include seasonal flowers, small trees, and turfgrass.

2.5.2. Environmental and societal culture associated with ornamental plants

2.5.2.1. Environmental culture

This includes practices and behaviours that reflect awareness of the importance of preserving the environment, such as cultivating ornamental plants to promote environmental sustainability and reduce pollution.

2.5.2.2. Societal culture

- **Traditions and cultural heritage**: In some communities, ornamental plants are associated with social traditions, such as gift-giving during events and celebrations.
- **Collective awareness**: This refers to the community's interest in decorating public and private spaces to enhance the living environment.
- **Environmental education**: This involves teaching future generations the importance of caring for plants through educational curricula and daily practices.

As lifestyles evolve, plants continue to hold value, being integrated into modern designs for both interior and exterior décor. This blend of tradition and contemporary practices reflects cultural adaptation while maintaining links to the past.

2.6. Cultural Heritage and Traditions Associated with Ornamental Plants in Algerian Society

2.6.1. Plants in Algerian cultural heritage

Plants occupy a symbolic place in Algerian heritage, being deeply connected to agricultural traditions and artisanal practices. For example, the use of plants in traditional gardens, such as Andalusian gardens, reflects a profound connection to nature and a pursuit of harmony between humans and their environment. These gardens are often centred around plants such as citrus trees, palms, and jasmine, embodying distinctive aesthetics and cultural and religious values.

Additionally, ornamental and medicinal plants play a significant role in the daily lives of both rural and urban communities. They are integrated into artisanal practices such as perfume-making or traditional remedies, thereby reinforcing their role in Algeria's intangible cultural heritage. For instance, certain traditional plants are cultivated in courtyards and home gardens for both aesthetic and spiritual purposes.

2.6.2. Spiritual and symbolic functions of ornamental plants in Algerian culture

Ornamental plants carry profound spiritual and symbolic meanings in Algerian culture, often linked to folk beliefs and religious rituals that reflect Algeria's rich cultural heritage.

2.6.2.1. Protection from evil and envy

- **Cactus (prickly pear)**: Often planted near house entrances, it is believed to ward off the evil eye and negative energy.
- **Henna and basil**: Used in cleansing rituals and for protection from harm, these plants are prominently grown in homes or hung as bunches near doors and windows.

2.6.2.2. Attracting luck and blessings

- **Fragrant plants (jasmine and orange blossom)**: Symbols of joy and blessings during festive occasions such as weddings and family celebrations.

- **Olive tree**: Represents peace and prosperity, often cultivated as a symbol of fertility and abundance.

2.6.2.3. Religious symbolism

- **Basil and Damask rose**: Used to decorate mosques and religious sites during Islamic occasions like Mawlid and Ramadan.
- **Palm branches**: Used for decoration during religious festivals and placed on graves as a sign of prayer and mercy.

2.6.2.4. Traditional rituals and folk beliefs

- **Marriage rituals**: Brides are adorned with garlands of aromatic flowers symbolising purity and beauty.
- **Seasonal celebrations**: In rural areas, seasonal festivals are often centred on blooming flowers or harvest times, with plants playing a central role in the rituals.

2.6.3. Use in traditional healing and spiritual practices

- **Sidr (lotus tree)**: Believed to have spiritual and physical healing properties, used in traditional healing practices and funeral rituals.
- **Holy basil**: Used in fumigation rituals to ward off evil spirits and promote psychological relief.

2.7. Spiritual and Symbolic Functions of Ornamental Plants in Sidi Aissa, M'sila

The city of Sidi Aissa in the M'sila province, located in the High Plateaus of Algeria, is distinguished by a rich cultural heritage that incorporates the use of ornamental plants in spiritual and traditional practices. These plants hold special symbolism in the social and religious life of the region's inhabitants.

2.7.1. Plants associated with protection from evil and envy

- **Cactus (prickly pear)**: Commonly planted around houses and entrances, it is believed to ward off envy and prevent negative energy from entering homes.

- **Sidr (lotus tree)**: Used in spiritual healing practices, including funeral rituals, and planted in courtyards as a symbol of purity and protection.

2.7.2. Plants associated with blessings and prosperity

- **Olive tree**: Symbolising blessings and continuity, its cultivation in M'sila reflects hopes for abundance and prosperity. Its fruits and oil are used in both domestic and religious contexts.
- **Palm tree**: Despite the semi-arid climate, small oases in the region host palm trees, which are symbols of fertility and generosity. In local folklore, planting a palm tree at home is believed to bring blessings to one's wealth and family.

2.7.3. Plants used in religious rituals and celebrations

- **Sidr**: In popular belief, Sidr is used in white magic to treat spiritual ailments. It is often taken from sacred shrines to create "blessed water" for spiritual purification.
- **Basil and Damask rose**: These plants are used to decorate homes and mosques during religious occasions, particularly Ramadan and Mawlid.
- **Henna**: Grown in home gardens and used in weddings and traditional celebrations as a symbol of joy and blessings.

2.7.4. Plants in social occasions

- **Weddings and celebrations**: Homes are adorned with jasmine and orange blossoms, while bouquets of local flowers are gifted as tokens of love and respect.
- **Funerals and mourning**: Graves are adorned with olive and basil branches as a sign of prayer and mercy.

This intricate relationship between ornamental plants and Algerian cultural heritage demonstrates their enduring importance in bridging traditions and contemporary practices, fostering both aesthetic and spiritual connections.

3. RESEARCH METHODOLOGY

3.1. Methodology Used

3.1.1. Qualitative approach

A qualitative methodology was adopted to understand the deep-seated reasons and psychological, cultural, and social factors behind individuals' interest in ornamental plants. This approach relies on in-depth interviews with individuals, exploring their personal experiences, motivations for engaging with ornamental plants, and their views on how this practice impacts their daily lives and surrounding environment. Field observation was also employed to monitor individuals' practices in caring for ornamental plants at their homes or workplaces.

3.1.2. Quantitative approach

A quantitative approach was utilised to collect statistical data on the prevalence of interest in ornamental plants in Sidi Aissa. Surveys were distributed to a sample of individuals to identify factors influencing the choice of ornamental plants, such as age, gender, education level, socio-economic status, and environmental orientations. This methodology enabled an estimation of the phenomenon's prevalence and highlighted differences across various societal groups.

3.1.3. Temporal scope

The field study spanned three months. Data collection took place during the first four weeks, followed by organisation and analysis of the gathered information.

3.1.4. Spatial scope

The field study was conducted in the city of Sidi Aissa, located in the southeast of Algiers, approximately 171 km from the capital. This historic city, with a population exceeding 185,000 in 2016, enjoys a Mediterranean climate, characterised by dry summers and cold winters.

3.2. Study Sample

The sample comprised 50 individuals, purposively selected from various residential neighbourhoods in Sidi Aissa. Efforts were made to ensure diversity in age groups, social classes, professions, and educational levels, aiming to provide a comprehensive picture of individual interests in ornamental plants within the city.

3.3. Research Tools and Techniques

- **Personal interviews**: Conducted with some participants to gain an in-depth understanding of their motivations, experiences, and perspectives regarding ornamental plants.
- **Observation and participant observation**: Conducted at local plant markets and during visits to homes with gardens or indoor plant arrangements.
- **Documentary analysis**: Utilised archives and prior studies on urban environments and cultural practices.
- **Surveys**: Distributed to individuals to gather quantitative data on characteristics influencing interest in ornamental plants in Sidi Aissa city.

4. PRESENTATION AND ANALYSIS OF RESULTS

4.1. Personal Motivations for Interest in Ornamental Plants

Most participants cited aesthetic reasons, such as improving home environments and creating green spaces, as their primary motivations. Some indicated that plant care is part of a "culture of place care," reflecting cleanliness and refinement. This aligns with Giddens' concept of "cultural hybridity," where modernity blends with traditional legacies, making ornamental plants a symbol of the fusion between the old and the new.

4.2. Influence of Customs and Traditions

Interviews revealed that Algerian customs and traditions play a significant role in fostering interest in ornamental plants. Many participants mentioned that plant care is tied to hospitality traditions, where plants are used as decorations during special occasions like weddings or religious celebrations. Some saw the presence of plants as enhancing cultural identity and maintaining connections with ancestral heritage. These practices underscore collective identity and cultural ties, supporting the idea that plants are not merely decorative but serve as social and cultural symbols, as highlighted by symbolic interactionism.

4.3. Environmental Impact

Some participants mentioned that their interest in ornamental plants reflects an increasing awareness of environmental conservation. They view plants as a means to improve indoor air quality, particularly in urban areas suffering from pollution. This aligns with the urban ecology theory of Park and Burgess, where plants emerge as a solution to challenges posed by urban density and pollution, reflecting a natural response to modern urban conditions.

4.4. Patterns of Plant Care Practices

Field observations revealed that most participants tend to their plants regularly, dedicating specific time to their care. Common plants included cacti, indoor flowers, and kitchen plants like parsley and mint. The findings show that regular plant care and the selection of specific types reflect individual and collective habitus. Preferences for certain plants and care practices are influenced by cultural capital and social class. For instance, choosing cacti or medicinal plants may reflect practical or health-oriented values tied to specific social norms.

4.5. Social and Cultural Factors

The study indicates that social and cultural factors significantly influence the growing interest in ornamental plants within Algerian society. A strong impact of cultural heritage and local customs on plant selection and care practices was evident, with many individuals viewing ornamental plants as part of their cultural heritage. Algerian hospitality traditions were found to encourage this interest, as 57% of participants reported that customs and traditions affect their choice of plants, considering them part of their cultural heritage. Furthermore, 60% of participants said they cultivate plants based on religious heritage, such as herbs used in religious or health rituals.

4.6. Environmental Awareness

The analysis suggests a growing role of environmental awareness in promoting interest in ornamental plants. Many participants see plants not only as enhancing aesthetic appeal but also as improving air quality and indoor environments. About 80% of participants stated that aesthetics were the main driver of their interest in ornamental plants, while 40% cited environmental awareness as influencing their plant choices.

4.7. Influence of Media and Social Networks

The findings reveal that media, especially social media, plays a significant role in fostering interest in ornamental plants. Social influences among individuals encourage this behaviour, reflecting a shift in the culture of place and environmental care. Results showed that social media significantly contributed to the popularity of ornamental plants, with 65% of participants indicating that friends or family members also engage in plant care. This underscores the role of modern socialisation in promoting this practice. Additionally, 40% said they were influenced by friends and family through various social media platforms. This aligns with symbolic interactionism, which sees cultural values and meanings as constructed and evolved through social interaction.

5. CONCLUSION

The study revealed that interest in ornamental plants in Algerian society, particularly in Sidi Aissa, reflects a clear interplay between personal, cultural, environmental, and social factors. On one hand, aesthetic motivations and the desire to improve home environments were key reasons for this interest, reinforcing the concept of a "culture of place care." On the other hand, local customs and traditions exert a significant influence, as ornamental plants are associated with Algerian hospitality traditions and social occasions, highlighting their role as a cultural element that strengthens identity and belonging.

The findings also demonstrate growing environmental awareness among individuals, with plants viewed as a means to improve air quality and address urban pollution challenges. Moreover, plant care practices have become more organised, with specific plant types such as cacti and kitchen herbs gaining popularity.

Additionally, social media played a crucial role in fostering the culture of ornamental plant care, reflecting a shift in social values and the influence of modern socialisation in encouraging this behaviour.

These results suggest that interest in ornamental plants is not solely about aesthetics or environmental factors but reflects a complex interaction between cultural heritage and modern societal changes, underscoring the importance of studying this subject as part of Algeria's cultural transformations.

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CHAPTER VI

Benefits of Growing Henna Shrubs in the Garden of a Rural House in Biskra

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1. INTRODUCTION

The presence of plants in an environment makes it beautiful; a beautiful environment is always cool and inviting. Plant-flavored shrubs around homes often add esthetic value to the environment (Baiyewu et al., 2005). Henna powder, which is used as a cosmetic product, is the dried leaves of the plant *Lawsonia inermis* L, a shrub or small tree that is indigenous to the area between North Africa and West. Even though known is grown in several countries of North Africa and the Middle East as cosmetic, aromatic, and ornamental plants, it remains in Algeria as an underutilized product. The henna plant has been introduced widely throughout the tropics and sub-tropics as an ornamental (frequently as a fragrant hedge), for home use as a dyestuff, and elsewhere as a commercial crop, notably in several North African countries (Green, 2005). Plants are often considered auspicious because of the favorable meanings of their names, those that refer to wealth, prosperity, and fortune, or because of certain of their characteristics. They include many indigenous plants, as well as those introduced from abroad. The belief in auspicious plants has been held by people from generation to generation (Krisanapook et al., 2019). The case of the henna plant is for the Muslim community one of the blessed, auspicious, valuable plants, why not if in Ahadiths of the Prophet Mohamed (Pray and Peace upon Him) it is described as a fragrant plant and also as a medicinal plant. This value is distributed not only from generation to next generation but also from the Arabic Penisula to all the Muslim world. Henna is cultivated as a hedge plant and as live fencing to protect crop fields from grazing animals (Choudhury et al., 2005).

In Africa, its culture is a source of income in most areas of the Sahelian state and more rarely in the Sudan. In Mali, the sale of its leaves contributes to the safety of food in some communities because the economic resources generated allow them to partially pay for the amount of cereals necessary to meet their needs (Mallé, 2011).Even for all the sited henna species, this plant is ranked in the list of neglected species and/or underutilized in Algeria (which they have been little or no research) and classified as an industrial plant. It is us-ed only for its dying purpose (Abdelguerfi, 2003; Abdelguerfi & Laouar, 2016).

Each city in Algeria is characterized by its famous ‘label’ product from fauna or flora species. The case of Biskra, we have in mind once we site the name of the Biskra district, the date fruit, especially DagletNour variety, and for those who are attracted to cosmetic plants their minds illustrate henna powder inside the date fruit or both products. Henna crops arecultivated in the Zibans (Oasis of Biskra) and especially in the Zribet El Oued"el'hanazribiya" region for more than 100 years. According to Dubost (1986), the henna is an industrial crop that is cultivated in the Ziban under traditional practices. According to Cataldo (1988), the extent of acreage devoted to henna differs from city to city; it has specified the town of Droue (one of the villages of Sidi Okba) where it marked strong production. According to Rivière (1900), the culture is typically Saharian but can advance in temperate regions where it will give low yields.In the Eastern region of the Biskra department, henna is cultivated for at list 100 years (Venderheden, 1934); actually, the same department is considered the leader of henna cultivation and production, and about 446 ha were cultivated during 2022/2023 with a yield of 20 quintals/ha.

In this chapter about the ornamental plants of Algeria, we want to introduce the Henna plant from Biskra district, located in the southeast of Algeria, well known or less for the reader, and we will introduce *Lawsonia inermis* (synonyme *Lawsonia alba* Lam) to them in our way.

2. THE DESCRIPTION OF THE STUDIED AREA

The province of Biskra is located in the eastern southern region of Algeria and is designated as the gate of the Sahara (Figure 1).

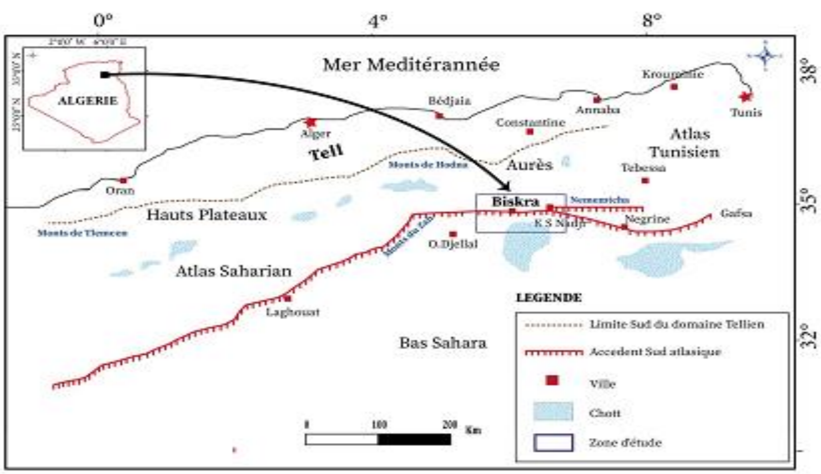

Figure 1: Localization of the town of Biskra (Reghais, 2023)

Our study area is located in the northeast of the Algerian Sahara, 400 km from the capital of Algiers (Figure 1). It is located in one of the most important agricultural regions of the country, in the northeast of Sahara, on the northern edge of the African platform, geographically delimited between 4° 55' 12" and 6°46' 12" E and 34° 16' 48" and 35° 23' 24" N (Figure 1). It extends to the Chott Melghir region to the southeast and covers a total area of 10,250 km (Reghais, 2023).

During field research on the knowledge valorization of henna farmers in Biskra, it became clear that they value henna bushes as ornamental plants. Out of 115 farmers, 20 of them own bushes in a field or at home, which are used as mother plants for seed regeneration. The plant that produces the seed is a shrub, while the henna crop in the fields are herbaceous plants (Figure 2).

Figure 2: Henna shrub in a field of Zribet El Oued region, Biskra (Original photo, 2014)

Henna is widely grown in gardens as an ornamental or hedge plant, and it is appreciated for the strong, pleasant fragrance of its flowers, which is reminiscent of the tea rose (*Rosa chinensis* Jacq.).

3. MORPHOLOGICAL DESCRIPTION OF THE HENNA PLANT

- Much-branched, glabrous shrub or small tree up to 6–12 m tall, with greyish-brown bark and quadrangular young branches, older plants sometimes with spine-tipped branchlets up to 3,5 cm long (Figure 3).

a/ Flowering of henna during summer, in a rural house Biskra city (Original photo)

b/ Henna shrub in a garden of an establishment, ripening fruit Ain Naga city (Original photo)

c/ Fruit of henna: unripe fruit (purple color), ripe fruit (brown color) (Original photo)

d/ Opening white flowers (Original photo)

Figure 3: Different vegetative stages of henna plant from Biskra district

- Leaves decussately opposite, simple and entire, almost sessile; stipules minute; blade elliptical to oblong or broadly lanceolate, 1–

8,5 cm × 0,5–4 cm, cuneate at base, acute to rounded at apex, pinnately veined.

- Flowers bisexual, regular, weet-scented; pedicel 2–4 mm long; calyx with up to 2 mm long tube and spreading, ovate lobes 2–3 mm long; petals orbicular to obovate, 1,5–4 mm × 4–5 mm, usually whitish, sometimes reddish; stamens 8, inserted in pairs on the rim of the calyx tube, filaments 4–5 mm long; ovary superior, 4-celled, style erect, up to 5 mm long, stigma head-shaped (table 01).
- The fruit is a globose capsule, 4-8 mm in diameter, contains many seeds, brown in color when ripe, and opens irregularly.
- Seeds are 3 mm across and angular, with a thick seed coat (Aweke & Tapapul Lekoyiet, 2005).

4. MEANING AND SYMBOL OF HENNA PLANT

Muslims and Arabic communities do not hold religious feasts or wedding ceremonies without henna tattoos on the hands and feet. The presence of henna is an indication of happiness.

Because of the great value of this plant for Muslims, Arabic names are given for each part of the plant. The vegetative period or the leaves are called: **Hina**; the fragrance flowers are called **Faghia**, and we call the fruit **Tamar hina.**

The Arabs spread henna in North Africa, from Mauritania to Mali and Andalusian Spain. This would explain the area of use of the Arabic root of this word and the virtues accorded to it in Muslim countries. It is the tree “that grows in paradise”. Its flower is said to have been the favorite of the Prophet “the queen, he said, of all the flowers with the sweet scent of this world and the next” (Gast, 2000).

All religious festivals and wedding ceremonies are preceded by a specific night ‘night of henna’ characterized by the preparation of the paste based on henna powder, which will be spread on the hands and feet of all people present during this happy event, women or men, from babies to old people. During the Eid of sacrifice where a sheep is sacrificed during the morning of the tenth day of the last month of the year Hidjy, even the forehead of the animal is dyed with henna paste.

The feet and hands of the bride must be stained with dark orange color from henna past, the pattern are so beautiful: flowers and leaves using adhesive pattern tape, or specialized woman draw this temporary tattoo on the body of the bride, it took at least two or three nights before the ceremony of henna night where all guest of the wedding are gathered, and the some approached women of the groom family come to put on here hand their own past of henna. Single women apply for henna in the hope that they will soon be engaged. They sing a henna song during this ceremony, and the word talks about the origin of the henna plant, which came from the blessed place 'Al Madina' the town of the Prophet Mohamed (Pray and Peace upon Him) from Saoudite Arabea. This heritage is strongly conserved and transmitted from generation to the next one.

Women from Biskra considered the henna plant as an auspicious and blessed plant because of its name: during a conversation of two person or more, if one person said the name of henna 'el hina', he /she will hear immediately 'May God have mercy on us' in Arabic language 'Rabi yahinaalin'ربي يحَن علينا.

When women buy a new item of great value, they put on it a small amount of the past of henna to be blessed and to be followed soon with other valuable purchases.

The first harvest of the henna crop growth from seeds has a great value for farmers and for women in Biskra because it is used as a medicinal plant more than a cosmetic plant. It is named ''L'hana aarous' or 'the bride henna', the color obtained from the past is even darker in color and more perfuming.

5. SOME OF THE BENEFITS OF THE HENNA SHRUB IN A HOUSE GARDEN

Henna shrub in the visited garden during the investigation of farmers' knowledge on henna cultivation was associated with other adapted fruit trees or ornamental plants, depending on the garden dimension: it was cultivated with date palm, fig tree, olive trees, citrus, pomegranate, rose shrub, and chaste tree (Figure 3).

5.1. Benefits of Henna as Ornamental Plants

Henna cultivation is very popular in warm subtropical regions; moreover, the henna plant gives more dye lawsone concentration. The dyeing power of the plant is obtained when it is cultivated in an arid Saharan climate.

The shrub is an evergreen plant that gives new branches in spring, and, the bloom occurs gradually during the summer (July –August).

The henna farmer harvests all leafy stems at ground level, two to three times per season (Benaissa, 2018). In the garden, the plant can be used as a hedge to delimit the garden because it tolerates frequent and repeated pruning. It is characterized by its fast development and ramifications. It can be frequently used as a hedge in fields or in urban areas, as a fragrant small tree, or as a climbing plant in the home garden or in some establishments.

The multiplication of henna is either from seeds or from cuttings; the coat of the seed is hard and needs a special manipulation (saoking seeds in water for a week), while the stems aged 2 to 3 years used as cuttings are easily rooted once put in water (one week to 15 days).

5.2. Benefits of Henna as a Cosmetic Plant

There are some conditions that women follow to obtain henna dried leaves or henna powder of the best quality. After harvesting the leafy stems, the drying of the leaves is obtained by placing the rods in a ventilated warehouse location that maintains the green color of the leaves and then the henna powder (the color is the visual indicator of the best quality of the product). The dried leaves are easily detached from stems when they are beat on the ground.

Cartwright-Jones (2006) estimated the needs of women about 1 kg of the best quality henna for wedding, circumcision or Id parties. In Biskra, usually, the women apply henna paste during all religious festivals and weddings throughout the year as a cosmetic tool to color hair (especially gray one) and, treat sick feet. The number of one kilo seem to be less that Biskra women need because the family gathers at such events.

Not only are leaves used to maintain healthy hair for Biskra women, flowers are also an ingredient of aromatic olive oil used in the region to promote hair growth.

5.3. Benefits of the Medicinal Henna Plant

In traditional Arab and Indian medicine, preparations made from the leaves and roots of henna are used to induce childbirth. A decoction made from plant leaves and roots is effective against certain forms of diarrhea (Aweke & Tapapul Lekoyiet, 2005). An infusion of the flowers is a valuable application to bruises. Decoction of the flowers describes as an emmenagogue (Chaudhury et al., 2010).

In Biskra, Benaissa (2018) reported that the plant parts used in traditional medicine are the leaves and the seeds. As a result of the investigation of the use of henna as a medicinal plant, the plant is used as a remedy to treat external diseases such as foot aches and diseases, headaches, migraines, and sunburn as well as hair-related problems. It is involved in the treatment of dermatological conditions healing wounds and tanning of the skin of newborns. It is used to treat burns as well as fractures. The main uses of the plant are: an anti-shock, high blood pressure, and anti-ulcer.

Because the "cold" virtue attributed to henna is believed to cure "hot" illnesses. As a poultice, it calms headaches and migraines. As an ointment with butter, henna treats burns or even spots like those from chickenpox (Gast, 2000).

The henna plant has recently been exposed to important scientific studies to detect secondary metabolites related to its antibacterial, antiviral, and antifungal effects.

5.4. Benefits of Henna Plant as Aromatic Plant

In recent years, the importance of essential oils as biocides and insect repellents has led to a more detailed study of their antimicrobial potential.

Since the last century, henna flowers have been used as a bio insecticide to protect wool against worms that may develop in it (Venderhyden, 1934).

Benaissa & Belhamra (2017) found that the henna plant cultivated in rural areas of Biskra (Zribet El Oued) contains 0,66% essential oil in its leaves and 0,79–1,38% essential oil in its flowers, depending on the apparatus used for essential oil extraction. The aromatic oils are of good quality according to AFNOR standards.

5.5. Other Benefits of Henna

Local people use plants that are usually growing in proximity for many purposes, for example pharmaceutical, food, fodder, decoration, fuel, toys, crafts, and ornamental (Güneş, 2017).

Other benefits of henna are:

The scent of henna flowers is specific, the flowering stage that last 2 months of the summer, when this plant is present in the garden, it makes memories in the human brain. The same think when we speak about the odor of the past of henna from powdered leave, from childhood, all Muslim people share the emotion of happiness and the perfumed and orange pattern of the henna on hand.

- From the traditional food of the Zibans, there is a local couscous prepared with herbs when an amount of henna powder is added to the others herbs to enroll the green big couscous and served especially to postpartum mothers since henna has an emmenagogue, antidiarrheal, antifungal and an antibacterial effect.
- The henna flowers are foraged by bees, and their fragrance attracts them. Organic products and the ethological uses of honey plants are interesting arguments for introducing henna to biological honey production.
- Describe henna in the category of an annuity product: it provides a source of income for the rural community. Among the customs of the region is giving a bag of henna (dried leaves or powdered) to guests, an expression of love and welcome.

6. CONCLUSION

The use of endemic plants in urban landscapes or in gardens is of great importance because they can support the hardest conditions of climate and soil. The obtained results show that the henna plant can be used frequently as a hedge in fields or in urban areas because it tolerates ripening, as a fragrant small tree with white flowers, or as a climbing plant in the home garden or in some establishments. Finally, in the Algerian culture, the women of the study area considered the henna plant as an auspicious and blessed plant because of its

Arabic name. Once introduced in a garden house, it has several uses enumerated in this chapter.

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PART III

Inventory of Ornamental Flora Across Algerian Regions

CHAPTER VII

The Plant Heritage of Saida Province: Unveiling Aromatic, Medicinal and Ornamental Traditions

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1. INTRODUCTION

The vegetation plays a crucial role in the structure and functionality of ecosystems, reflecting their biological potential. However, in this region, the natural vegetation cover faces dual stress. On one hand, it undergoes soil and climate constraints, and on the other, it is subjected to significant human pressure. According to the State of the World's Plants report (Gardens, 2016; Willis, 2017), approximately 391,000 vascular plant species belonging to 452 plant families are described worldwide. At least 28,187 plant species are currently recorded as having medicinal uses (Willis, 2017).

The Mediterranean basin is one of the planet's 34 "hotspots”, characterized by high species richness, high rate of endemism, and increasing anthropogenic threats (Myers et al., 2000; Myers, 2003). It is home to approximately 10% (25,000) of the world's known vascular plants, covering an area representing less than 2% of the Earth's land surface (Radford et al., 2011).

Algeria, with its vast expanses of forests and maquis covering approximately 4,1 million hectares, plays a crucial role in maintaining the country's physical and biological balance. The northern region of Algeria, with a forestation rate of 16,4%, contributes significantly to this vegetation cover. However, when the arid Saharan regions are taken into account, the national forestation rate drops to only 1,7% (FAO, 2021). Today, Algeria is considered one of the Mediterranean countries richest in plant diversity, with 3,164 species of vascular plants (Gupta et al., 2003). It is characterized by a flora rich in medicinal and aromatic plants, due to its climatic and topographic diversity (Azzi et al., 2012), which are used by the Algerian population to treat various ailments (Reguieg, 2011).

Algeria possesses an extremely rich and varied flora represented by aromatic and medicinal plants, most of which exist in the wild. Many species of medicinal plants are harvested by the local population and herbalists. These plants are still largely unknown and are exploited in a traditional manner (Abdelguerfi & Ramdane, 2003; Miara et al., 2013). The development and utilization of these plants remain a field of great importance for the country (Hamza et al., 2019).

In addition to medicinal and aromatic plants, Algeria is also home to a variety of ornamental plants that enhance the beauty and diversity of its landscapes. Ornamental plants, with their vibrant colors, attractive shapes, and enchanting fragrances, have been appreciated by humans for centuries. There are tens of thousands of species of ornamental plants, with new varieties and hybrids introduced each year by passionate horticulturists. These plants, ranging from delicate flowers to majestic trees, are cultivated for their beauty and ability to enhance indoor and outdoor spaces. The global market for ornamental plants is vast and dynamic, reflecting the universal love for the beauty of nature.

The combination of excessive plant exploitation and climate change poses a serious threat to the survival of many species. Algeria, with its unique floristic diversity, is not immune to this problem. The overexploitation of plant resources, whether through excessive use for medicinal purposes, deforestation, or soil degradation, negatively impacts ecological balance (Djebbouri et al., 2022a; Djebbouri & Terras, 2022; Dahmani et al., 2023). Furthermore, climate change exacerbates these effects, making some species rare and pushing others to the brink of extinction (Bouasla & Bouasla, 2017; Djebbouri et al., 2022b; Zouidi et al., 2023).

Understanding the conservation status of these species is important for developing effective conservation strategies. Well-informed policies based on robust scientific data are essential to guide conservation efforts and ensure the long-term survival of these plants (Williams et al., 2013; Djebbouri et al., 2021; Abla et al., 2024).

This work aims to identify the wild plants in the forest formations harvested for medicinal, aromatic and ornamental purposes by the local populations of the Saïda region. It also seeks to document their uses and local names, with the goal of creating a database of aromatic and medicinal plants (AMP). The core of its content relies on a comprehensive synthesis concerning taxonomic and nomenclature issues, aiming to clear up ambiguities regarding certain species, particularly from a taxonomic perspective.

2. MATERIALS AND METHOD

2.1. Presentation of the Study Region

This work is conducted in the province of Saïda, nicknamed the "province of waters" due to its numerous springs, located in northwestern Algeria (34°40′0″ N; 0°19′60″ E). With a population of 350,765 inhabitants, Saïda covers an area of 5,536.73 km². It is bordered to the north by the province of Mascara, to the south by the province of El Bayadh, to the west by the province of Sidi-Bel-Abbbs, and to the east by the province of Tiaret. This position grants it a role as a link between the steppe provinces in the south and the Tell provinces in the north, allowing for the extension of plant species biodiversity.

The forest formations in the Saïda region, situated between 35°6'23.68" and 34°35'9.14" North latitude and 0°25'10.89" West to 0°47'28.58" East longitude in northwestern Algeria, occupy an area of approximately 174,361 hectares (Figure 1).

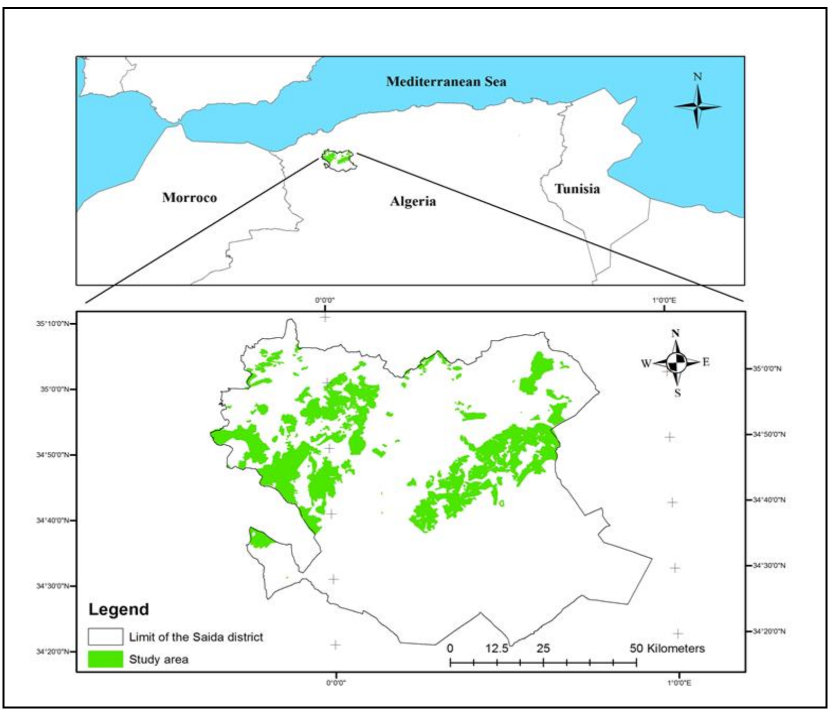

Figure 1: Location of the study area

2.2. Climate of the Region

According to data from the nearest climatological station (Rebahia station), over a 35-year period from 1985 to 2020, the annual rainfall is approximately 361 mm per year. The average maximum temperature in the hottest months (July and August) and the average minimum temperature in the coldest months (January and February) were 27°C and 3°C, respectively. The climate of the study area is Mediterranean semi-arid; the seasonal regime of the area is of the HAPE type (winter, autumn, spring, and summer) with a dry period lasting nearly 6 months from May to October (Zouidi et al., 2019).

2.3. Soil Quality

Saïda province, located in northwestern Algeria, exhibits a diversity of soils reflecting the climatic and geological conditions of the region. Several studies on the soils of this area have revealed several distinctive characteristics. Firstly, the soils in the Saïda province are primarily calcareous, with a high presence of carbonates. This characteristic is influenced by the semi-arid climate of the region, which promotes the accumulation of carbonates in the soil. Secondly, the soils are generally shallow, with a thickness ranging from 20 to 50 cm. This shallow depth is due to the presence of outcropping rocks and the rocky nature of the terrain (Zouidi et al., 2019; Allam et al., 2023).

The soil texture in the region is predominantly loam-clay, with a significant proportion of clay and silt. This texture influences the soil's water and nutrient retention capacity, thereby affecting plant growth. The soils are also characterized by their low organic matter content, which can be attributed to deforestation and past intensive agricultural practices. This low organic matter content affects soil fertility and its ability to retain water (Borsali et al., 2017).

Regarding chemical quality, the pH ranges from slightly acidic to slightly alkaline, with an average around 7,5. The electrical conductivity, indicating the presence of ions in the soil, is generally low, suggesting low salinity (Zouidi et al., 2019; Allam et al., 2023).

2.4. Plant Communities

According to phytoecological studies conducted by several researchers in this region, it has been possible to provide a fairly representative average floristic composition of the different plant communities. The forest ecosystem covers more than 26% of the total surface area, a rate higher than the national average, giving the area a predominant forest vocation. The state forests of Tendfelt, Djaafra, and Fenouane are the most significant; they are dominated by the Aleppo pine community and the Holm oak community, followed by the Olea-lentisque community and the *Tetraclinis articulata* community (Djebbouri & Terras, 2019a; Djebbouri & Terras, 2022); Aouadj et al., 2023).

2.5. Methodology

In this work, the list of plant species in the forest formation of the Saïda region, established from 215 phytoecological surveys conducted in the area (Djebbouri & Terras, 2019b), was used as a database to select species for aromatic and medicinal purposes. The selection of these species was carried out following a scientific methodology based on an ethnobotanical survey among local experts and practitioners of phytotherapy. We also consulted traditional healers present in the daily markets ("souks") of the region, as well as experienced herbalists and florists.

The update of the botanical nomenclature was conducted by referring to the index of the North African database (Dobignard & Chatelain, 2010-2013). The identification of the recorded flora was performed using the "New flora of Algeria and the southern desert regions" (Quézel & Santa, 1961-1962). The scientific names of the families follow the classification of the Angiosperm Phylogeny Group 2016 (Byng et al., 2016). The rarity of various taxa in Algeria was determined exclusively based on the reference flora for Algeria by Quézel and Santa (Quézel & Santa, 1961-1962).

The chorological types and endemism of the species are the result of a synthesis work referring to the indications provided by the following floras: "New flora of Algeria and the southern desert regions" (Quézel & Santa, 1961-1962) and the "Index synonymique de l’Afrique du Nord" (Dobignard & Chatelain, 2010-2013).

Species with special status were identified by referring to two main sources. Firstly, the list of non-cultivated plant species protected in Algeria, as defined by executive decree no. 12-03 of 10 Safar 1433 (January 4, 2012). Secondly, the lists of the International Union for Conservation of Nature (IUCN) from 1997 provide additional information on the conservation status of these species (Walter & Gillett, 1998).

2.6. Assessment of Abundance Degree

To evaluate the degree of abundance of each species within each type of landscape, we analyzed their relative frequency in relation to the total number of surveys conducted in each area.

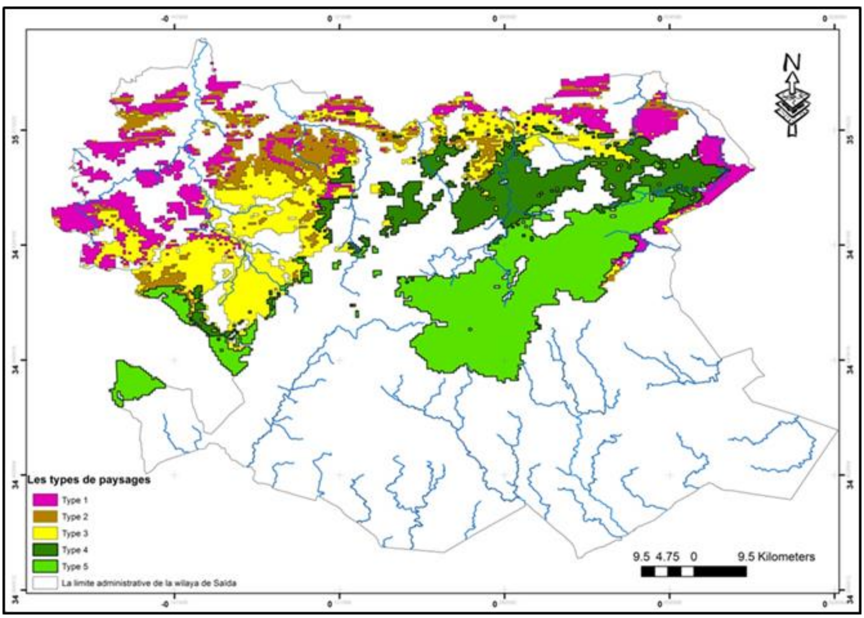

Figure 2: Type of landscapes (Djebbouri, 2020)

We assigned an abundance degree to each species using the following scale:

- R: Rare, relative frequency less than 5% in each type of landscape.
- AR: Semi-rare, relative frequency between 5% and 10%.
- AC: Fairly common, relative frequency between 10% and 20%.
- C: Common, relative frequency greater than 20%.

This scale allows us to assess the prevalence of each species within the different identified landscapes (Figure 2).

3. RESULTS AND DISCUSSION

3.1. Botanical Diversity

The inventory and floristic analysis of the natural vascular vegetation of an area are essential to understand the overall composition of existing taxa, i.e., phytodiversity, the biogeography of the recorded species, and the ecology of the study area (Hammada et al., 2004). The survey conducted among herbalists identified 92 species of wild plants with aromatic and medicinal uses utilized by the local population. These plants belonged to 73 genera and 30 families. The Lamiaceae dominate the list of traditional remedies with 11 species (13%), followed by the Asteraceae with 10 species (12%), the Apiaceae with 6 species (7%), the Fabaceae with 5 species (6%), and the Poaceae with 4 species (4%). These results indicate considerable diversity and suggest that the region hosts a wide range of plants with potential medicinal and aromatic properties (Table 1, Figure 3).

Table 1: List of plants of medicinal interest inventoried

Family	Species	Arabic name	Rarity	Part used	Phytogeography
Amaryllidaceae	*Allium paniculatum* subsp. *fuscum* (Waldst. & Kit.) Arcang.	الثوم البري	AC	tuber	Paleo-temperate
Amaryllidaceae	*Allium roseum* L. subsp. roseum	الثوم البري	C	tuber	Mediterranean
Anacardiaceae	*Pistacia lentiscus* L.	الضرو	CC	stems	Mediterranean
Apiaceae	*Ammi majus* L.	النوخة	CC	stems	Mediterranean
Apiaceae	*Ammoides pusilla* (Brot.) Breistr.=*Ammoides verticillata* (Desf.) Briq.	النوخة	CC	stems	Mediterranean
Apiaceae	*Daucus carota* L. subsp. carota	جزر	R	root	Mediterranean
Apiaceae	*Elaeoselinum asclepium* subsp. meoides (Desf.) Fiori	الكليخة	CC	root	Mediterranean
Apiaceae	*Ferula communis* L.	الكلخ	CC	root	Mediterranean

Apiaceae	*Foeniculum vulgare* Mill.	البسباس	CC	stems	Mediterranean
Apiaceae	*Kundmannia sicula* (L.) DC.	زياتة	CC	stems	Mediterranean
Apiaceae	*Scandix australis* L.	حر جوان	CC	stems	Mediterranean
Apiaceae	*Smyrnium olusatrum* L.	الحيار	CC	root	Mediterranean
Apiaceae	*Bifora testiculata* L. Spreng.	قصبر الخلا	AC	stems	Mediterranean
Apiaceae	*Bunium fontanesii* (Pers.) Maire	تارغودة	R	tuber	North African Endemic
Apiaceae	*Daucus crinitus* Desf.	مسيسخر	AC	root	North African Endemic
Apocynaceae	*Nerium oleander* L.	الدفلة	CC	stems	Mediterranean
Arecaceae	*Chamaerops humilis* L.	الدوم	CC	root	Western Mediterranean
Asparagaceae	*Asparagus altissimus* Munby	السكوم	AC	root	Algeria-Morocco Endemic
Asparagaceae	*Drimia fugax* (Moris) Stearn=*Urginea fugax* (Moris) Steinh.	البصيلة	AC	tuber	Mediterranean
Asparagaceae	*Asparagus acutifolius* L.	السكوم	CC	root	Mediterranean
Asparagaceae	*Asparagus albus* L.	السكوم	C	root	Western Mediterranean
Asteraceae	*Artemisia campestris* L.	لالال	C	stems	Circumboreal
Asteraceae	*Carthamus pinnatus* Desf.= *Carduncellus pinnatus* (Desf.) DC.	قرن جدي	R	fruits	Sicily-North Africa-Libya
Asteraceae	*Cynara cardunculus* L.	الحرشف البري	CC	leaves	Mediterranean
Asteraceae	*Echinops bovei* Boiss.=*Echinops spinosus* subsp. bovei (Boiss.) Murb.	تسكرة	CC	root	South Mediterranean Saharan
Asteraceae	*Helichrysum fontanesii* Cambess.= *Helichrysum stoechas* subsp. rupestre auct.	لتاي الخلى	CCC	stems	Western Mediterranean
Asteraceae	*Matricaria chamomilla* L.	البابونج	/	stems	Eurasia, Macaronesia, Maghreb
Asteraceae	*Phagnalon rupestre* (L.) DC.	لتاي الخلى	/	stems	Circummediterranean
Asteraceae	*Phagnalon saxatile* (L.) Cass.	لتاي الخلى	CC	stems	Western Mediterranean
Asteraceae	*Rhaponticum acaule* (L.) DC.	تافغة	C	fruits	North Africa
Asteraceae	*Silybum marianum* (L.) Gaertn.	شوكة مريم	CCC		Cosmopolitan
Asteraceae	*Anacyclus pyrethrum* (L.) Link	تينغطس	C	root	Iberian-Mauritanian
Asteraceae	*Atractylis caespitosa* Desf.= *Atractylis*	الكنودة	CC	stems	Iberian-Mauritanian

	humilis subsp. caespitosa (Desf.) Maire				
Asteraceae	*Carlina gummifera* (L.) Less.= *Atractylis gummifera* L.	الحلتيت/ لاداد	CC	root	Mediterranean
Asteraceae	*Achillea santolinoides* Lag.	/	AR	stems	Iberian-Mauritanian
Brassicaceae	*Lobularia maritima* (L.) Desv.	تسلغة	CC	stems	Mediterranean
Caryophyllaceae	*Herniaria hirsuta* L.	فتاتة الحجر	AC	stems	Paleo-temperate
Caryophyllaceae	*Paronychia arabica* subsp. *cossoniana* (J. Gay ex Batt.) Batt.	/	C	stems	Eastern Mediterranean
Caryophyllaceae	*Paronychia argentea* Lam.		C	stems	Mediterranean
Caryophyllaceae	*Petrorhagia illyrica* (Ard.) P.W. Ball & Heywood=*Tunica illyrica* subsp. *angustifolia* (Poir.) Maire	عود الريح	AC	root	Eastern Mediterranean
Cistaceae	*Cistus creticus* L.= *Cistus villosus* L.		AC	stems	Mediterranean
Cistaceae	*Cistus salviifolius* L.		CC	stems	Eurasian Mediterranean
Cupressaceae	*Juniperus oxycedrus* L. *subsp. oxycedrus*	الطاقة	CC	root/fruits	Atlantic-Circum-Mediterranean
Cupressaceae	*Tetraclinis articulata* (Vahl) Mast. = *Callitris articulata* (Vahl) Link	عرعار الغابة	CC	fruits	Iberian-Mauritanian-Malta
Ericaceae	*Arbutus unedo* L.	اللنج	CC	root/stem	Mediterranean
Fabaceae	*Calicotome spinosa* (L.) Link	القندول	CC	root	Western Mediterranean
Fabaceae	*Ebenus pinnata* Aiton		C		North African Endemic
Lamiaceae	*Lavandula stoechas* L.	ريحة وخزامة	CC	leaves	Mediterranean
Lamiaceae	*Marrubium alysson* L.	مريوية	CC	leaves	Iberian-Maghreb
Lamiaceae	*Marrubium supinum* L.	مريوية	R	leaves	Iberian-Mauritanian
Lamiaceae	*Marrubium vulgare* L.	مريوية	CC	leaves	Cosmopolitan
Lamiaceae	*Mentha pulegium* L.	فليوا	AC	leaves	Eurasian
Lamiaceae	*Mentha suaveolens* Ehrh.= *Mentha rotundifolia* auct.	تيمرضاد	CC	leaves	Atlantic-Mediterranean
Lamiaceae	*Rosmarinus eriocalyx* Jord. & Fourr.= *Rosmarinus tournefortii* (de Noé ex Jord. & Fourr.) Murb.	الحلحال	R	leaves	Endemic
Lamiaceae	*Salvia argentea* L.	فراش	C	leaves	Mediterranean

		الندى			
Lamiaceae	*Salvia verbenaca* L.	عشبة الفكرون	CC	leaves	Mediterranean-Atlantic
Lamiaceae	*Teucrium polium* L.	جعيدة	CC	leaves	European-Mediterranean
Lamiaceae	*Thymus lanceolatus* Desf.	زعتر	R	leaves	Endemic
Lamiaceae	*Thymus munbyanus* subsp. *ciliatus* (Desf.) Greuter & Burdet= *Thymus ciliatus* (Desf.) Benth.	زعتر	CC	leaves	North African Endemic
Lamiaceae	*Thymus pallescens* de Noé=*Thymus fontanesii* Boiss. & Reut.	زعيترة	C	leaves	Algeria-Morocco Endemic
Lamiaceae	*Ziziphora hispanica* L.	نابطة	AC	leaves	Iberian-Mauritanian
Lamiaceae	*Ballota hirsuta* Benth.	مريوية	AC	leaves	Iberian-Mauritanian
Lamiaceae	*Ajuga iva* (L.) Schreb. subsp. *iva*	شندقورة	CC	leaves	Mediterranean
Lamiaceae	*Ajuga iva* subsp. *pseudoiva* (DC.) Briq.	شندقورة	CC	leaves	Mediterranean
Malvaceae	*Malva sylvestris* L.	الخبيز	CC	leaves	Eurasian
Oleaceae	*Olea europaea* L. subsp. *Europaea*= *Olea europaea* var. oleaster (Hoffmanns. & Link) DC.	الزبوج	CC	leaves	Mediterranean
Oleaceae	*Phillyrea angustifolia* L.= *Phillyrea angustifolia* L. subsp. *Angustifolia*	الكتم	R	leaves	Mediterranean
Oleaceae	*Phillyrea latifolia* L.= *Phillyrea angustifolia* subsp. *latifolia* (L.) Maire	الكتم	CC	leaves	Mediterranean
Orchidaceae	*Ophrys fusca* Link	حية وميتة	C	Tuber	Mediterranean
Orchidaceae	*Ophrys speculum* Link	حية وميتة	AC	Tuber	Circummediterranean
Orchidaceae	*Ophrys tenthredinifera* Willd.	حية وميتة	C	Tuber	Circummediterranean
Orchidaceae	*Orchis anthropophora* (L.) All.=*Aceras anthropophorum* (L.) Aiton	حية وميتة	C	Tuber	Atlantic-Mediterranean
Papaveraceae	*Papaver rhoeas* L.	بنعمان	C	Flowers	Paleo-temperate
Pinaceae	*Pinus halepensis* Mill.	الصنوبر	CC	Grains /ecorce	Mediterranean
Plantaginaceae	*Plantago albicans* L.	لالمة	CC	stems	Mediterranean
Poaceae	*Macrochloa tenacissima* (L.) Kunth= *Stipa tenacissima* L.	الحلفاء	CC	leaves	Iberian-Mauritanian

Poaceae	*Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz	الديس	CC	stems	Western Mediterranean
Ranunculaceae	*Nigella damascena* L.	السانوج	C	fruits	Mediterranean
Ranunculaceae	*Clematis cirrhosa* L.	العشبة الكحلة/العشبة الحارة	C	root	Mediterranean
Ranunculaceae	*Clematis flammula* L.	العشبة الكحلة/العشبة الحارة	RR	root	Mediterranean
Resedaceae	*Reseda phyteuma* L. subsp. *phyteuma*	العشبة الباردة	R	leaves	Mediterranean
Rhamnaceae	*Rhamnus alaternus* L. subsp. *alaternus*	ملالز	CC	leaves	Mediterranean
Rhamnaceae	*Ziziphus lotus* (L.) Lam.	السدرة	CC	leaves	Mediterranean
Rubiaceae	*Rubia peregrina* L.	الفوا	CC	root	Mediterranean-Atlantic
Rutaceae	*Ruta angustifolia* Pers. = *Ruta chalepensis* subsp. *angustifolia* (Pers.) Cout.	فيجل الجبل	C	stems	Mediterranean
Rutaceae	*Ruta montana* L.	الفيجل	C	stems	Mediterranean
Tamaricaceae	*Tamarix gallica* L. subsp. *gallica*	الطرفة/ العريش	CC		North Tropical
Thymelaeaceae	*Daphne gnidium* L.	لازاز	C	leaves	Mediterranean
Thymelaeaceae	*Thymelaea hirsuta* (L.) Endl.	المتنان	CC	leaves	Mediterranean
Xanthorrhoeaceae	*Asphodelus ramosus* L. = *Asphodelus microcarpus* Viv.	البلوز	CC	tuber	Canary-Mediterranean

AC: fairly common, C: common, CC; very common, CCC: particularly widespread. AR: fairly rare, R: rare, RR: very rare, RRR: extremely rare

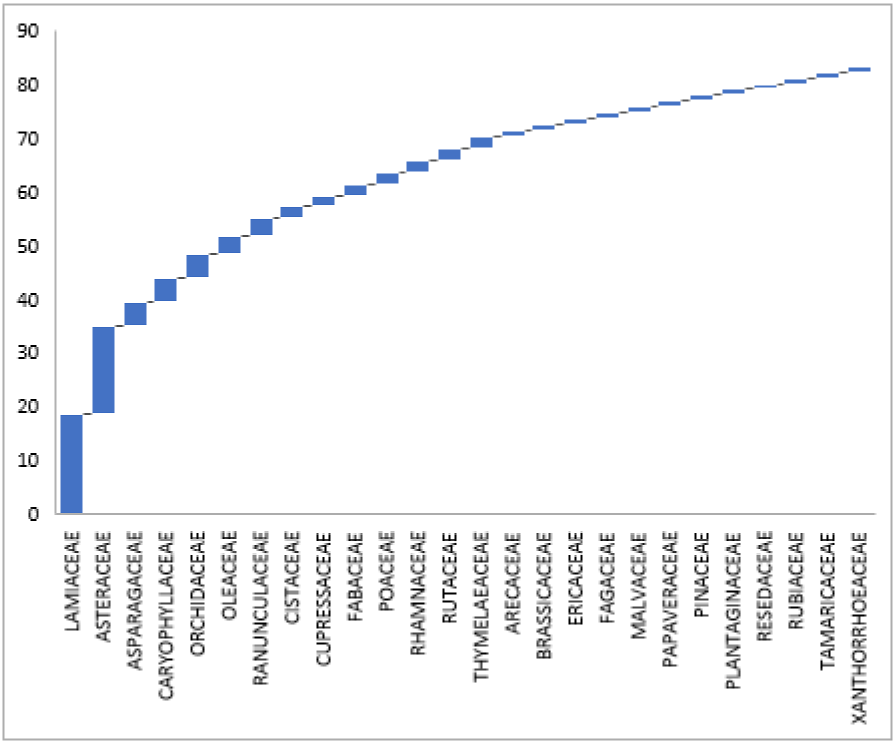

Figure 3: Contributions of botanical families in percentage

3.2. Endemism and Rarity

The chorological analysis of the aromatic and medicinal plant species identified in this study clearly shows the dominance of native Mediterranean elements over all other types (Figure 4). The rate of endemism is well represented with 9 endemic species. The rarity of species is used to assess the risk of extinction of medicinal plants and to identify the species most threatened with extinction before the start of conservation efforts (Figueiredo & Grelle, 2009; Chen et al., 2016). It is necessary to determine the rarity of each species and to know precisely which plants to exploit to avoid harvesting rare or very rare taxa. A study conducted in the study area showed that among 398 species inventoried, the category of rare taxa accounted for more than 13% of the studied flora (52 taxa) and identified 35 regional endemic species, including 19 Algerian-Moroccan endemics and 3 species strictly endemic to Algeria (Djebbouri & Terras, 2019b).

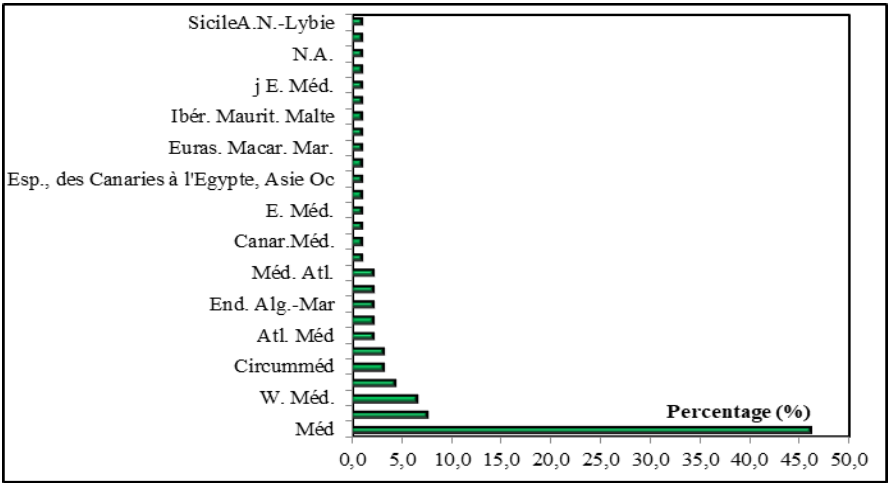

Figure 4: Contributions of biogeographical types in percentage

The other elements: Cosmopolitan, Eurasian, and Euro-Mediterranean are less represented compared to all the remaining elements. Indeed, it seems that the plants used in traditional medicine in the region are predominantly native, meaning that the majority are of Mediterranean origin.

In our study, the rate of aromatic or medicinal species with a status of rare species is presented at a percentage of 9,30%, specifically 9 species and subspecies (Figure 5). As mentioned earlier, there is significant confusion and imprecision regarding the vernacular names and their corresponding scientific names, such as the case of the three species of the genus *Asparagus,* commonly called "sakoum".

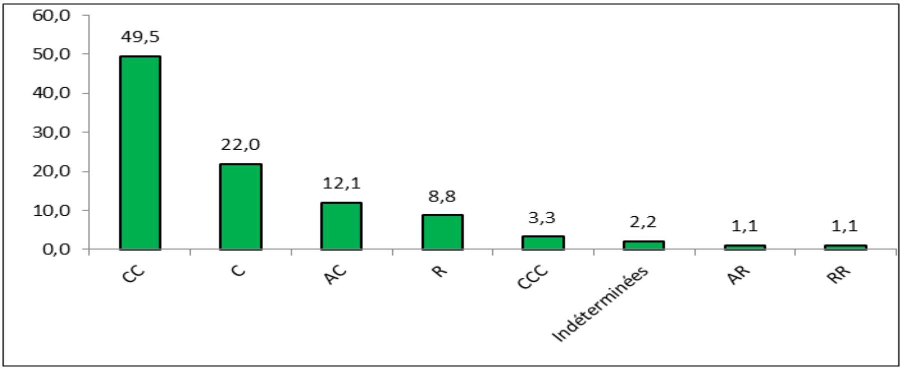

Figure 5: Percentages of economically significant plants according to their abundance levels

The example of the genus *Marrubium* is also significant. This plant, commonly called "maruwya," is widely exploited in our region without particular precautions. However, there are three species with different taxonomic statuses, degrees of rarity, presence, and distribution areas. For instance, *Marrubium vulgare* L. and *Marrubium supinum* L. are often confused, although the latter is a very rare species (Quézel & Santa, 1961-1962) and protected by law in Algeria (J.O.R.A, 2012).

Thus, endemic species can be eliminated forever without anything in return if the species are very rare. There are many examples. Let's take the case of *Thymus munbyanus* subsp. *ciliatus* (Desf.) Greuter & Burdet and *Thymus lanceolatus* Desf. These two are often confused, whereas the latter is a rare and strictly endemic species in the northwest of Algeria.

3.3. Plants with Special Status

Among the list of plants recorded in the studied area and in the market, two species are regional endemics (*Thymus pallescens* de Noé and *Thymus lanceolatus* Desf.), four are protected species included in the Algerian list of non-cultivated plant species protected by Executive Decree No. 12-03 of 10 Safar 1433 – January 4, 2012, and one is listed in the IUCN Red List (*Marrubium supinum* L., *Tetraclinis articulata* (Vahl) Mast., *Thymus lanceolatus* Desf., *Juniperus oxycedrus* L. subsp).

3.4. Used Parts

The results of this survey show that the leaf is the most used part of medicinal plants (62,6%), followed by stems (19,8%) and roots (8,2%). The combined total for bulbs, rhizomes, bark, and resins is 9,4%. The increased use of leaves has also been reported in several studies (Zerbo et al., 2011; Diatta et al., 2013; Chermat & Gharzouli, 2015). This can be explained by the ease and speed of harvest, as well as the fact that leaves are the site of photosynthesis and are very rich in active principles (Adams & Terashima, 2018). Next come stems, bulbs, tubers, seeds, roots, and sometimes even the entire plant (Table.1).

3.5. Ornamental Plants

Based on the survey conducted, we have identified numerous ornamental plants in our study area, with approximately 25 species distributed across 5 families. Among these, we can mention *Lavandula stoechas, Nerium oleander* L, *Rosmarinus eriocalyx*, and *Phillyrea latifolia* L. The most dominant family is Lamiaceae, followed by Asteraceae (Figure 6).

Ornamental plants play a crucial role in enhancing the aesthetic appeal of gardens, landscapes, and urban environments. Their importance has become indisputable in decoration and for the population (Séguéna et al., 2013). These plants, selected for their beautiful flowers, foliage, and overall appearance, significantly contribute to the beautification of spaces, bringing visual interest and a sense of tranquility. Ornamental plants offer numerous ecological benefits.

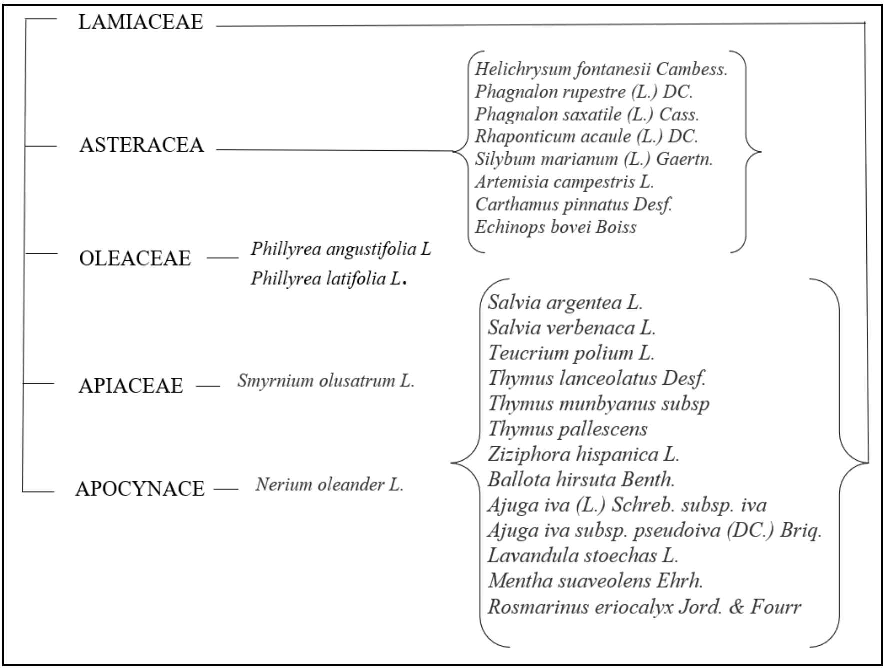

Figure 6: Main ornamental plants

They contribute to biodiversity by supporting various pollinators such as bees, butterflies, and birds, thus playing a vital role in maintaining healthy ecosystems. Their presence also has psychological benefits, as it has been shown that green spaces with diverse plantings reduce stress, improve mental health, and enhance overall well-being. Additionally, ornamental plants often possess medicinal properties and can be used in traditional remedies, adding to their multifaceted importance. By incorporating a variety of ornamental species, such as those listed in this study, we not only create visually appealing environments but also promote ecological balance and human health.

Today, the intense degradation of forests poses a serious problem for the survival of wild plants, particularly those used for food purposes. These plants are genuine sources of nutritional supplements and play a crucial role in the rural economy. According to studies by Kouamé et al. (2008) and Aké-Assi et al. (2020), these plants contribute not only to the dietary diversity of rural populations but also to their economic security by generating income. The loss of this plant biodiversity due to deforestation and habitat degradation compromises the availability of these vital resources. It is therefore imperative to protect this important plant heritage, both for its ecological value and for its essential contribution to the nutrition and economy of rural communities. The conservation of forests and wild plants must be a priority in order to preserve these resources for future generations and to maintain the ecological and economic balance of rural areas.

4. CONCLUSION

The richness of aromatic and medicinal plants in Algeria represents an untapped potential, but their survival is threatened by excessive and unregulated exploitation. In the study area, the harvesting of these plants is driven by market demand, often without consideration for their biological cycles or sustainable assessment of harvest quantities. This overexploitation has pushed some species, such as orchids, to the brink of extinction due to abusive harvesting practices. A sustainable management approach is imperative to safeguard these valuable medicinal plants. Currently, exploitation is characterized by a lack of understanding of the true productivity of ecosystems, the exact identity of species, and their biological and ecological characteristics. The situation is alarming, as even rare or endemic plants are harvested indiscriminately, exposing them to imminent danger.

Given the increasing demand for derivatives of aromatic and medicinal plants both nationally and internationally, promoting sustainable exploitation is urgently needed. Three priority actions are proposed:

- Intensifying scientific research to clearly identify taxonomic, chorological, biological, and ecological aspects of species, and assess their optimal sustainable productivity.
- Developing and adopting a national charter, along with a best practices guide, to establish rules and procedures aimed at minimizing damage to species and their habitats.
- Encouraging the cultivation of aromatic and medicinal plants to reduce pressure on wild species.

Implementing these measures is essential to ensure sustainable and effective management of these plants, thereby contributing to biodiversity preservation and sustainable development of the region.

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CHAPTER VIII

Inventory and Update of Ornamental Flora in the Southern Constantian Steppes: The Case of the Town of M'sila (Algeria)

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1. INTRODUCTION

In the Mediterranean basin, the flora is unanimously considered to be exceptionally diverse, and as such deserves special consideration for its conservation (Hechemi et al., 2012). Arid and semi-arid Mediterranean regions are influenced by climatic variations and anthropo-zoogenic actions. The latter accelerate the phenomena of drought, erosion and soil degradation, and consequently the degradation of plant cover. All these conditions have increasingly led to the regression of the steppe surface and the increase in Algeria's desert area, 80% of which is considered arid and hyperarid (Khabtane, 2010; Gamoun et al., 2010).

Ornamental plants, developed over thousands of years, adapt and harmonize perfectly with all conditions, particularly in arid environments. They play a key role in the design of gardens, public spaces and interiors. They are appreciated not only for their aesthetic appeal, but also for the many benefits they bring to the environment and to people's well-being. An ornamental plant is a species cultivated primarily for its decorative qualities. These plants can be distinguished by their colorful flowers, original leaf shapes or graceful habit. They can be found in a variety of forms:

- **Trees and shrubs:** such as roses, cypresses and bougainvilleas;
- **Herbaceous plants:** such as daisies, petunias and begonias;
- **Climbing plants:** such as jasmine and wisteria;
- **Indoor plants:** such as monstera, orchids and pothos.

The M'sila area is a key link between the north, south, east and west of Algeria. Its geographical position on the arid and semi-arid bioclimatic stages, allows the installation of ornamental plants which find refuge in these stressful conditions of the environment where the ground constitutes an essential element of the biotopes to the terrestrial ecosystems.

The aim of this investigation is to inventory the ornamental plants that find refuge in the green spaces and public gardens of the city of M'sila, followed by a taxonomic, biological and chorological analysis and update of this flora.

2. PRESENTATION OF THE STUDY AREA

2.1. Geographical Location of M'sila

The wilaya of M'sila, within its current boundaries, occupies a privileged position in the central part of northern Algeria as a whole, and is part of the Central High Plateaux region, covering an area of 18,175 km^2.

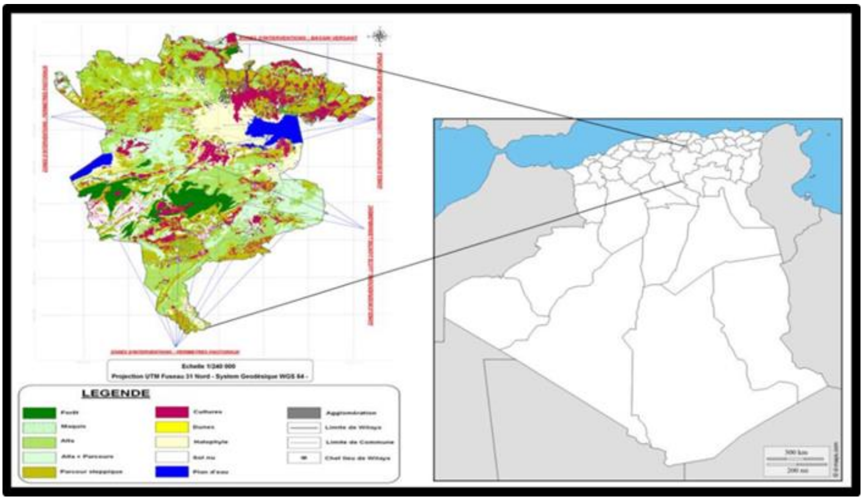

Figure 1: Location Map of the wilaya of M'sila

It lies at 35°40' north latitude and 04°30' east longitude, at an altitude of around 441 m. The wilaya of M'sila lies in the semi-arid zone, with a rainfall of less than 250 mm/year. It is bordered to the northeast by Bordj Bou-Arreridj and Setif, to the northwest by Medea and Bouira, to the east by the wilaya of Batna, to the west by the wilaya of Djelfa, and to the southeast by the wilaya of Biskra (Figure 1).

2.2. Relief

The physical configuration of this perimeter shows that the territory of the wilaya constitutes a hinge and transition zone between the two major mountain ranges, the Tellian Atlas and the Saharan Atlas. The geographical configuration is as follow :

- A mountainous area on either side of the Chott El Hodna;
- A central zone consisting mainly of plains and high plains;
- A zone of chotts and depressions, with the Chott El Hodna in the central east and the Zahrez Chergui in the central west;

- An area of aeolian sand dunes.

2.3. Soils

Soils in the M'sila area vary in character. In general, they are poor and fragile, with calcareous crusts sometimes outcropping on the surface. Six (6) types of soil can be distinguished: Brown calcareous soils in association with regosols and lithosols; crude mineral soils and soils with little regosolic development; soils with little alluvial development; soils with little alluvial development (little steppe, calcimorphic and hydromorphic); soils with little halomorphic development; sodic soils.

2.4. Climate and Bioclimate

Climate is an essential factor governing the existence and distribution of living beings on earth, and its description is based on several parameters, essentially rainfall and temperature. The climate of the wilaya of M'sila is characterized by extreme cold in winter, heat and drought in summer, low rainfall and high temperatures with a seasonal diet ASWS (Autumn, Spring, Winter, Summer).

3. WORKING METHODOLOGY

3.1. Sampling

Subjective sampling is the simplest, and involves selecting areas that appear homogeneous and representative (Gounot, 1969). The survey area must be at least equal to the minimum area, containing almost all the species present. This area is determined by the number of species recorded over increasingly larger surfaces, until the number of species recorded no longer increases (Gounot, 1969; Glande et al., 2003).

For our study, sampling is carried out during the months of March, April and May 2023 and 2024 at representative stations. At each station, vegetation counts are carried out on three randomly selected minimum areas.

3.2. Species Identification

Species are collected and placed in herbariums, and identification is carried out in the laboratory, for species not identified in the field, using the new flora of Algeria by Quezel & Santa (1962-1963)a, and (1962-1963)b. Identified species are updated using the Flora Corsica by Jeanmonod & Gamisans (2007), commented synonymic catalog of the Flora of Tunisia (Le Floc'h et al., 2010), the Synonymic Index of the Flora of North Africa by Dobignard & Châtelain (2010-2013).

Therefore, to reach a reliable definition, we consulted descriptive documents and studies (Encyclopedias, Botanical treatises, Atlases, Herbaria, Flores, Guides. etc.), theses obtained from references such as Beniston et al. (1984); Maurières & Rey (1995); Marouf (2000); Beloued (2005); Bounab & Ouanas (2005); Bounab (2014), and Bounab (2020).

4. RESULTS

4.1. Floristic Composition in Families, Genera and Species and Chorology

The ornamental plants inventoried in the green spaces and public gardens of the town of M'sila are listed in the Table 1 below, presented by family, species, chorology, etc. The green spaces and public gardens are home to 109 wild plants belonging to 31 families, most of which are determinate. And some ornamental species grown in public gardens in the town of M'sila are shown in Figure 2.

Table 1: Floristic composition of some ornamental plants found in the town of M'sila

Botanical family	Taxa	Description	Chorology
Anacardiaceae	***Schinus molle*** L.	The species is also grown as an ornamental in South and Central America and in Mediterranean gardens. It is used as fuel and as a barrier in fields and pastures, and is planted along dry-stone walls to support them. Its bark and resin have recognized medicinal properties.	South America
	***Schinus terebinthifolia* L.**	*Schinus terebinthifolia* is a tree that can reach 3 to 10 meters, occasionally 15 meters, with a trunk 10-30	South America

		cm in diameter (sometimes 60 cm); it has often proved highly invasive. Throughout South and Central America, Brazilian pepper is considered astringent, antibacterial, diuretic, digestive stimulant, tonic, antiviral and healing.	
Apocynaceae	***Nerium oleander* L.**	Oleander is a species of shrub or small tree. A widespread ornamental tree in the Mediterranean region, it is practical because it is resistant to drought and pruning, and forms hedges and thickets in private gardens, parks and near public buildings. Toxic: all parts of the plant contain oleandrin, a cardiotonic heteroside, which is fatal in small doses; indeed, a few leaves can kill an adult. In North Africa, beware of stream water soaked in oleander roots. Even the smoke from burning its branches is harmful.	Mediterranean basin, Asia, India and Japan
Arecaceae	***Washingtonia robusta* H. Wendl.**	This palm is widely grown in parks and along streets in regions with a mild climate. *Washingtonia robusta* grows in warm, sunny regions. It tolerates high temperatures well, and is not overly afraid of infrequent rainfall. It can withstand cold temperatures down to around -6°C.	Native to Baja California and Sonora, where it grows in arid areas and canyon bottoms
Asparagaceae	***Yucca aloifolia* L.**	It is appreciated as an ornamental plant. Aloe yucca is a hardy plant, thriving in dry, draining soils such as sandy coastlines. It requires sunny exposure, and prefers warm temperatures, germinating between 25 and 35°C.	Mexico and the southern United States
Asteraceae	***Gazania linearis* (Thunb.) Druce**	An annual plant for creating beautiful spots of color in rock gardens, flower beds and flowerbeds. It can also be grown in pots and window boxes.	South Africa
	***Gazania rigens* (L.) Gaertn.**	An annual plant for creating beautiful spots of color in rock gardens, flower beds and flowerbeds. It can also be grown in pots and window boxes.	South Africa and Mozambique
	***Argyranthemum frutescens* (L.) Sch. Bip.**	These more or less lignified herbaceous plants can reach 60 cm to 1 m in height, depending on the cultivar. Depending on the cultivar, the flowers are white, yellow, pink or red.	Canary Islands

	***Osteospermum ecklonis* (DC.) Norl.**	The different species include evergreen perennials, annuals and sub-shrubs. When in bloom, they form a veritable carpet of color.	South Africa and the Arabian Peninsula.
	***Dimorphotheca sinuata* DC.**	*Dimorphotheca* is a perennial plant with limited resistance to the cold (-5°C), as heat is essential to its heliophilic nature.	Native to the sandy, semi-arid regions of South Africa and tropical Africa
Bignoniaceae	***Podranea ricasoliana* Sprague**	Pink bignone is an evergreen climbing shrub with woody, voluble stems, devoid of tendrils, that can reach heights of 5 m. The species is considered invasive in Australia, New Zealand and Hawaii. Its vigorous habit and dense masses of foliage and branches tend to choke out surrounding vegetation.	South Africa, Malawi, Mozambique and Zambia
Bignoniaceae	***Jacaranda mimosifolia* D. Don**	This is a subtropical tree species. It has been widely planted elsewhere because of its beautiful, long-lasting blue summer flowering.	Native to south-central South America
Casuarinaceae	***Casuarina equisetifolia* L.**	Filao is a pioneer tree, capable of colonizing soils that are very poor in mineral elements. In saline areas, its leaves evacuate the salty surplus, making the soil at its foot infertile for other species. Filao is widely planted to stabilize coastal areas with sandy soils.	Originally from Australia
Celastraceae	***Euonymus japonicus* Thunb.**	Japanese fusain is an evergreen shrub up to 3 m tall, with green, teret (cylindrical), hairless branches. It has frequently been used to create single-species hedges in parks and gardens.	Japan
Cupressaceae	***Platycladus orientalis* (L.) Franco**	Drought-resistant, it is often used as an ornamental tree and for hedging, as it can withstand all kinds of pruning. There are dwarf varieties that can be grown in tubs or treated as bonsai. Its wood is used in Buddhist temples, both for construction work and to make incense.	Originally from China, but naturalized from Iran to Japan
	Cupressus sempervirens	Tree Woody plant developing a strong main stem (trunk) and reaching at least 7 m in optimal growth conditions, with smooth reddish-grey bark, irregular branches and twigs, tight, erect-applique, forming a long, narrow crown.	Native to Eastern Europe and Western Asia

	Juniperus communis	Shrub Woody plant not exceeding 7 m in height and not developing a strong main stem (no trunk) but numerous stems branching from the base: Roses, Privet, Fusain, Juniper, scattered or erect shrub 1-6 meters tall, with scaly buds and triangular branchlets.	Europe; western and northern Asia; northern Africa and America
	Juniperus phoenicea	Conical, fastigiate shrub or small tree. Scaly leaves. Fruits globose, 8 to 10 mm long, dark red. Slow-growing, monoecious species.	Southern Europe, North Africa to Saudi Arabia
Fabaceae	***Ceratonia siliqua* L.**	It has been used since Antiquity for its fruits (carobs), both for humans and livestock. Able to produce on poor soils on the bangs of crops or on hillsides that are difficult to cultivate, the carob tree has provided a vital resource for many Mediterranean peoples. This tree with its beautiful foliage provides much-appreciated shade in sunny countries. In Tunisia, it is used as a base for soft drinks called boga and El-Meddeb cider.	Eastern Mediterranean region
	***Leucaena leucocephala* (Lam.) de Wit**	It's a small, fast-growing tropical tree used for a variety of applications: vegetable, firewood, fiber and livestock fodder. This invasive species has become naturalized in all tropical regions of the world. This species tolerates all types of soil, appreciates the sun and is perfectly adapted to drought. It is also particularly efficient in nitrogen fixation, with over 500 kg / ha/ year. It is therefore useful as a green manure, but also for shading plantations and combating erosion.	Native to Mexico and Central America
Lamiaceae	***Salvia rosmarinus* Spenn.**	Fresh or dried, this condiment herb is used in Mediterranean cuisine, and a domesticated variety is grown in gardens. It is a honey-bearing plant; rosemary honey, or “miel de Narbonne, is renowned. It is also frequently used in perfumery. Last but not least, it has many phytotherapeutic virtues.	Native to the Mediterranean basin
Malvaceae	***Hibiscus rosa-sinensis* L.**	This is the best-known hibiscus, and has been used in numerous hybridizations. *Hibiscus* is a shrub that is more commonly grown	

		indoors, in pots. It's a superb flowering plant that we like to use in late spring or summer to embellish balconies, terraces and gardens by growing it indoors in pots. The plant will appreciate a little revitalizing air. Hibiscus can also be grown in rich, well-drained soil, but only in milder regions.	Native to tropical areas of Southeast Asia
Mimosaceae	***Acacia retinodes* Schltdl.**	This evergreen ornamental shrub can flower at several times of the year. Unlike most other species, it can tolerate calcareous soils, hence its frequent use as rootstock	Native to the far south of Australia
Moraceae	***Ficus carica* L.**	Highly decorative, it can also be grown in a tub and placed on a balcony. The fig we eat is actually the receptacle of the flower that botanists call a “sycone”. The real fruits, however, are the many tiny seeds, called achenes, enclosed in the flesh.	Originally from Afghanistan
	***Ficus microcarpa* L.**	It is commonly cultivated as a houseplant in temperate regions, particularly as a bonsai.	Native to Asia, Southeast Southeast and Oceania
	***Morus alba* L.**	White mulberry was widely cultivated for its leaves, the exclusive food of the silkworm. For sericulture, the white mulberry is often grown as a hedge to facilitate leaf harvesting. The white mulberry is traditionally a roadside tree, and its dense shade is pleasant in summer.	Originally from China
Myoporaceae	***Myoporum laetum* G. Forst.**	*Myoporum laetum* is a shrub found in the coastal areas of New Zealand. It has antibacterial properties and the leaves are traditionally used by Maoris to protect their skin from mosquitoes.	Originally from New Zealand
Oleaceae	***Jasminum officinale*** L.	It's a large shrubby liana, most often deciduous in our climate, forming long, sappy stems capable of climbing to the tops of small trees. It flowers in summer and autumn, abundantly if the soil remains a little cool, in the form of a multitude of small, white, star-shaped flowers, famous for their heady perfume.	Native to China, more specifically to the Himalayas
	***Ligustrum japonicum* Thunb**	The species spreads easily by sowing or cutting and can become invasive. It grows quickly, bears pruning well and is often used to create topiaries.	Originally from southern Japan

	Olea europaea **L.**	Found throughout Africa, Asia and Mediterranean Europe, one variety has been domesticated and cultivated to become the olive tree. Representatives of the *Olea europaea* species are evergreen bushes, shrubs or trees that can grow up to 15 m tall.	Native to Asia
Pittosporaceae	***Pittosporum tobira*** **Banks ex Gaertn.**	This tree is not very hardy. *Pittosporum tobira* easily reaches three to five meters in height unpruned, growing at high density. The brown, branched trunk ends in a panicle bearing leaves and flowers.	Native to the Pacific islands and warm regions of Asia
Platanaceae	***Platanus orientalis*** **L.**	The Oriental plane is a large tree, around 30 m high, with a wide, irregular crown. It is used as an ornamental tree. Its wood can be used for joinery.	Native to Southeast Europe and the Middle East
Poaceae	***Festuca ovina*** **L.**	Turfgrass is widely used in mixtures to create hardy lawns, particularly in dry conditions. It can grow on very poor soil, but is less tolerant of trampling than red fescue.	Native to temperate and cool regions of Europe and Asia
Rosaceae	***Rosa chinensis*** **Jacq.**	The Chinese Rose (*Rosa chinensis*) is a species of rose classified in the Chinenses section. This species is widely cultivated in China as an ornamental plant; many cultivars have been selected for their colorful, multi-petaled, double or full flowers.	Native to central China
Rutaceae	***Citrus lemon*** **(L.) Burm.f.**	The lemon tree was originally used as an ornamental plant in pleasure gardens in the Middle Ages, notably Islamic gardens. Lemons were gradually introduced into the food industry.	Mediterranean
Verbanaceae	***Lantana camara*** **L.**	*Lantana camara* is a thorny, rounded or spreading, bushy shrub. It reaches a height of 0.5 to 3 m. *Lantana camara* can be planted outdoors or indoors. It has invasive status and is fire-resistant, growing rapidly on burnt areas, even becoming a serious obstacle to the natural regeneration of important native species.	Native to the West Indies and Central America

Figure 2: Some ornamental species grown in public gardens in the town of M'sila

5. CONCLUSION

Ornamental plants adapted to the Algerian steppe are distinguished by their resilience to extreme climatic conditions and their ability to thrive in poor soils. As well as embellishing the landscape, they often help to protect against erosion and reclaim degraded land.

Our study is a contribution to a new line of research that has long been neglected. In this respect, it's worth noting that the creation of a botanical garden and nurseries went through the inventory stage and the determination of propagation techniques in arid and semi-arid zones. Given the economic importance of these ornamental species, it is essential that this inventory continues. The pharmacological industry and the essential oil extraction industry currently play an important role on the international market.

The study of plants that acclimatize to these zones should be given greater importance.

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CHAPTER IX

Ornamental Plant Species in Urban Green Spaces of Constantine: An Ecological Assessment

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1. INTRODUCTION

The Mediterranean basin is one of the 34 planet's "hotspots" of biodiversity, characterized by high species richness, high rate of endemism, and increasing anthropogenic threats (Myers et al., 2000; Myers, 2003). It is home to approximately 10% (25,000) of the world's known vascular plants, covering an area representing less than 2% of the Earth's land surface (Cuttelod et al., 2008). Urban green spaces are considered essential components of urban infrastructure. Their forms, locations, and sizes vary depending on the specific needs they address and the urban environment in which they are integrated. These spaces contribute to urban aesthetics, providing natural areas for breathing, relaxation, and recreation for city dwellers. Additionally, green spaces fulfill other functions: they can serve as production areas, such as forests or agricultural lands, and contribute to the preservation of natural and human resources, as well as offering opportunities for relaxation, oxygenation, or leisure (Long & Tonini, 2012; Austin, 2014).

Green spaces are highly valued for their contribution to the quality of life in urban environments. Efforts to improve urban centers in developed countries have almost always been accompanied by a focus on the use of outdoor spaces, particularly green spaces. Furthermore, initiatives addressing issues such as education, housing, unemployment, and crime have often been considered in parallel with urban green spaces (Heckscher, 1977; Quintas & Curado, 2009). These spaces can be vegetative or aquatic. They form a network of public and private, non-buildable areas that serve multiple functions: agricultural or forestry production, conservation of natural heritage, education, outdoor recreation, and structuring the urban fabric from city centers to the peripheries. They are public infrastructures that offer urban residents uses connected to the presence of natural elements (vegetation, animals, water, etc.) (Donadieu, 2012).

Green spaces provide a setting where ornamental plants can thrive. When carefully planned and maintained, these spaces maximize the aesthetic and ecological potential of ornamental plants, ensuring their harmonious integration into the urban environment. Ornamental plants contribute to the natural living beauty of these spaces, enhancing the quality of human life and representing a significant economic sector within the ornamental industry.

Worldwide, plants grow in various sizes, shapes, and appearances. Some provide us with food, shelter, or building materials, while others offer purely visual delights. Commonly known as garden plants, these plants are primarily valued for their beauty, whether for screening, accenting, specimen display, color, or aesthetic purposes. Typical ornamental features include foliage, fragrance, fruits, stems, and bark (Grimaldi & Rafaelli, 2003; Kendal et al., 2012).

In Algeria, ornamental plants are cultivated for various benefits, including reducing temperature, cooling the air, serving as windbreaks, decreasing pollution, and improving the environment (Fekhar, 2012). These plants can belong to different categories depending on the desired effect and the location where they are grown. They may include herbaceous plants—annuals, biennials, or perennials—woody plants such as trees, shrubs, and subshrubs, as well as climbing plants or those with trailing foliage. Some plants only become ornamental when dried or through specific actions by the gardener. For instance, certain shrubs are cultivated for bonsai art and will lose their decorative properties if not regularly pruned. The same applies to grasses, which need to be regularly mowed (Alioune, 2018).

The city of Constantine is renowned for its beautiful green spaces, which add a touch of nature and freshness to the urban environment. These green spaces provide residents and visitors with a peaceful retreat while enhancing the city's beauty and appeal. Notable green spaces such as Bennacer, Belair, and Bardou are celebrated for their diversity of cultivated ornamental plants and natural beauty. They are frequently visited by locals seeking tranquility and serenity or simply to enjoy the fresh air and calming ambiance.

The main objective of this study is to compile an inventory of the ornamental and wild plants that find refuge in the main green spaces of Constantine. This will be followed by the identification, taxonomic analysis, and determination of the structure and composition of all the plant species using resources such as Quézel & Santa's flora (1962-1963), the synonymic index of North African flora, various guides, and online platforms that focus on ornamental plants.

2. MATERIALS AND METHOD

2.1. Study Area

Constantine, the capital of eastern Algeria, is located approximately 431 kilometers from Algiers. It is one of the country's important cities, covering an area of about 2,297.20 km². Located midway between the northern coast and the Aurès Mountains to the south, it serves as a connecting point between southern cities and those along the coast. Its geographical coordinates are 36° 17' latitude and 6° 37' longitude, with an elevation ranging from 350 m to 1,100 m (Figure 1).

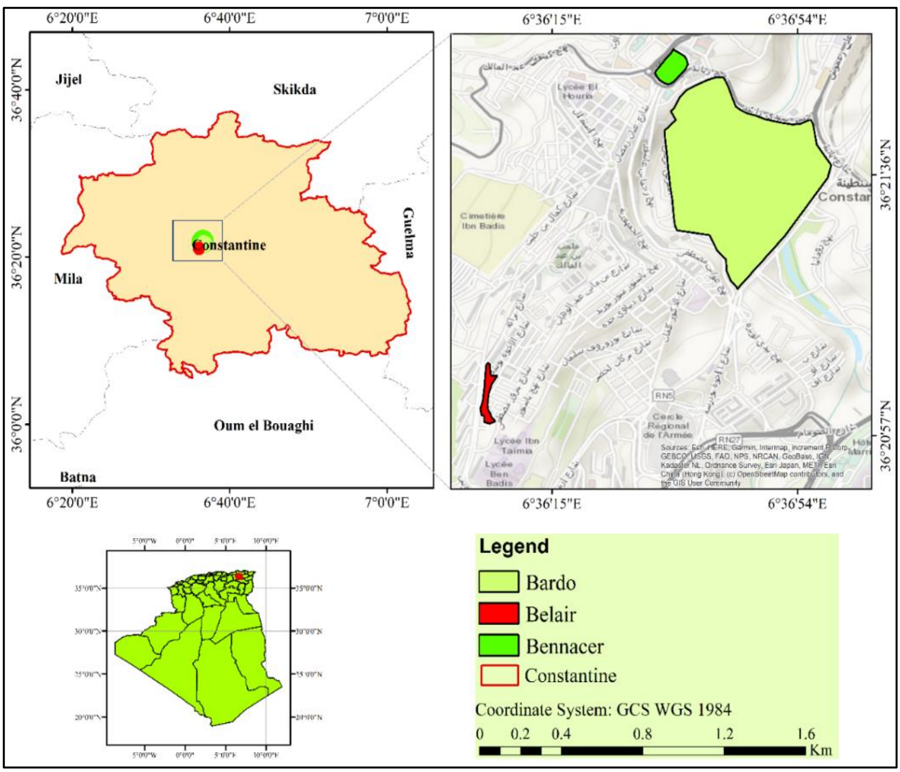

Figure 1: Location of the study area

The city has a population of approximately 836,977, with a population density of 400 inhabitants per km² and an annual growth rate of -0.68% (Benoumeldjadj et al., 2023). The region experiences a continental climate, transitioning to a Mediterranean climate in the north, characterized by irregular rainfall and a prolonged summer drought. Consequently, the city's climate is classified as cool semi-arid, with two distinct seasons (Gherraz, 2021; Kehal et al., 2022).

2.2. Methodology

The methodology adopted for this study involved selecting three main green spaces in the city of Constantine, namely Bennacer, Belair, and Bardou, based on the number of daily visitors. Field visits were conducted in these three spaces to record the diversity of plant species.

During these visits, all types of plant species were located, identified, photographed, and their frequencies were recorded. The data collected were meticulously recorded on field sheets, ensuring a complete and detailed inventory of the plant diversity in each green space.

For the identification and classification, we relied on the website (URL-1) for the nomenclature of plant species in the Maghreb. For non-Maghreb species, we used the platform (URL-2). Additionally, to verify whether trees and shrubs belong to North Africa, we utilized the platform (URL-3).

2.2.1. Diversity indices

2.2.1.1. Alpha diversity

Richness: Richness expresses the local diversity of a station or survey site. It is determined by the number of species recorded at a survey site, representing the most commonly used index of diversity in measuring the biodiversity of a station.

Shannon Diversity Index (Shannon, 1948):

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

Where:

H': The Shannon index value

i: A species in the study area

pi: The proportion of species I (relative frequency) compared to the total number of species (S) in the study area, which is calculated as follows:

$$p(i) = \mathbf{n}i/N$$

Here, (n*i*) is the number of individuals of species (i) and (N) is the total number of individuals (all species combined).

Simpson's Diversity Index:

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

Where:

D: Simpson's index

i: A species in the study area

pi: The proportion of species (i) compared to the total number of species (S) in the study area, calculated as:

$$p(i) = ni/N$$

Here, (n*i*) is the number of individuals of species (i) and (N) is the total number of individuals (all species combined).

Pielou's Evenness Index (Pielou, 1966):

$$E = \frac{H}{H_{max}} \text{ ou } E = \frac{H}{lnS}$$

Where:

E: Pielou's evenness index

S: The number of species (or richness) in each survey.

2.2.1.2. Beta diversity

Beta diversity expresses the percentage of similarity between two or more sites. A high beta diversity index indicates low similarity between sites, meaning the sites have different species compositions. In this study, Sørensen's index was used to measure beta diversity between the different gardens of Constantine, according to the following equation:

$$B_{SOR} = \frac{b+c}{2a+b+c}$$

Where:

a: Represents the number of species common to both sites.

b: Represents the number of species present in the first site but not in the second.

c: Represents the number of species present in the second site but not in the first.

3. RESULTS AND DISCUSSION

Urban green spaces, particularly parks and public gardens, serve as valuable resources for relaxation and leisure. Ideally, they contribute to emotional healing (therapeutic) and physical relaxation. Overall, vegetation is an important, if not essential, component of the urban environment. Urban green spaces are our allies in promoting the health and well-being of city dwellers, making a vital contribution not only to the quality of life but also to the attractiveness of our cities (Gherraz, 2021).

The study of major green spaces in the province of Constantine has revealed a remarkable environmental and aesthetic awareness among the city's residents. There is a deep interest in green spaces and an appreciation of their importance in urban life. The citizens of Constantine have demonstrated a strong connection with nature, reflected in their active engagement with the environmental department in the creation and maintenance of these green spaces. Planting trees and ornamental plants is not just an aesthetic activity but also reflects an understanding of the ecological benefits it brings. The citizens of Constantine recognize the importance of trees and ornamental plants in enhancing the quality of life, promoting health, softening the atmosphere, adding beauty, and contributing to the creation of more sustainable and livable cities by preserving urban biodiversity.

3.1. Botanical Diversity

For the three gardens combined, we recorded 40 species belonging to 25 botanical families. The Oleaceae family is represented by six species, followed by the Rosaceae family with four species, the Asteraceae family with three species, and the remaining families are represented by either two or one species each (Figure 2; Table 1).

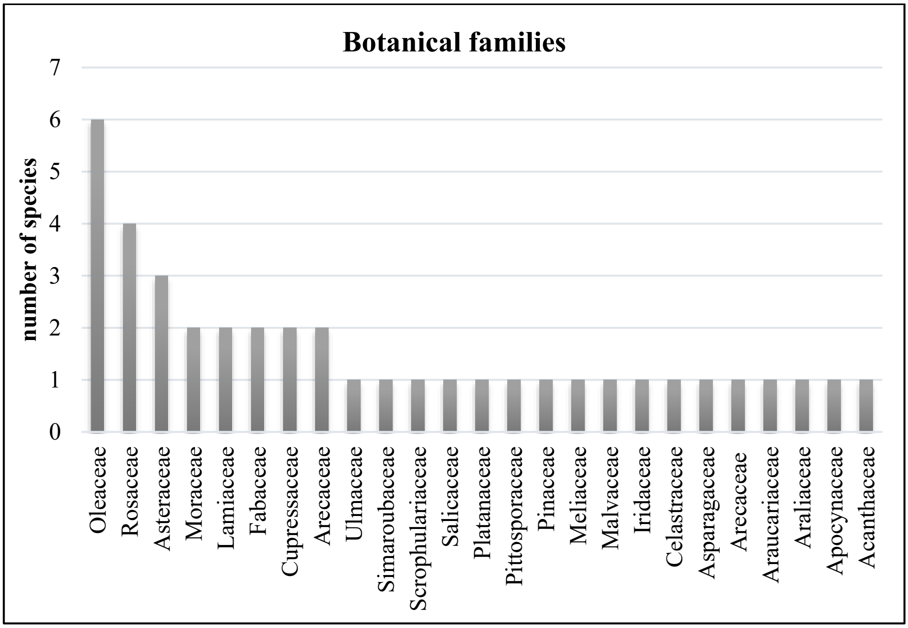

Figure 2: Botanical families recorded in the three gardens

The uneven distribution of species among families may also reflect specific management practices of the gardens, where certain species are favored for aesthetic, ecological, or practical reasons. For example, the Oleaceae and Rosaceae families, known for their beauty and utility (such as olives and roses), are often selected for landscaping (Huang et al., 2019; Lahaye et al., 2021). The choice of plantings in the garden, environmental conditions, or management strategies influence the floristic composition. The data suggest that some gardens may favor specific families or introduced species, which could have implications for local biodiversity.

3.2. Alpha Diversity

Species richness

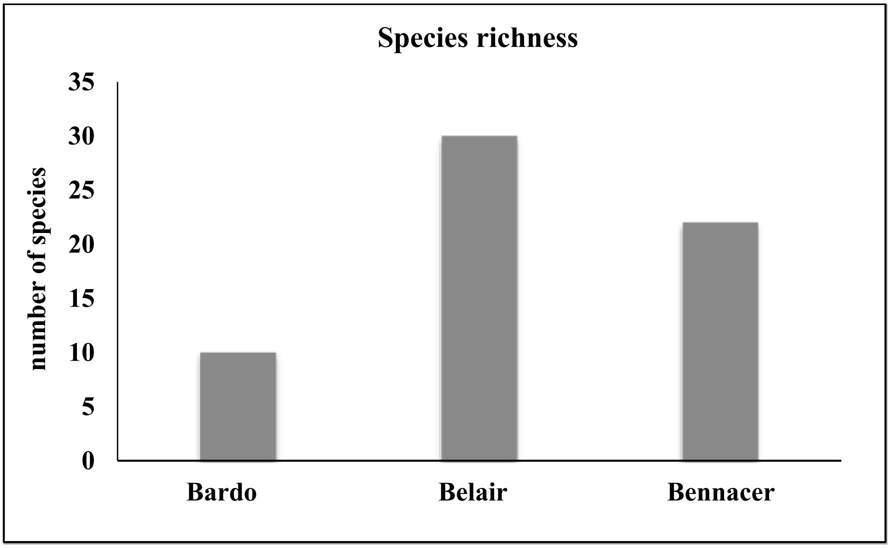

Figure 3: Species richness index for the three gardens

The results regarding species richness in the three studied gardens show significant differences. Belair garden records the highest number of species, with 30 species documented (Figure 3). This high richness in Belair garden suggests active and diverse management, as well as the introduction of various species to maximize floral and landscape diversity. In contrast, Bardo garden exhibits the lowest species richness, with only 10 species (Figure 3). This may be attributed to its location and large size, making its management more complex, which has led to a focus on a limited number of ornamental species. This low diversity could also be a result of standardization in management practices, thereby limiting the variety of plants introduced or maintained in this garden (Smith et al., 2006).

Shannon Diversity Index

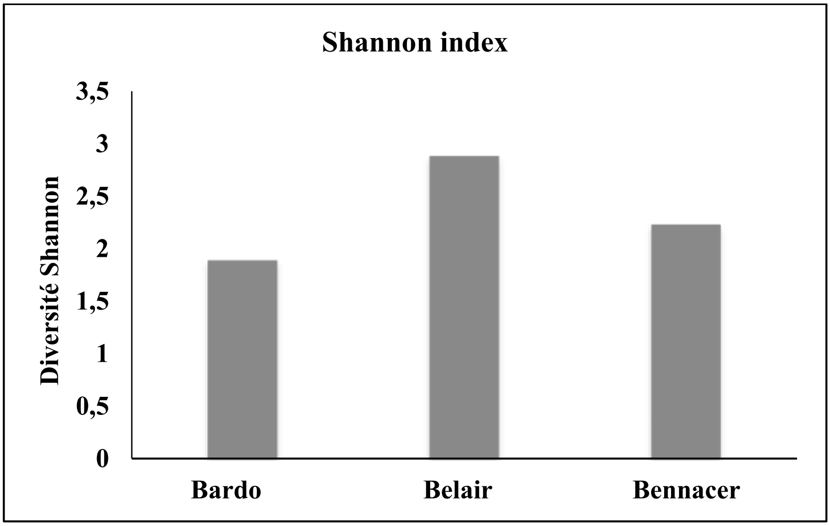

Figure 4: Shannon Index for the three gardens

The Shannon diversity index values measure the species diversity of a community. A higher index indicates greater diversity. In our study, the Belair Garden shows the highest diversity of ornamental plants cultivated, with an index of 2,88, followed by Bennacer with 2,23, and finally Bardo with 1,89 (Figure 4). Anthropogenic disturbances critically affect biodiversity and the structural characteristics of the community (Neji et al., 2018). Studies on the impacts of anthropogenic activities on floristic composition and vegetation have been conducted in Egypt (Hussein et al., 2021), Tunisia (Neji et al., 2018), Morocco (Challi et al., 2023), and Algeria (Mekideche et al., 2018; Djebbouri et al., 2022). Preservation and maintenance of high-value artificial or semi-natural green spaces have been undertaken.

Gardens with high botanical diversity are generally more resilient to environmental disturbances, such as droughts or insect infestations (Tilman et al., 2001). Greater botanical diversity also contributes to more robust ecosystem services, such as climate regulation, air purification, and improved human well-being (Diaz et al., 2006). These aspects can be discussed in relation to the management of urban gardens in similar Mediterranean contexts.

Simpson Diversity Index

The Simpson diversity index, calculated for the three gardens, shows values of 0,81 for Bardo, 0,91 for Belair, and 0,83 for Bennacer (Figure 5). This index measures the probability that two randomly chosen individuals from a sample belong to the same species. The closer the index is to 1, the higher the diversity. The highest Simpson index value for Belair garden indicates a more balanced distribution of species and greater diversity, suggesting effective management that supports the coexistence of a large number of abundant species. Gardens with higher diversity, such as Belair, are often more resilient to ecological disturbances, as a greater variety of species allows for better response to environmental stress. Tilman et al. (2006) demonstrated that ecological diversity promotes ecosystem stability and resilience. Urban green space management should consider species diversity to maximize ecosystem services, such as climate regulation, biodiversity, and air quality. Belair garden, with its high Simpson index, could serve as a model for the sustainable management of urban gardens.

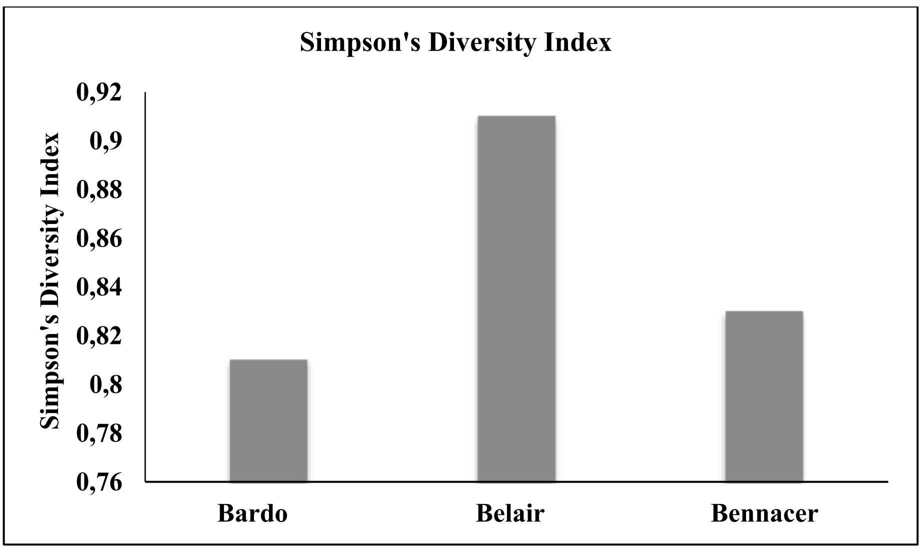

Figure 5: Simpson's Diversity Index for the three gardens

Equitability Index

The equitability index measures how individuals are distributed among different species. An index closes to 1 indicates that all species have similar abundance, while an index close to 0 indicates that one or more species dominate the ecosystem. Belair garden showed a significant increase in the equitability index (0,84), suggesting a more uniform distribution of species compared to the Bardo and Bennacer gardens, where the index is lower (0,72 for Bennacer) (Figure 6). This uniformity can be an indicator of the ecological health of the garden, as a balanced ecosystem tends to be more resilient to disturbances.

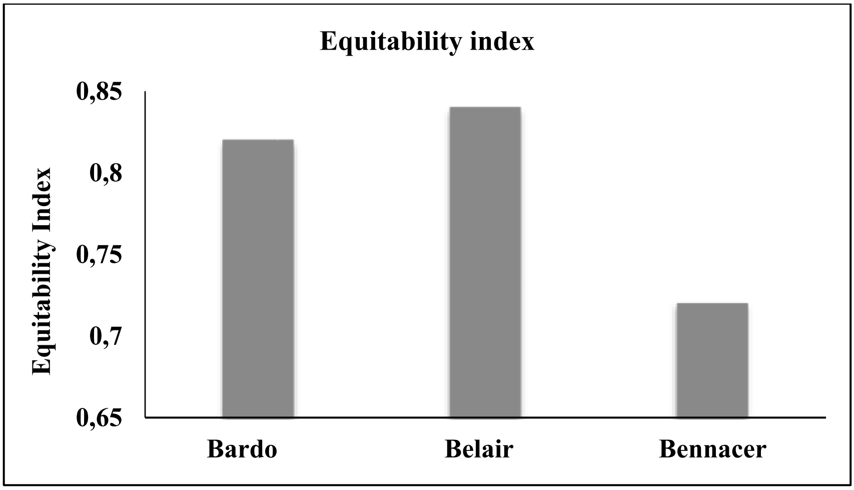

Figure 6: Equitability index for the three gardens

3.3. Number of Common Species and Beta Diversity

The Venn diagram shows that the three studied gardens share only three common species, indicating low floristic similarity between these gardens. The differences in floristic composition are even more pronounced between the Bennacer and Bardo gardens, which share only four common species (Figure 7).

The beta diversity index of 0,62 indicates moderate heterogeneity between the gardens. An index closes to 1 would signify high dissimilarity, while an index closes to 0 would indicate high similarity. In this case, the value of 0,62 suggests that the gardens have a relatively distinct species composition from one another.

The low similarity between the gardens may be explained by human management practices that influence the distribution of plant species. The moderate beta diversity indicates that each garden uniquely contributes to the city's overall diversity, highlighting the importance of conserving these different green spaces to maintain local biodiversity. Urban green spaces have been under intense pressure in recent years due to increasing population growth (Twumasi et al., 2020). While rapid urban growth has significant social and economic consequences, including congestion and environmental degradation of these spaces, research published by various authors on the environmental impacts of urban expansion shows pressure on undeveloped green spaces (Güneralp & Seto, 2008; Li et al., 2013).

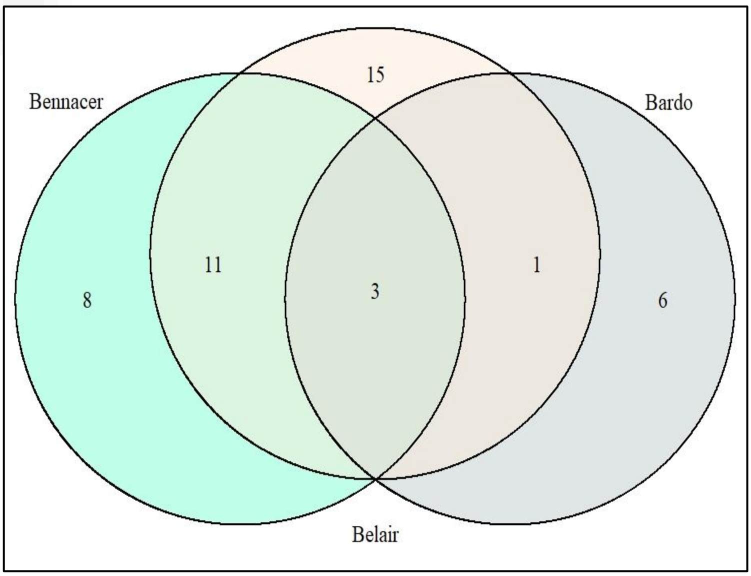

Figure 7: Venn Diagram for the three gardens

3.4. Floristic Composition of Ornamental Plants and Species Origin

Table 1 presents a list of plant species found in three gardens in the commune of Constantine, Algeria. Among the 44 recorded species, 19 are native to the region, representing about 43% of the documented flora, and 25 are introduced species, accounting for approximately 57% of the total flora. This indicates a prevalence of introduced species in these gardens, likely due to landscape management practices that favor the introduction of exotic species for aesthetic or horticultural reasons.

The plants are predominantly woody (80% of the recorded species), with a dominance of phanerophytes, indicating good adaptation to local conditions. While the significant presence of exotic species enhances diversity, it also raises ecological concerns, particularly regarding invasiveness and the impact on local ecosystems. Therefore, garden management must balance aesthetic enrichment with the preservation of local biodiversity.

The geo-ecological distribution of species in the gardens of Constantine reveals a notable diversity in their origins. A significant proportion originates from the Mediterranean region and Central and Southern Europe. Indeed, several species present in these gardens are introduced, such as *Argyranthemum haouarytheum* or *Ficus retusa*. The literature shows that the introduction of non-native species can increase species diversity, as noted by Jones et al. (2018). However, this can also pose risks to native species and local ecosystems (Castri et al., 2019).

Urban gardens with rigorous maintenance tend to exhibit greater species diversity. A study conducted by Miller et al. (2017) on public gardens showed that maintenance practices, such as regular irrigation, fertilization, and pest control, increase the diversity of both introduced and native plants. This observation could explain why Belair shows greater diversity compared to Bardo.

Table1. List of species in the green space in the Municipality of Constantine

Nom scientifique	Origine	Morphology types	Biological types	Native range	Families
Agave sisalana Perrine	Introduced	Woody perennial	Hémicryptophyte	Mexico (Yucatan Peninsula).	Asparagaceae
Ailanthus altissima (Mill.) Swingle	Introduced	Woody perennial	Phanérophyte	Origine : Chine	Simaroubaceae
Araucaria heterophylla (Salisb.) Franco	Introduced	Woody perennial	Phanérophyte	Norfolk Island (incl. Philip Island).	Araucariaceae
Argyranthemum haouarytheum Humphries & Bramwell	Introduced	Herbaceous perennial	Hémicryptophyte	Canary Islands (La Palma)	Asteraceae
Argyranthemum maderense (D. Don) Humphries	Introduced	Herbaceous perennial	Hémicryptophyte	Origine : Canary Islands (Lanzarote)	Asteraceae
Artemisia thuscula Cav.	Introduced	Woody perennial	Phanérophyte	Canary Islands	Asteraceae
Cercis siliquastrum L.	Introduced	Woody perennial	Phanérophyte	France to Afghanistan	Fabaceae

Crataegus azarolus L.	Native	Woody perennial	Phanérophyte	N. Africa, E. Medit. to Iraq.	Rosaceae
Cupressus sempervirens L.	Introduced	Woody perennial	Phanérophyte	E. Medit. to Iran.	Cupressaceae
Euonymus japonicus Thunb	Introduced	Woody perennial	Phanérophyte	Korea, Japan to Nansei-shoto	Celastraceae
Ficus carica L.	Introduced	Woody perennial	Phanérophyte	E. Medit. to Central Asia and Afghanistan	Moraceae
Ficus macrophylla Pers.	Introduced	Woody perennial	Phanérophyte	E. Australia, Lord Howe Island.	Moraceae
Ficus retusa L.	Introduced	Woody perennial	Phanérophyte	S. Borneo to Jawa.	Oleaceae
Fraxinus angustifolia Vahl	Native	Woody perennial	Phanérophyte	Central & S. Europe and Pakistan, NW. Africa.	Oleaceae
Fraxinus ornus	Native	Woody perennial	Phanérophyte	E. Medit. to Central Asia	Oleaceae
Hedera canariensis Willd.	Introduced	Woody perennial	Phanérophyte	Canary Islands.	Araliaceae
Iris albicans Lange	Introduced	Herbaceous perennial	Geophyte	Arabian Peninsula	Iridaceae
Justicia adhatoda L.	Introduced	Woody perennial	Phanérophyte	Afghanistan to Indo-China	Acanthaceae
Lavandula dentata L.	Native	Woody perennial	Chaméphyte	W. Medit., NE. Tropical Africa, Jordan, Arabian Peninsula	Lamiaceae
Ligustrum japonicum Thunb	Introduced	Woody perennial	Phanérophyte	SE. China to Temp. E. Asia	Oleaceae
Ligustrum japonicum Thunb.	Introduced	Woody perennial	Phanérophyte	SE China, Japan, Korea, Taiwan, and the Ryukyu Islands (Temperate East Asia)	Oleaceae
Livistona australis (R.Br.) Mart.	Introduced	Woody perennial	Phanérophyte	E. & SE. Australia	Arecaceae
Malvaviscus penduliflorus Moc. & Sessé ex DC.	Introduced	Woody perennial	Phanérophyte	Texas to Venezuela and Peru.	Malvaceae
Medicago arborea L.	Introduced	Woody perennial	Phanérophyte	S. Europe to Türkiye.	Fabaceae
Melia azedarach L.	Introduced	Woody perennial	Phanérophyte	Tropical and Subtropical Asia to Northern and Eastern Australia	Meliaceae
Myoporum laetum G. Forst.	Introduced	Woody perennial	Phanérophyte	New Zealand	Scrophulariaceae
Nerium oleander L.	Native	Woody perennial	Phanérophyte	Medit. to Myanmar.	Apocynaceae
Olea europea L.	Native	Woody perennial	Phanérophyte	Africa, Medit. to S. Central China.	Oleaceae
Phoenix canariensis H. Wildpret	Introduced	Woody perennial	Phanérophyte	Canary Islands.	Arecaceae

Pinus halepensis Mill.	Native	Woody perennial	Phanérophyte	Mediterranean Basin	Pinaceae
Pittosporum tobira (Thunb.) W.T.Aiton	Introduced	Woody perennial	Phanérophyte	Southern Korea, Southern and Central Japan, and the Nansei Islands	Pittosporaceae
Platanus orientalis L.	Introduced	Woody perennial	Phanérophyte	Eastern Mediterranean to Iran	Platanaceae
Platycladus orientalis (L.) Franco	Introduced	Woody perennial	Phanérophyte	Russian Far East to E. Central China and Korea	Cupressaceae
Populus nigra L.	Native	Woody perennial	Phanérophyte	Central and Southern Europe to Xinjiang and Western Himalaya.	Salicaceae
Prunus avium (L.) L.	Native	Woody perennial	Phanérophyte	Europe to Afghanistan, N. Africa.	Rosaceae
Prunus cerasifera Ehrh.	Introduced	Woody perennial	Phanérophyte	SE. Europe to Central Asia and Himalaya.	Rosaceae
Rosa canina L.	Introduced	Woody perennial	Phanérophyte	Macaronesia, NW. Africa, Europe to Central Asia and Pakistan.	Rosaceae
Salvia fruticosa Mill.	Introduced	Woody perennial	Phanérophyte	Central & E. Medit.	Lamiaceae
Ulmus minor Mill.	Native	Woody perennial	Phanérophyte	Europe to Central Asia and N. & NW. Iran, NW. Africa.	Ulmaceae
Washingtonia robusta H.Wendl.	Introduced	Woody perennial	Phanérophyte	Mexico (S. Central & S. Baja California).	Arecaceae

4. CONCLUSION

Green spaces in Constantine play a crucial role in urban aesthetics and quality of life. They provide fresh air, acting as the city's lungs, and offer places for relaxation, leisure, and sports activities for all ages.

The inventory of ornamental species in the main green spaces of Constantine revealed very interesting results. Although not exhaustive, this inventory identified 25 families comprising around forty species, primarily valued for their decorative and ornamental qualities, playing a crucial role in microclimate regulation, pollution reduction, and the promotion of citizens' well-being. The majority of the ornamental plants in the studied green spaces are woody, representing 80% of the recorded species, with a predominance of phanerophytes, indicating their good adaptation to local conditions. The analysis highlighted a preference for certain botanical families, such as Oleaceae and Rosaceae, favored for their aesthetic qualities and adaptability to local conditions. However, the dominance of introduced species raises concerns about the potential impact on local biodiversity, underscoring the need for careful management and ongoing monitoring to prevent the invasion of exotic species.

Urban landscaping, including the creation of green spaces and the planting of ornamental plants in Algeria, is becoming a priority for our local communities.

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CHAPTER X

State of Green Spaces in The City of Tiaret

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1. INTRODUCTION

A green space is a natural or landscaped area, predominantly planted, accessible to the public for recreational, aesthetic or ecological purposes. Parks, gardens, urban forests and agricultural areas in urban areas are examples of green spaces.

These spaces suffer from several problems such as rapid urbanization: Population growth and expansion of built-up areas encroaching on green spaces, lack of planning: Many cities lack a clear strategy for preserving or creating green spaces and for degradation and pollution: Existing green spaces often suffer from neglect, vandalism and pollution.

The presence of natural species in cities can be disrupted by contact with a dense population, industrial, social and commercial activities in urban areas (Kinzing & Grove, 2001), climate change (including increased frequency and intensity of extreme events) (Boucher & Fontaine, 2010), the spread of invasive or disease-carrying species (Siron, 2010) and pollution (Alberti, 2005).

Urban natural species are subject to harsh conditions, including human conflict, decreased vital air, weathered, compacted and potentially contaminated soils (Mckinney 2002), and the disappearance of native species (Boucher & Fontaine, 2010).

Thus, several difficulties related to the precarious nature of the natural elements in the city and the human presence can limit the success of projects for restoration of original ecosystems.

1.1. Location of the City of Tiaret

The wilaya of Tiaret is located in the west of the country, it extends over an area of 20,086.64 km^2, it is a region located in the highlands of Algeria, to the west between the Tell Mountains in the north and the Atlas Mountains in the south.

The Wilaya of Tiaret is characterized by a varied relief and an altitude between 800 and 1200 m. It is a region with a Sylvo-Agro-Pastoral vocation, it is bounded by several wilayas (Figure 1) namely:

North: Tissemsilt and Relizane

South: Laghouat

West: Mascara and Saida

East: Djelfa and Medea

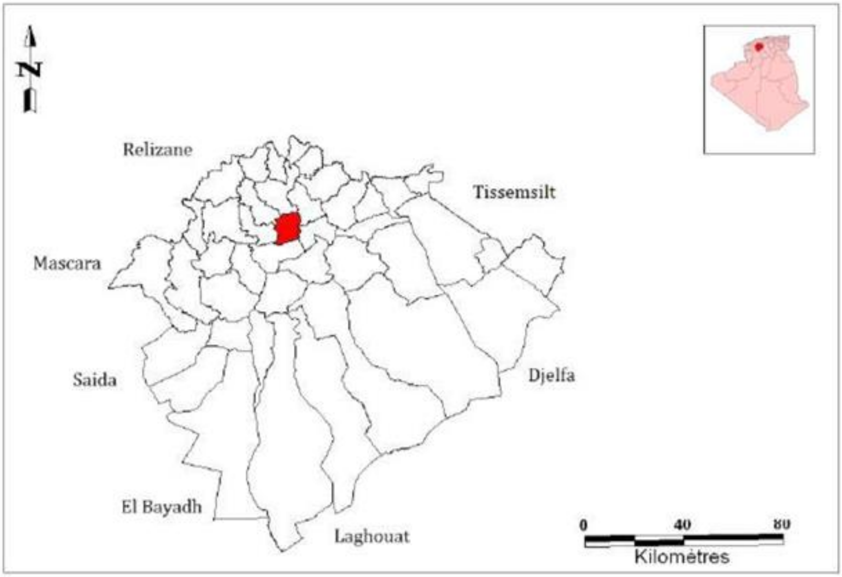

Figure 1: Location of Tiaret wilaya (Nouar, 2016)

According to this position, it can be said that the region of Tiaret appears as an important centre of liaison between several regions, and point of contact between the South and the North.

Its size gives it a heterogeneous character:

A mountainous area in the north;

High plains in the centre;

Semi-arid areas in the south.

2. CLIMATE OF THE STUDY AREA

2.1. Precipitation

The Tiaret region lies between the 153 mm isohyetes to the south and 534 mm to the north. It is characterized mainly by a continental climate with cold winter wet and hot summer dry.

The average rainfall over a period of 31 years (1985 to 2016) is 335,18 mm.

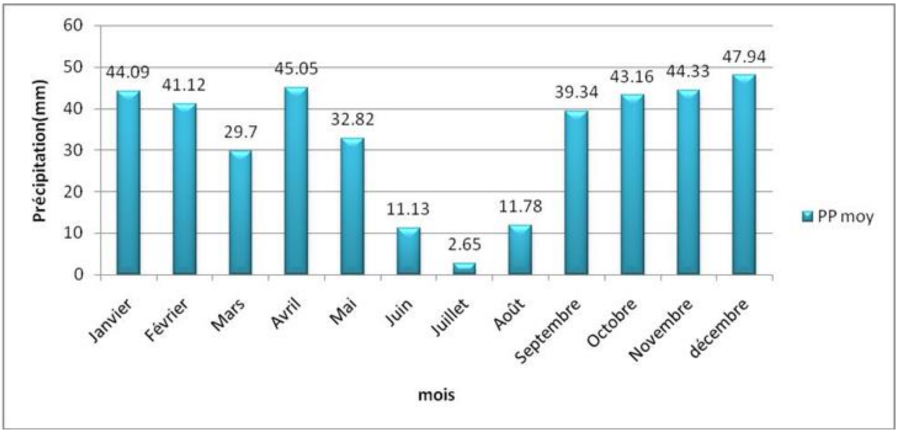

Figure 2: Monthly precipitation histogram (1985 to 2016)
(Source: AIN Bouchekif Weather Station)

The values of rainfall during these years (Fig. 2) varied between a minimum of 153,4 mm recorded in 1985 and a maximum of 542,54 mm in 2009. The most wet years were 1997, 2003, 2004, 2006, 2007, 2009 and 2010 when rainfall exceeded 400 mm. The driest year is 1985 where rainfall does not exceed 160 mm.

2.2. Temperature

The importance of temperature is that it is considered as one of the fundamental elements of climate, directly affecting biological and chemical processes in the biosphere and human activity in general.

This is one of the most important elements in characterizing the type of climate and determining its humidity regime.

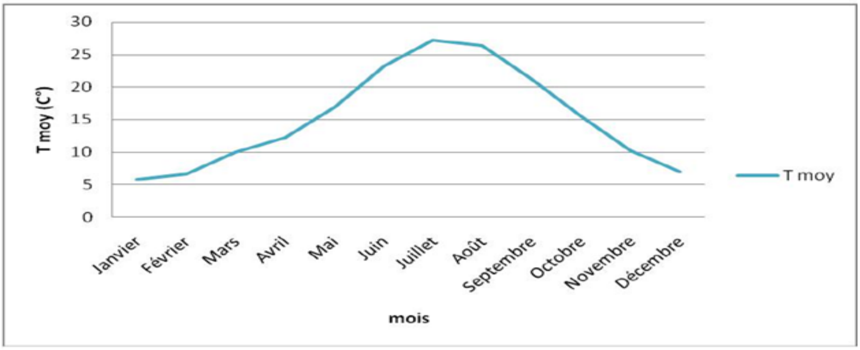

Figure 3: Average temperatures of the Tiaret wilaya, (1985 to 2016) (Source: AIN Bouchekif Weather Station)

Based on Figure 3, we see that average temperatures are reaching low values in December, February and especially in January, and it reaches the highest values in June July and August.

So:

- The coldest months are (December, January and February) it is winter season.
- The hottest months are (June, July, August and September) it is summer and early autumn.

Which leads to: that the seasons are distinct which reveals a hot summer and a cold winter.

2.3. Climate Synthesis

2.3.1. GAUSSEN Ombrothermic Diagram

According to Ozenda (1982), it is a diagram that gives an idea of the dry and wet periods in a given region. A month is dry when its total mm rainfall is equal to or less than twice its average temperature in °C.

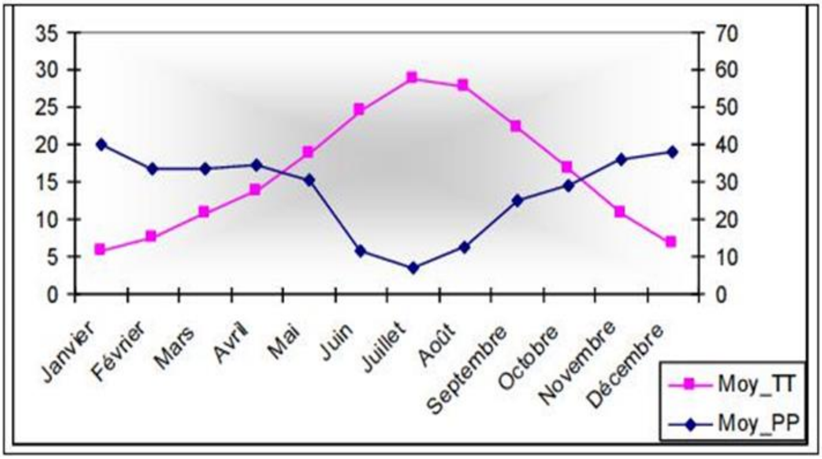

Figure 4: Ombrotherm diagram of Banghouls and Gaussen

According to the ombrotherm diagram (Fig. 4), the dry period is spread over 5 and a half months, which goes from June until the beginning of September and the wet period from October to May.

2.3.2. Emberger rainfall coefficient (Q2)

The Emberger rainfall coefficient classifies different types of Mediterranean climates (Dajoz, 2006).

Based on the criteria for mean annual precipitation (P in mm), mean minima of coldest month of year (m) and mean maxima of warmest month(M), this index is described by the following formula (Quezel & Médail, 2003):

$Q2 = 2000P/M^2 - m^2$.

Where:

P: Average annual rainfall in mm

M: Average of the maxima of the hottest month in °K

m: Average of minima of coldest month in °K

The Q2 of the Tiaret region (Fig. 5) for the period (1985-2016) is equivalent to 34.37.

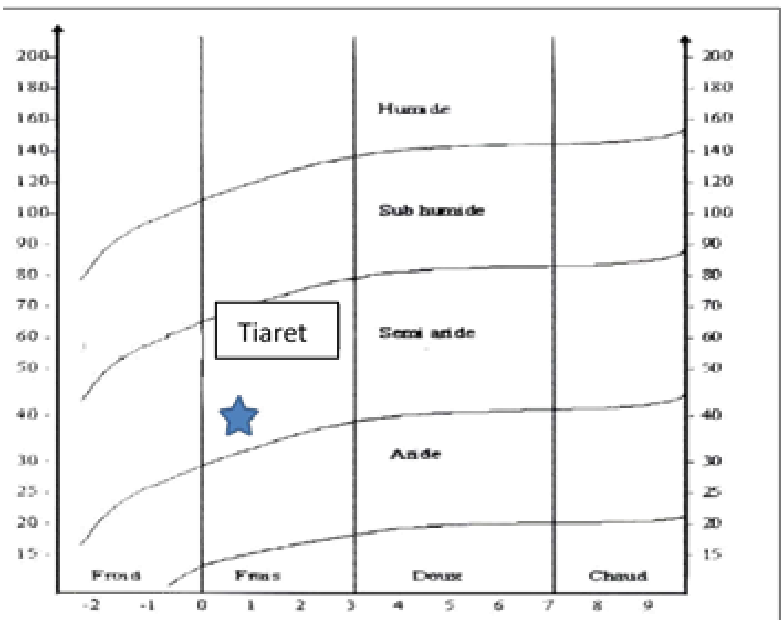

Figure 5: Bioclimatic situation of the Tiaret wilaya

2.4. Accidental Phenomena

-Frosts:

Frosts occur during the period of low temperatures, usually between November and April with a different number of days from one season to another.

-Snow:

The average number of days of snowfall for the period of September 1999 and August 2009 is 4.4 days/year in the period between November and April.

-Wind:

The winds throughout the Tiaret wilaya are strong, especially from the northwest during the winter season. In summer, it is the Siroco coming from the South-West and causes a sudden increase in temperature.

3. THE SPECIES OF THE CITY OF TIARET

According to the Environmental Directorate (2019), Tiaret has 36 green spaces with an area of 112895.5 m^2

It has 12 rows of woodland with a total length of 19,896 m.

3.1. Floristic Analysis

The inventory we have made has allowed us to identify 50 urban plant species.

These plants belong to:

Dominant botanical families

Biological types

Table 1: Urban specific diversity in the city of Tiaret

Family	Species	Biological type
Arecaceae	*Washingtonia robusta*	Tree
	Washingtonia filifera	Tree
	Phoenix dactylifera	Tree (palm)
Apocynaceae	*Nerium oleander*	Shrub
Cupressaceae	*Juniperus oxycedrus*	Shrub/tree

	Juniperus polycarpos	
Casuarinaceae	*Casuarina equisetifolia*	Tree
Salicaceae	*Salix alba*	Tree
Myrtaceae	*Eucalyptus globulus*	Tree
Oleaceae	*Olea europaea*	Tree
Moraceae	*Morus alba*	Tree
	Morus nigra	Tree
	Ficus carica	Tree
Fabaceae	*Retama raetam*	Shrub
	Acacia dealbata	Tree
	Ceratonia siliqua	Tree
	Robinia pseudoacacia	Tree
Ulmaceae	*Ulmus minor*	Tree
Rosaceae	*Rosa* spp.	Shrub
	Prunus armeniaca	Tree
	Rubus fruticosus	Climbing plant
Asteraceae	*Chrysanthemum cinerariifolium*	Herbaceous
	Artemisia herba-alba	Underbrush/herbaceous
Musaceae	*Musa paradisiaca*	Herbaceous
Solanaceae	*Capsicum annuum*	Annual herbaceous
Meliaceae	*Melia azedarach*	Tree
Pinaceae	*Cedrus atlantica*	Tree
	Pinus halepensis	Tree
	Pinus pinea	Tree
Vitaceae	*Vitis vinifera*	Climbing plant
Lauraceae	*Laurus nobilis*	Shrub/tree
Apiaceae	*Eryngium campestre*	Herbaceous
Cactaceae	*Opuntia* spp.	Succulent
Tamaricaceae	*Tamarix* spp.	Shrub/tree
Cistaceae	*Cistus* spp.	Shrub
Lythraceae	*Punica granatum*	Tree
Rutaceae	*Citrus limon*	Tree
Poaceae	*Arundo donax*	Herbaceous

Table 1 shows that the urban biodiversity in the Tiaret region includes 38 species under 25 families.

3.2. Biological Type of Biodiversity in the Area Studied

During the observations we listed five biological types, the following figure n° 6 shows the variations of type populations encountered at this site.

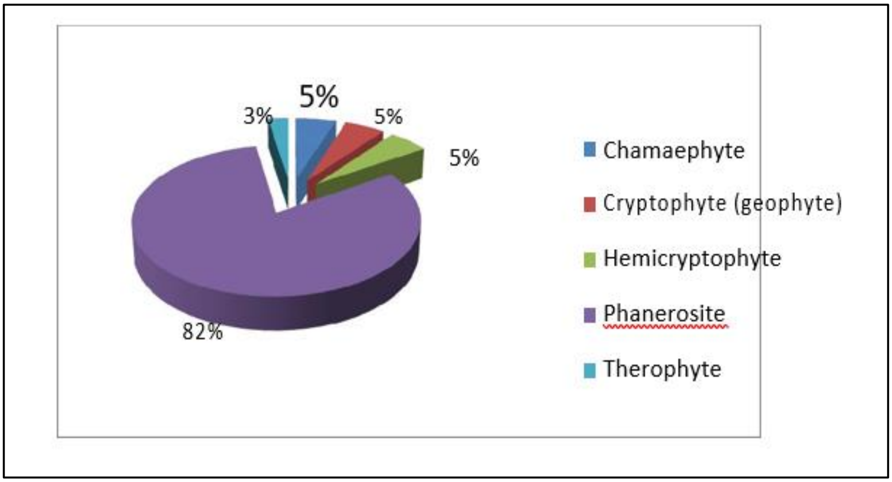

Figure 6: Tiaret city biological type

Phanerophytes are the most represented with a percentage of 82% with 31 species inventories, followed by Chamaephytes, Cryptophytes and Hemicryptophyte with a percentage of 5%, the Therophytes are poorly represented with a percentage of 3% with 1 species inventories.

3.3. State of Green Spaces in the City of Tiaret

The analysis of Figure 7 indicates that the condition of the green spaces in the city of Tiaret are 50% good, 35% their condition is average and 13% are degraded. 2% are highly degraded.

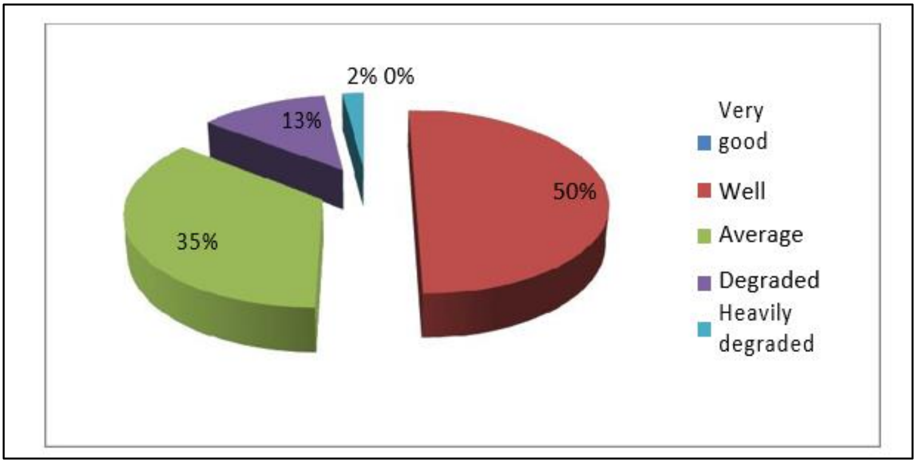

Figure 7: State of the green spaces in the city of Tiaret

These findings are due to the limited participation of affected and interested stakeholders due to internal personal factors and external factors related to social factors, i.e. the impact of society and authorities, and physical factors, the design and layout of spaces, affecting the participation of users and associations.

These findings are intended to assist urban decision-makers in developing appropriate local strategies, rethinking the management and governance policy adopted and ensuring the proper design and development of public urban green spaces.

4. CONCLUSION

Following this work, some recommendations could be made for planners interested in greening urban areas.

To succeed in a project to restore biodiversity in cities, it is essential to consult citizens and take into account their preferences. it is also important to work with multidisciplinary teams for complementary collaboration, for a good planting, it is necessary to carry out a preliminary analysis of the soil, to enrich well-the right plant to use, preferably indigenous complaints.

Finally, the initial implementation of a pilot project to predict the success of field work is strongly recommended.

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PART IV

Ecology, Environment, and Bioremediation

CHAPTER XI

Evaluation of the Antibacterial Activity of Noble Laurel Essential Oils

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1. INTRODUCTION

For thousands of years, mankind has used various plants found in its environment; in order to treat and cure all kinds of diseases, they represent a huge reservoir of potential compounds attributed to secondary metabolites that have the advantage of being of a great diversity of chemical structures and they possess a very wide range of biological activity (Lahsissene & Kahouadji, 2010).

According to the World Health Organization (WHO), nearly 80% of populations depend on traditional medicine for primary health care (WHO, 2003). Advantages considerable economic impact on the development of this medicine and the use of medicinal plants for the treatment of various diseases has been noted (Muthu et al., 2006). Therefore, the search for the potential active principles of the plant is more than never relevant. However, their therapeutic virtues may vary depending on the used part of the plant. The pharmacopoeia is increasingly moving towards treatments with herbal because the creativity and efficiency of chemical synthesis by man has reached its limits (Iserin, 2001).

Considerable interest has been generated in essential oils extracted from plants aromatic and with antimicrobial activities against pathogenic microorganisms (Alzoreky & Nakahava, 2003). Many studies have been conducted with a view to estimating of the antiseptic power of essential oils for a very long time. In fact, in 1881, Koch tested the bactericidal action of turpentine essential oil on anthrax spores then Chamberland in 1887 studied the activity of oregano, cinnamon and clove essences on *Bacillus* and finally, in 1919, Bonnaure studied the antiseptic power of lavender (Ribeiro Rocha Monteiro et al., 2000).

The richness and originality of the study of Algerian flora is of scientific interest fundamental to the knowledge of traditional pharmacopoeia. In the treatment of several diseases in Algeria and the field of valorisation of natural substances, thanks the diversity of the climate and the fertility of the soil, characterize the different regions of Algeria which influence the quality and chemical composition of these medicinal plants, which makes them endowed with specific characteristics (Baba Aissa, 1991; Beloued, 2005), they constitute so natural remedies that can be used in curative and preventive treatments (Belouad, 2001).

To this end, and within the framework of the promotion of Algerian flora in general, we have interested in the species of the Lauraceae family which is one of the most used families as a source of extracts with significant antimicrobial power on a global scale in addition to their use in cooking in the daily life of humans *Laurus nobilis* against pathogenic bacterial strains *(Escherichia coli* and *Staphylococcus aureus).*

2. FAMILY: LAURACEAE

In the order of Laurales we find the family of Lauraceae. Considered among the most primitive of the angiosperms, these are distributed in tropical areas and subtropical (Figure 1) (Watson & Dallwitz, 1992; Richter & Werff, 1996; Mabberley, 1997; Steven, 2001), this family is poorly represented in Africa but very common on the continent American or Asian, in Australia and Madagascar (Watson & Dallwitz, 1992; Richter & Werff, 1996; Mabberley, 1997; Steven, 2001; Anton et al., 2005).

It is also widely cultivated for commercial production in many countries.

Arab countries such as Libya and Morocco (Sayyah et al., 2002; Barla et al., 2007; Demir et al., 2007). Currently this species, wild or cultivated, is present in the south and west of Europe, and in the United States as an ornamental plant (Ivan, 2005; Emam et al., 2010).

In Algeria, it grows in forests, ravines, humid and shaded places (Beloued, 2001). It grows on the banks of watercourses. It adapts to all types soils (Messouadi, 2008).

Figure 1: Distribution of Lauraceae throughout the world (Steven, 2001)

This family contains approximately 2000 to 2500 species (Barla et al., 2007) distributed in fifty genera including *Cinnamomum* (cinnamon), *Cryotocarya, Laurus* (laurel) and *Persea* (avocado) (Spichiger et al., 2002). Mainly composed of woody plants, trees or fragrant shrubs, most of which are aromatic (Spichiger et al., 2002).

2.1. Genus *Laurus*

This genus is native to the Canary Islands and the Mediterranean basin. It includes three species of evergreen trees or shrubs: *Laurus nobilis* L, *Laurus azorica* and *Laurus novocanariensis.*

2.2. *Laurus nobilis* L.

The noble laurel is a symbol of glory and success; its foliage was used for to make the famous laurel wreath of victory. Held in high esteem by the Ancients, the laurel was the mark of the gods, represented in the form of branches or a crown of Laurel was an honorary distinction awarded to triumphant Roman generals and a reward for the winners of sports competitions. It later became the attribute of the emperor marking his power. In Greek and Roman mythologies, the laurel is the symbol of Apollo (Takaku et al., 2007). The nymph Daphne – Apollo's first love – was changed into a laurel tree so that she could escape her suitor. From then on, Apollo dedicated this plant to triumphs, songs and poems. Thus, it acquired the name of ‘Apollo's laurel tree’.

Besides its magical and mystical powers recounted in Antiquity, the laurel was a plant renowned medicinal whose properties have been gradually forgotten. Nowadays, it is mainly known for its aromatic leaves in cooking, hence its name “bay laurel” (Ballabio & Goetz, 2010).

The laurel *(Laurus nobilis* L.) is a shrub or tree of the Lauraceae family, with leaves persistent and tough (Figure 2) (Ballabio & Goetz, 2010). Etymologically, the Latin name *Laurus* meaning "evergreen" alludes to the plant's evergreen foliage and *nobilis* from the Latin "famous" (Pariente, 1997). His name is also a symbol of success in our days through the baccalaureate from the Latin “Bacca Lauri” meaning laurel berries (Zhiri & Baodoux, 2005).

Figure 2: Noble laurel shrub (Ballabio & Goetz, 2010)

3. BOTANICAL DESCRIPTION

The laurel is an aromatic shrub or tree from 2 to 10 m and can reach 15 m in height at slow growth (Baba Aissa, 1991), and with a straight trunk branching from the base with a summit conical, and rounding over time (Figure 3) (Anton et al., 2005).

a- Straight stem, gray in its lower part, green at the top (Beloued, 2005). These branches rise obliquely with young, thin, glabrous, brown shoots reddish with narrow, reddish green buds 0,2 to 0,4 cm long (Quézel & Santa, 1962).

b- The leaves are persistent and aromatic, simple, alternate and leathery and whose petiole measures 2 to 5 cm, 5 to 12 cm long and 2 to 6 cm wide. They are lanceolate, slightly wavy and notched at the edge; dark green in color, shiny on the upper side and light green below with lateral veins pinnate and reddish (Quézel & Santa, 1962).

c- The flowers are dioecious (male and female flowers on separate plants), from 0,4 to 0,8 cm with a greenish-yellow color (Patrakar et al., 2012), with a simple perianth fused to the base.

Figure 3: Morphological aspect of *Laurus nobilis* (Beloued, 2005)

Grouped in 4 to 6 umbels. Male flowers have 8 to 12 stamens rudimentary, while the female flowers have a hypogynous ovary with a compartment with a stigma. They appear in the month of March-April of the year (Richter et al., 1996).

d- The fruit is an ovoid berry, supported by the slightly dilated perianthial tube of 2 cm length to 1cm width, it is varnished black and contains a single free seed (Beloued, 2005).

4. BOTANICAL CLASSIFICATION

The systematic position of noble laurel is represented in the following Table 1.

Table 1: Systematic position of *Laurus nobilis* (Quézel & Santa, 1962; Guignard, 2001)

Taxonomy	Vascular plants
Branch	Spermatophytes
Under Branch	Angiosperms
Class	Dicotyledons
Subclass	Dialypetals
Order	Laurales
Family	Lauraceae
Genus	*Laurus*
Species	*Laurus nobilis* L.

5. PHYTOCHEMICAL COMPOSITION

Laurus nobilis, like all medicinal and aromatic plants, has two metabolites, according to Tchoumbougnang et al., (2008) we distinguish:

1. **Primary metabolites** are found in all plant cells. They are essential for the life of the plant: sugar, lipids, proteins, amino acids.

2. **Secondary metabolites** are have only a limited distribution in the plant and are not are not part of the basic materials of the cell. These compounds are not found normally only in particular tissues or organs at specific stages of the development. Their action is decisive for the adaptation of the plant to the environment natural: protective agents against physical stress, defence against attacks external, pigmentation of the plant to capture solar energy or the opposite protect the body against the harmful effects induced by solar radiation.

Several secondary metabolites are:

a. **Essential oil:** *L. nobilis* contains an essential oil which has an analgesic action as powerful as the morphine, and an anti-inflammatory action comparable to Piroxicam which is an anti-nonsteroidal inflammatory drug (NSAID) based on an *in vivo* study conducted on mice in 2003 at the University of Bejaia in Algeria and at the University of Toulouse III Paul Sabatier, Faculty of Pharmaceutical Sciences (2013), *L. nobilis* EO has also been shown to be active against most Gram-positive and Gram-negative bacteria. This activity could be due to the presence of certain compounds which are 1,8-cineole (35-45%), linalool (7%), eugenol, alpha (1.5-4.5%) and beta pinene (< 10%) (Tchoumbougnang et al., 2008).

b. **Aporphinic alkaloids:** *L. nobilis* contains some aporphinic alkaloids, such as cryptodorine, and actinodaphnin which are responsible for cytotoxic activity (Kivçak & Mert, 2002).

c. **Sesquiterpene lactones:** Studies have been carried out on the isolation and identification of compounds from the leaves and new sesquiterpene; lauroxepine. These active substances have proven to be highly cytotoxic against the ovarian cancer cell line A2780 (Barla et al., 2007).

d. **Flavonoids:** Flavonoids isolated from *L. nobilis* are polar (glycosylated derivatives of quercetin, kaempferol and catechin), and can also be apolar (four acyl derivatives of kaempferol) (Kivçak & Mert, 2002).

e. **Tocopherols:** Demo et al., (1998) demonstrated the presence of tocopherols (vitamin E), mainly ÿ-tocopherol, in the leaves of *L. nobilis* obtained in the fraction apolar by hexane extraction. In this study it was reported that the tocopherol content is closely correlated with the antioxidant activity of *L. nobilis* leaves.

f. **Phenylacrylic and phenolcarbonic acids:** These acids can be free or esterified, we also find other acids like p-coumaric, ferulic, sinapic, gentisic and vanillic (Kivçak & Mert, 2002).

6. DETERMINATION OF THE YIELD OF ESSENTIAL OILS FROM NOBLE LAUREL

We extracted the noble laurel essential oil from the leaves, in different states. The extraction time was approximately three hours for each sample.

The yield of essential oils in fresh leaves of *Laurus nobilis* is 0,16%, while the yield of essential oil in air-dried leaves is 0,83%, following by 0,42% and 0,35% respectively for the leaves dried by steaming at low and high temperature.

The variation of essential oil yield of bay leaves at different states is represented by the following histogram.

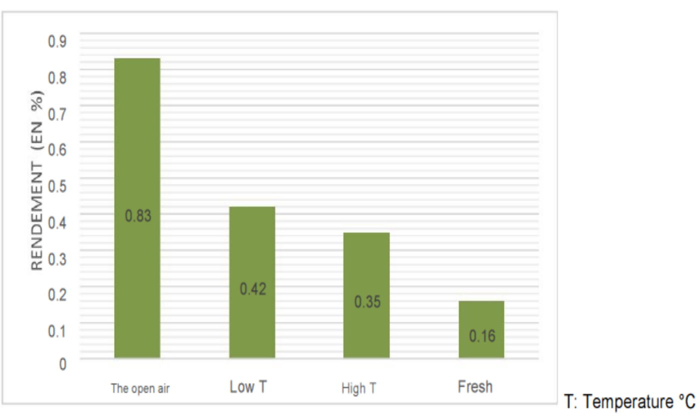

Figure 4: Yield variation depending on the condition of bay leaves

The yield of essential oils from plants is influenced by climate, geographical area, plant genetics, the organ used, drying time, and extraction method (Figure 4) (Ouafi et al., 2017). According to AFNOR (1996), the yield of the species studied is highest during flowering.

7. ANTIBACTERIAL ACTIVITY

7.1. Aromatogram

The antibacterial activity of pure *Laurus nobilis* essential oils could be estimated in based on the diameters of the inhibition zone measured by a caliper on a colony counter (Figures 5, 6, and 7) then comparing them to the scale given by Kheyar et al., (2014).

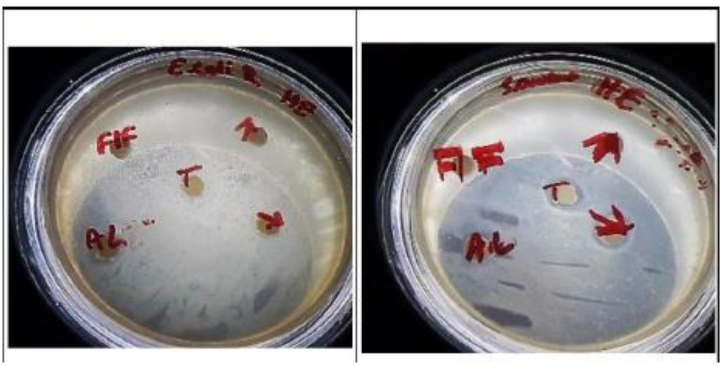

Figure 5: Appearance of HE zones on reference strains

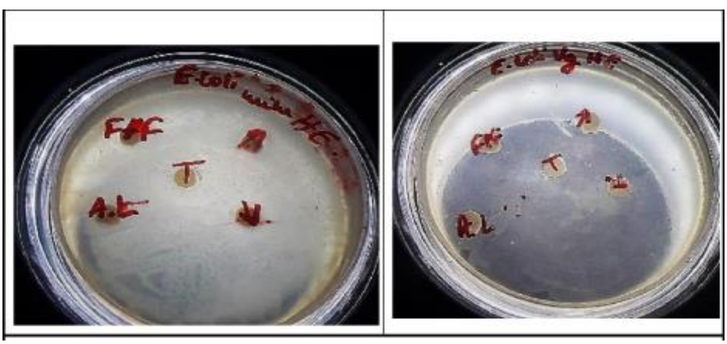

Figure 6: Appearance of HEL inhibition zones on *E.coli*

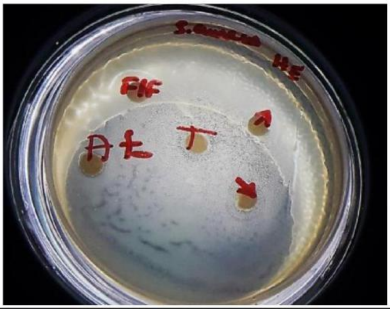

Figure 7: Appearance of HEL inhibition zones on *S. aureus*

The diameters of these are interpreted in the following Table 2, 3, and 4.

Table 2: Aromatogram results of Laurel HEL on *Escherichia coli*
"The diameters are expressed in mm"

	***E. coli* "R"**	***E. coli* "U"**	***E. coli* "V"**
HEL pur	**8,92**	**00**	**6,06**

R: reference, U: sample from urine, V: vaginal sample

Table 3: Aromatogram results of Laurel HEL on *Staphylococcus aureus*
"The diameters are expressed in mm"

	***S. aureus* «R»**	***S. aureus* «PB»**
HEL pur	**12,98**	**7,53**

R: reference, PB: oral wound sampling

The results obtained show that the HEL has a broader spectrum of activity on the Gram+ bacteria *(Staphylococcus aureus)* than Gram- bacteria *(Escherichia coli),* this is due to the penetration capacity of the active compounds present in the oils essential at the level of the bacterial wall.

In Gram-negative bacteria, the outer membrane constitutes a permeability barrier effective; lipopolysaccharide, thanks to its negative surface charges, prevents the diffusion of hydrophobic molecules (Hogan & Kolter, 2002). However, bacteria with Gram-positive are less protected against antibacterial agents, peptidoglycan only hinders the diffusion of molecular weights at 50KD (Kheyar et al., 2014).

Noble laurel essential oil has a notable anti-infectious activity. This can be considered moderate compared to other HE, but nevertheless interesting in therapeutic. Furthermore, numerous studies confirm its antibacterial activity at broad spectrum in vitro, due to its high concentration of 1,8-cineole associated in particular with eugenol or its methyl (Alili & Tantar, 2017).

Oxides have antibacterial and antiviral properties, among them we find 1,8cineole which is the main component of laurel EO and which stimulates the mucin glands as well as the movement of the cilia of the mucosa of the respiratory tree. The role of these molecules is to dissolve the colloid-lipid complexes of the secretions in order to allow the destruction of germs buried there (Djilan & Dicko, 2012).

Bay laurel EO is commonly used to treat mouth sores. A study confirms its anti-staphylococcal power: it has the capacity to inhibit oral strains of *S. aureus* with significant anti-biofilm activity. It could thus have a role promising in the prevention of oral infections. In addition, in *vitro,* it inhibits ÿ-glucosidase activity greater than 90% at a concentration of 7,5 µL/mL, by inhibition competitive (Khan et al., 2008).

The ester of laurel essential oil corresponds to the alcohols they contain, acetate of Linalyl derived from linalool is the most common ester named terpenyl acetate (Djilan & Dicko, 2012).

8. CONCLUSION

This work was carried out as part of the study of the antibacterial activity of oils essential oils of Nobel Laurel. In this context we are interested in extracting the oil essential of the leaves of *Laurus nobilis* L.

Hydro distillation is a method of choice for the extraction of essential oils.

The results obtained indicate that the estimated essential oil yield varies between 0,16 and 0,83% per 100 g of leaves depending on the condition used.

Antibacterial activity tests carried out *in vitro* by the aromatogram method by the diffusion technique on a gel medium, the results obtained demonstrated that the essential oil has an inhibitory activity on all strains tested, the sensitivity the highest was given by *S. aureus* with a DZI equal to 12.98 mm.

At the end of this research, the noble laurel is a plant with medicinal cauline interest and ornamental, which makes it interesting to further research this species.

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CHAPTER XII

PHYTOREMEDIATION BY ORNAMENTAL PLANTS IN ALGERIA

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1. INTRODUCTION

Over the past two decades, the rapid growth of industrial activities, accelerated urban expansion, and significant population increase have led to a substantial accumulation of toxic wastes in many regions of the world. These hazardous residues, encompassing a wide range of organic and inorganic contaminants, pose a serious threat to ecosystems by exerting considerable pressure on their stability and resilience (Chandra & Kumar, 2017).

Heavy metals represent the dominant category of inorganic contaminants, resulting from the application of municipal sludge or compost, the use of pesticides and fertilizers, as well as emissions from waste incinerators, motor vehicles, metal mining operations, and smelters. The most commonly encountered metals and metalloids in contaminated sites include lead (Pb), chromium (Cr), arsenic (As), cadmium (Cd), zinc (Zn), copper (Cu), nickel (Ni), and mercury (Hg) (Seddiki, 2024).

The presence of these elements in soils can pose significant risks to human health and ecosystem functioning, while also impairing the biodegradation processes of organic contaminants (Mitra et al., 2022). Once introduced into the environment, these pollutants disrupt various biological and physiological processes; some minerals can accumulate in different human organs, leading to the development of severe diseases, including cancer (Briffa et al., 2020).

Mechanical or physico-chemical remediation technologies, such as stabilization/immobilization or thermal desorption, can be applied for contaminant removal. However, these approaches are generally costly, significantly disrupt soil biological processes, and do not allow for complete destruction of contaminants (Varjani, 2017). In this context, phytoremediation has attracted increasing scientific and practical interest (Belluck et al., 2006; Marques et al., 2009).

Phytoremediation is an innovative approach that exploits the potential of plants to remove or degrade contaminants present in soil and water. This technology can be divided into five main strategies: phytodegradation, phytoextraction, phytostabilization, phytovolatilization, and rhizofiltration. In the case of inorganic substances, the dominant mechanisms are phytostabilization and phytoextraction (Babu et al., 2021). It is a “green” technology offering a viable alternative from ecological, landscape, and economic perspectives, while aligning with the principles of sustainable development (Shirdam et al., 2008).

However, the appropriate selection of plant species is a critical factor in phytoremediation research. Plants can be categorized into different groups based on their capacity to accumulate heavy metals. In particular, species intended for the removal of these contaminants must exhibit high tolerance and be capable of translocating metals from the soil to the aboveground parts via the rhizosphere (Fischerová et al., 2005).

This chapter highlights the use of ornamental plants in Algeria for phytoremediation, exploiting their ability to extract, stabilize, or degrade contaminants present in soils and water, while maintaining aesthetic and landscape value. This approach allows for the combination of environmental restoration, sustainability, and visual integration within both urban and rural areas.

2. POLLUTION

Pollution therefore corresponds to any unfavorable modification of the natural environment which appears in whole or in part as a by-product of human action, through direct or indirect effects altering the criteria for distributing energy flows, levels of radiation, the physico-chemical constitution of the natural environment and the abundance of living species. These modifications can affect humans directly or through agricultural resources, water and other biological products (Kinne, 1968).

2.1. Heavy Metals

The term “heavy metals” is generally referred to as natural metallic elements, metals or in certain metalloid cases, characterized by a density exceeding 5 g/cm^3 (Koller, 2004).

This name includes elements that, for some, are indeed metals such as Ni, Cu, Zn, Pb, Cd, Hg, Al and which are metalloids as well: As, Se. These are most often present in the environment in the form of trace amounts. The most toxic of these are cadmium, arsenic, lead and mercury. These elements are found naturally in the Earth's crust and in all living organisms, at different levels concentrations vary according to the environment and the organisms.

According to the legislation, the Toxic Metal Pollution (METOX) includes seven metals and one metalloid (chromium, zinc, copper, nickel, lead, arsenic, cadmium and mercury) (Koller, 2004).

According to Kabata-Pendias (2000), Heavy metals constitute a particular pollutant, as a few of them are:

- Metallic trace elements that are essential for life and therefore necessary for the biological machinery (Fe, Cu, Zn, Mn, Mg, Co, Mo, and probably Ni etc.), but that when present in excess in the cells of living organisms become toxic.

- Non-essential metals that are toxic at extremely low cell concentrations (Cd, Pb, Hg, Tl etc.). Metals are constituents integrated into the biosphere, and they are found by therefore naturally in soils and plants. All these heavy metals, when they are in excess in the environment, can be toxic to most living organisms: wildlife and aquatic flora, microfauna and soil microflora, plants and animals (Biney et al., 1994).

Among the depollution techniques are techniques that use superior plants to achieve phytoremediation of the environment. Phytoremediation is an innovative green technology based on using plants to eliminate, stabilize or degrade contaminants present in soil, water and air. This method exploits the natural abilities of plants to accumulate, transform or immobilize toxic substances, such as heavy metals, pesticides and hydrocarbons. It is considered an ecological and economical solution for the rehabilitation of contaminated sites, because it minimizes environmental disturbance and can be implemented in situ (Salt et al., 1995; Bhat et al., 2022; Oladoye et al., 2022).

The various response mechanisms of higher plants to the presence of metals in the soil are currently being used for soil rehabilitation. The use of plants in wastewater treatment dates back more than three centuries, according to (Cunningham & Berti, 1993). However, the use of higher plants for soil rehabilitation has only been developed relatively recently (Baker & Brooks, 1989; Salt et al., 1995).

3. PHYTOREMEDIATION

3.1. Definition

Phytoremediation is a remediation technology that involves the use of plants to eliminate, stabilize or degrade pollutants in soil, water or air. This approach takes advantage of abilities of plants to accumulate, transform or immobilize toxic substances, including heavy metals, pesticides, and hydrocarbons. It is regarded as an ecological and economic alternative for the rehabilitation of polluted land, in virtue of the fact that it minimizes environmental disturbance of the environment (Salt et al., 1995; Bhat et al., 2022; Oladoye et al., 2022).

Cunningham & Berti (1993) define phytoremediation as the use of vascular plants to extract or detoxify pollutants in the environment or render them harmless.

This technique can be categorized into a diverse type that act internally within the plant or externally in its rhizosphere (Figure 1).

3.2. Phytoremediation Techniques

Phytoremediation engages different mechanisms including phytoextraction, phytostabilization, rhizofiltration and phytodegradation. Such processes allow the plant to absorb heavy metals, organic pollutants, and other contaminants from the environment (Salt et al., 1998).

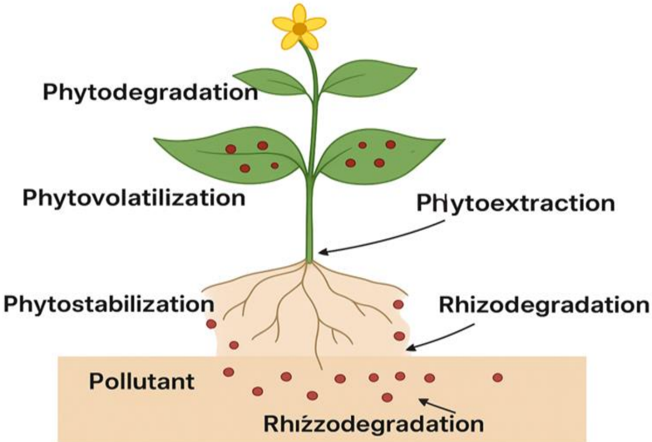

Figure 1: Mechanisms involved in phytoremediation (Pilon-Smits, 2005)

Generally, in the phytoremediation several of these mechanisms can occur at the same time or in a series of reactions (Susarla et al., 2002).

Phytoremediation of heavy metal contaminated soil has multiple mechanisms, which include phytoextraction (uptake, accumulation and translocation of heavy metals), phytostabilization (stabilization of heavy metals intheroot zone), phytovolatilization (emission to atmosphere) and phytotransformation (plant degradation) (Shah & Daverey, 2020).

3.3. Ornamental Plants in Phytoremediation

The exploitation of ornamental plants was especially extensive in Greek and Roman culture, when a multitude of ornamental plants (such as hyacinth, ivy, and narcissi) were related to myths. As further proven by the recent COVID-19 outbreak, ornamental plants are not only luxuries, they are essential to humanity (Toscano et al., 2019), these plants are known for their leaves, in particular flowers with brilliant color, we have relatively little knowledge of them (Wilson et al., 2016).

Ornamental plants are utilized in various settings, including home gardening and landscaping, and across a wide range of green open spaces (streets, parks, and gardens) that greatly foster life quality, in rural and urban environments (Rocha et al., 2022). Along with the increasing environmental issues and global changes in the recent years the ornamental plants were viewed as plants not only for their ornamental characteristics but also for environmental benefits and enhancing the quality of our lives (Savé, 2007).

Consequently, the application of ornamental plants in the restoration of degraded land, energy and water conservation, erosion control and enhancement of the visual quality of both indoor and outdoor environments in which humans reside was suggested (Toscano et al., 2019).

Ornamental plants accompanied the history of men in different civilizations and continents (Wilson et al., 2016).

The focus of this review was to highlight the significance of combining ornamental plants in phytoremediation. The choice of the appropriate plant species can offer numerous benefits to the environment.

The application of ornamental plants for phytoremediation in Algeria, a country with severe environmental problems, could be a strategic solution for improving rangeland restoration with land restoration.

Ornamental plants represent an eco-efficient approach for the decontamination of water and soil, offering significantly lower installation and maintenance costs compared to conventional treatment systems. They therefore emerge as a sustainable option well-suited to socio-economic contexts characterized by limited financial resources (Calheiros et al., 2015).

Certain ornamental species used in phytoremediation exhibit remarkable efficiency in the retroactive removal of contaminants from soils and aquatic environments, making them prime candidates for the remediation of polluted sites (Rocha et al., 2022), as well as for wastewater treatment in remote areas or regions lacking adequate infrastructure (Calheiros et al., 2015). Their ability to rapidly decontaminate polluted environments is attributed to their short growth cycle, which promotes accelerated absorption and degradation of pollutants (Rocha et al., 2022).

Studies have shown that the phosphorus removal capacity is particularly pronounced in fast-growing species with deeply developed root systems (Prodanovic et al., 2019). Furthermore, other research has demonstrated the ability of certain tree species to absorb and accumulate various industrial contaminants namely cadmium, zinc, copper, and lead in their leaves, even when growing on contaminated soils, including in urban environments (Czaja et al., 2020).

3.4. Algerian Environmental Regulations

Algeria is currently facing serious pollution problems. In fact, the pollution caused by the emissions of harmful gases, production of hazardous waste, discharge of untreated industrial water, desertification, deforestation, desertification, and degradation of ecosystem pose serious environmental problems (Ramdane, 2010).

These policies intervene in particular to help industrial companies reduce or eliminate their pollution and the waste collection, treatment, and recycling unit, as well as than by the new ecological taxation based on the polluter pays principle in order to encourage more environmentally friendly behavior.

On the legislative and regulatory level, several laws have been promulgated:

- Law No. 91-25 of December 18, 1991 establishes the tax on polluting activities or Dangerous.

- Executive Decree No. 93 – 160 of July 10, 1993 regulating effluent discharges industrial liquids;
- Ordinance No. 96-13 of June 15, 1996 amending Law No. 83-17 of July 16, 1983 bearing the water code stipulates the obligation to purify wastewater from urban origins or industrial;
- The law of 01-02 of July 19, 2001 establishes the creation of a National Fund for the environment and depollution;
- Entry into application of ecological taxation in January 2005, the amount of the tax is 24,000 da/tons of waste linked to the care activities of hospitals and clinics;
- Executive Decree No. 06-141 of April 19, 2006 defining the limit values for discharges industrial liquid effluents;
- Ratification of the Kyoto Protocol.

Several studies have been conducted in Algeria which reveal the effectiveness of certain ornamental plants for phytoremediation in different towns

4. GENERAL OVERVIEW OF SOME ORNAMENTAL PLANTS IN ALGERIA

4.1. *Zea mays* L.

Maize (Figure 2) is an annual herbaceous plant belonging to the Poaceae family. Originally from the American continent, it is now cultivated on a large scale worldwide. Its remarkable ability to adapt to a wide variety of climates and soils explains its extensive distribution as well as its major role in economic, nutritional, and scientific contexts (Meers et al., 2010).

Zea mays L. is an annual grass species with an upright growth habit, typically reaching an average height of 2 to 3 meters, and occasionally up to 7 meters under optimal soil and climatic conditions (Eubanks, 1995).

Maize is a monoecious plant, characterized by the presence of unisexual flowers grouped into two distinct types of inflorescences. The male flowers are clustered at the top of the stem, forming the terminal panicle, while the female flowers develop as axillary ears inserted at the leaf bases.

Figure 2: *Zea mays* L. (Atma, 2016)

The leaves, which are broad, elongated, and ribbon-like, are arranged in two alternating rows on opposite sides of the stem. This organization gives the plant symmetrical leaf architecture, promoting optimal light capture for photosynthesis and growth (Escalante, 2012).

The root system of maize is fibrous and seasonal. It includes adventitious roots arising from two to three nodes above the soil, as well as primary roots that can penetrate up to 2 meters deep and extend laterally up to 1,2 meters (Atma, 2016).

4.2. *Helianthus annuus* L.

The sunflower, or common sunflower (*Helianthus annuus* L.), belongs to the Asteraceae family (Figure 3). It is a vigorous, fast-growing annual herbaceous plant. Its stem, generally unbranched or slightly branched, can reach between 1.5 and 1.8 meters in height within a few months, with some varieties exceeding 3 meters. The leaves are alternate, long-petioled, and heart-shaped, densely pubescent, and have a rough texture to the touch.

The inflorescence of the sunflower, known as the capitulum (or flower head), is a large floral structure composed of numerous small flowers grouped together on a thick receptacle (Laporte, 2013).

Cultivated primarily for its oil-rich seeds, the sunflower also exhibits a strong potential for phytoremediation, particularly in the decontamination of soils polluted by heavy metals (Atma, 2016).

The vegetative cycle of the sunflower consists of five successive stages: germination and emergence (appearance of the cotyledons), the vegetative phase corresponding to leaf development, the appearance and growth of the floral bud, flowering (opening of the capitulum and seed formation), and finally maturation, characterized by seed filling and the gradual drying of the plant.

Overall, the sunflower's life cycle, from germination to physiological maturity, spans a period of 120 to 160 days, or approximately three to four months (Ben, 2005; Tourte et al., 2005).

Figure 3: *Helianthus annuus* L. (Singh et al., 2022)

4.3. Arundo *donax* L.

Arundo donax L. (Poaceae) (Figure 4) is a large, erect, perennial grass of cane- or reed-like type, known for its diverse economic and biomedical uses, notably in biofuel production (Pansuksan, 2020).

Considered one of the largest herbaceous grasses, this plant can reach a height of 2 to 10 meters. Its particularly vigorous and well-developed root system provides strong soil stability. The rigid stems, or culms, are segmented by nodes, measuring 1 to 4 cm in diameter. They generally branch during the second year of growth, rarely producing more than one lateral branch per node (Al-Snafi, 2015).

The leaves, pale bluish-green in color, widely encircle the stem at their base, forming a heart-shaped sheath often covered with hairs.

Figure 4: *Arundo donax* L. (Atma, 2016)

They measure 2 to 6 cm in width at the base and can reach 70 cm or more in length. The leaves are arranged alternately along the culm, in a bipinnate pattern and in a single plane. The flowers, on the other hand, are grouped into large feathery panicles measuring 30 to 65 cm in length, located at the tips of the stems. Flowering generally occurs from March to September, during which the plant fully expresses its vegetative development (Atma, 2016).

4.4. *Phragmites australis* (Cav.) Trin. ex Steud.

It is a vascular plant belonging to the Poaceae family (grasses) (Figure 5). This perennial species can reach a height of over 6 meters and form very dense monospecific colonies, sometimes containing up to 325 stems per square meter (Lavoine, 2008).

Common reed is widely used in planted filter systems for the treatment of effluents and sewage sludge, due to its high adaptability and its effective role in phytoremediation processes.

The plant has erect, rigid but brittle stems, generally unbranched, which tend to dry out during the winter. Its root system consists of a long, creeping, highly branched, woody rhizome covered with small scales, providing the plant with a strong capacity for regeneration and soil colonization.

The leaves, somewhat glaucous, have sharp edges. They can reach up to 50 cm in length and 1 to 3 cm in width, tapering to a pointed tip and detaching from the stem in autumn. The ligule is reduced to a row of fine hairs.

The flowers, in the form of spikelets measuring 10 to 16 mm in length, comprise 2 to 10 florets (Hazelton et al., 2014; Prost-Boucle & Maeder-Pras, 2024).

Figure 5:*Phragmites australis* (Kleche et al., 2013)

4.5. *Alyssoides utriculata* L.

The species ***Alyssoides utriculata* L.,** belonging to the Brassicaceae family, is primarily found in the northeastern Mediterranean region (Figure 6). It preferentially grows on calcareous, marble, sandstone or serpentine substrates and is frequently encountered on rock outcrops, cliffs, and screes (Roccotiello et al., 2015).

It is a small ornamental shrub, typically ranging from 20 to 50 cm in height. The unbranched stem bears basal leaves that are narrowly obovate, entire, and covered with a few simple or stellate hairs, sometimes even glabrous.

The cauline leaves, more numerous, are lanceolate and sessile. The inflorescence is initially umbel-shaped, then gradually elongates to form an extended raceme.

Figure 6: *Alyssoides utriculata*

The petals, bright yellow in color, measure 15 to 20 mm in length, while the fruit, subglobose and swollen in shape, has a diameter of approximately 1 cm (Ucuncu, 2024).

4.6. *Nerium oleander* L.

Oleander (*Nerium oleander* L.) (Figure 7) is a species belonging to the Apocynaceae family. It is mainly found in regions of the Mediterranean Basin, where it represents a typical plant element (Moulsma et al., 2000).

Originally from the Near East, this plant grows spontaneously on rocky riverbanks and sometimes in coastal areas, where it coexists with halophilic species.

Possessing high drought tolerance, *Nerium oleander* L. is also highly valued for its ornamental qualities, particularly because of the beauty and variety of its flowers (Bruneton, 2001).

Nerium oleander L. is an erect shrub typically reaching 2 to 4 meters in height, occasionally up to 5 meters.

Its root system, whitish in color, contains a sparse astringent latex, while the wood contains a bitter, milky or translucent sap.

The evergreen leaves, arranged in whorls of three or opposite, are slender, leathery, and lanceolate, measuring on average 15 cm in length and 2,5 cm in width, with dark green color flowers (Bruneton, 2001).

The flowers, most often pink, are grouped in terminal corymbs. The corolla, 4 to 5 cm wide, opens into five spreading lobes, single or double, and occurs in several ornamental color variations. The fruit, which appears later, contains small fluffy seeds with a silky apical tuft that facilitates wind dispersal (Jouve, 2009; Hussain & Gorsi, 2004).

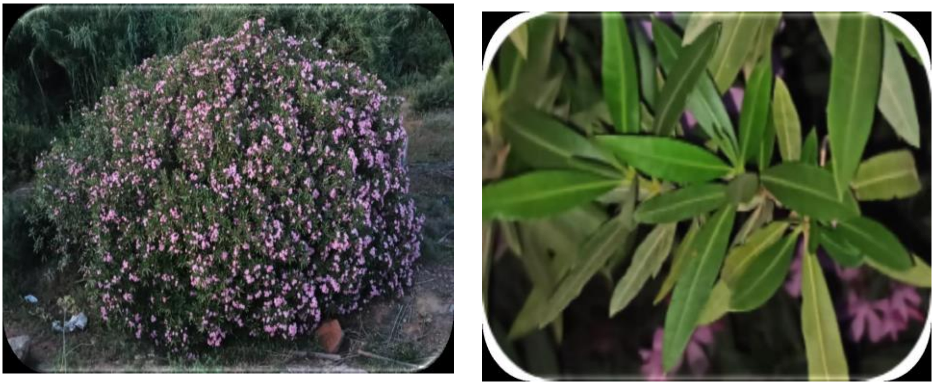

Figure 7: *Nerium oleander* (Ouali, 2022)

5. PHYTOREMEDIATION USING ORNAMENTAL PLANTS IN ALGERIA

The study by Atma conducted in 2016 on the purification potential of certain plants demonstrated that the nickel (Ni) concentrations measured in *Zea mays* L. plants from the Mascara region (Algeria) reached 996,24 mg/kg. These values are considerably higher than those observed in maize from Pakistan, which recorded 54,9 mg/kg (Sabir et al., 2011), and in maize plants cultivated in Poland, which reached 610,3 mg/kg (Antonkiewicz et al., 2016). This plant has proven effective for treating water contamination by Ni, both in hydroponic culture and in soil. However, higher Ni uptake was observed in hydroponic cultures compared to soil-grown conditions (Atma, 2016).

In contrast, in *Helianthus annuus* L., nickel (Ni) exhibits higher toxicity than lead (Pb) for sunflower plants (Mukhtar et al., 2010). Different plant species possess variable capacities for accumulation and tolerance to heavy metals (Mahmood et al., 2015).

The results also showed that Cd and Ni concentrations generally exert a positive effect on the growth and biomass production of *Helianthus annuus* L.

This species demonstrated greater tolerance to cadmium, which it accumulates more efficiently than nickel, confirming the observations of Mukhtar et al. (2010) and Mahmood et al. (2015) regarding the differential resistance of plants to heavy metals.

Moreover, *Arundo donax* L., when grown on substrates contaminated with heavy metals, demonstrates a remarkable ability to absorb Ni, reaching concentrations exceeding the phytotoxicity thresholds generally observed in plant species (Cristaldi et al., 2020). This plant is characterized by high biomass productivity and an efficient capacity to translocate (Ni) from *Arundo donax* L. has attracted particular interest for the remediation of metal-contaminated soils due to its high potential for absorbing phosphorus (P), cadmium (Cd), and nickel (Ni). However, the effectiveness of this plant as a remediating species depends on environmental conditions and its ability to meet the general criteria for plants used in phytoremediation (Alshaal et al., 2015). The root system to the aerial organs, particularly the stems and leaves (Hou et al., 2020).

According to Papazoglou et al. (2007), the high nickel concentrations present in the soil did not have a significant effect on dry biomass production or on the growth of stems, leaves, and branches of *Arundo donax* L.

This plant is capable of absorbing and accumulating heavy metals present in the soil. It is therefore highly useful for phytoremediation, particularly in phytoextraction and phytostabilization processes, especially when combined with a chelating agent that facilitates metal uptake (Atma, 2016).

As it is non-edible, this plant poses no risk to humans or animals. In addition to its decontaminating abilities, *Arundo donax* L. has an attractive aesthetic appearance, allowing it to be used for decorative purposes while contributing to the remediation of contaminated soils and waters over large areas.

The presence of nickel in the various parts of these plants indicates the transfer of this element from the soil to the roots and then to the aerial organs. The assessment of Ni accumulation, bioconcentration, and translocation is carried out using several indicators, including the translocation factor (TF), the bioaccumulation factor (BF), and the bioconcentration factor (BCF) (Mukhtar et al., 2014). According to Antonkiewicz et al. (2016), the translocation factor (TF) allows for estimating the plant's capacity for phytoextraction. High Ni concentrations observed in the aerial organs can contribute to an increase in biomass, thereby causing an apparent rise in TF. This increase does not necessarily reflect better translocation but may rather result from a decrease in Ni concentration in the roots.

According to Badache & Seghairi (2024), *Arundo donax* and *Phragmites australis* exhibit a strong capacity to remove heavy metals from industrial wastewater in Biskra (Algeria). These species reduced metal concentrations by 94 to 98%. Their bioaccumulation factors (BAF > 1) confirm their ability to accumulate these elements in their tissues, classifying them as hyperaccumulator plants. These results validate the effectiveness of phytoremediation using macrophytes for wastewater treatment and environmental decontamination.

The study on the absorption, accumulation, and translocation capacity of trace elements in *Phragmites australis* conducted by Sellal &Belattar (2024) in the Bordj Bou Arreridj region, at the Oued K'sob (Algeria), revealed that the bioconcentration factors (BCF) of all analyzed metallic elements were greater than 1. Zinc (Zn) showed the highest values, with BCF, bioaccumulation factor (BF), and translocation factor (TF) also exceeding 1. These results indicate that the studied plant can be classified as a hyperaccumulator species for Zn, Fe, Cu, and Pb. Consequently, *Phragmites australis* appears as an ecological and sustainable solution for the phytoremediation of contaminated environments, particularly for reducing high zinc concentrations in aquatic or wetland ecosystems, as well as for the treatment of industrial effluents (Zinicovscaia et al., 2025). Chitimus et al. (2023) indicate that this species is particularly well-suited for soil phytoremediation.

The study conducted by Kleche et al. (2018) on the phytoremediation of wastewater in the suburban area of Annaba (Algeria) showed that *Phragmites australis* and *Typha angustifolia* exhibit a strong potential for bioaccumulation of organic pollutants. These aquatic plants have proven to be excellent bioindicators and can serve as a reliable biomonitoring model for assessing organic contamination in aquatic ecosystems.

The study conducted by Roccotiello et al. (2015) on the Mediterranean shrub *Alyssoides utriculata* evaluated its capacity to accumulate and translocate Ni in order to determine its potential for the phytoremediation of contaminated soils.

The results show a high accumulation of Ni in the leaves (> 1000 µg g^{-1}), indicating that *A. utriculata* is a hyperaccumulator species. The bioaccumulation (BF) and translocation (TF) factors, both greater than 1, confirm its ability to extract and transport the metal from the roots to the aerial parts. These findings suggest that *Alyssoides utriculata* represents a promising native species for nickel phytoextraction in contaminated Mediterranean ecosystems.

The study conducted by Boussaïd & Cheboutimeziou (2019) demonstrated the effectiveness of *Phragmites australis* and *Arundo donax* in the phytoremediation of contaminated waters from Lake Réghaïa (Algeria).

Analysis of the translocation factors (TF) revealed a significant transfer of heavy metals from the roots to the aerial parts. In *Phragmites australis*, translocation rates reached 63% for nickel (Ni), 46,2% for silver (Ag), 11,4% for zinc (Zn), and 9,38% for copper (Cu). Meanwhile, *Arundo donax* stood out for its high nickel accumulation capacity, accompanied by notable translocation percentages of 60.46% for Ni, 43,63% for Cu, 40,24% for Ag, 31,94% for Zn, and 17,92% for lead (Pb).

This hyper accumulation capacity reflects a high tolerance of these two species to elevated heavy metal concentrations (Al-Homaidan et al., 2020). The high values of the biological transfer coefficient (BTC) and the bioconcentration factor (BCF) confirm that *Phragmites australis* and *Arundo donax* represent promising species for the phytoremediation of contaminated aquatic environments (Bello et al., 2018).

According to the study conducted by Seddiki et al. (2024), which evaluated the effectiveness of three plant species; *Nerium oleander* L., *Sorghum bicolor* L., and *Anredera cordifolia* in the phytoremediation of soils contaminated with Ni, Cd, and Pb in the Mascara region (Algeria), the results showed that:

Anredera cordifolia proved to be an excellent accumulator of heavy metals, regardless of the treatments applied.

Nerium oleander exhibited high BCF and TF values (>1) for Cd, indicating hyperaccumulator behavior and good potential for Pb phytostabilization.

In contrast, *Sorghum bicolor* was ineffective for Cd and Ni but effective for Pb phytoextraction, with TF and BCF values greater than 1 (Shafiei Darabi et al., 2016). Al Chami et al. (2015) reported that *S. bicolor* proved to be more efficient than *Carthamus tinctorius* for metal uptake due to its high biomass production and relatively high metal concentration in the aerial parts. *S. bicolor* could be successfully used for phytoremediation o These results highlight the potential of *Nerium oleander* L. and *Anredera cordifolia* in the decontamination of soils polluted with Cd and Pb (Ibrahim & El Afandi, 2020), and confirm the relevance of developing phytoremediation technologies within the Algerian environmental context in marginal soils moderately contaminated with heavy metals.

According to the study by Benhammou & Benhammou (2024) on the phytoremediation of hydrocarbon-contaminated soils in the Tizi Ouzou region (Algeria) using ornamental plants, the results indicate that *Chlorophytum comosum* exhibited the highest capacity for PAH absorption, with a rate of 9,36 mg/g dry matter. In comparison, other species showed lower values: *Pothos sp.* with 7,33 mg/g DM, *Syngonium* sp. with 4,05 mg/g DM, and *Crassula ovata* with 3,45 mg/g DM. These findings highlight the potential of *Chlorophytum comosum* for the phytoremediation of PAH-polluted soils in this region.

Soil biological activity is closely correlated with its decontamination process. The species *Syngonium* sp., *Chlorophytum comosum*, and *Pothos* sp. caused a significant decrease in soil hydrocarbon concentrations while exhibiting the highest biological activity. This activity is closely linked to degradation processes, suggesting that the main mechanism involved is phytostimulation, especially since certain fractions of polycyclic aromatic hydrocarbons (PAHs) are absent in soils associated with these three species. These plants primarily degraded light PAHs, thereby confirming their phytostimulation capacity and high potential for phytoremediation.

In contrast, *Crassula ovata*, although showing some effectiveness, appears to have limitations in the complete removal of all PAHs. However, its root morphology, characterized by extensive texture and surface area, still promotes hydrocarbon absorption (Benhammou & Benhammou, 2024).

Crassula ovata appears capable of absorbing and accumulating hydrocarbons present in the soil, indicating the likely involvement of phytoextraction in the management of these contaminants. After absorption, the hydrocarbons are transferred to the aerial organs of the plant, particularly the stems and leaves, thereby promoting effective pollutant concentration within the succulent tissues. This translocation and storage process suggests intracellular compartmentalization of organic compounds, particularly in the vacuoles of leaf cells, where they can be temporarily sequestered.

Some pollutant fractions disappeared from the soil and were not detected in the plant tissues, suggesting that *Pothos* may also utilize mechanisms such as phytodegradation, phytostimulation, or phytovolatilization. Hydrocarbon removal could occur either through leaf volatilization (Reichenauer & Germida, 2008; Sheng et al., 2008) or by microbial degradation in the rhizosphere (Tang et al., 2010).

The species *Syngonium* sp. and *Chlorophytum comosum* appear to have played an active role in the phytodegradation of polycyclic aromatic hydrocarbons (PAHs), as evidenced by the disappearance of a fraction of these compounds in the soil, without detectable accumulation in plant tissues. Although their decontamination efficiency is lower than that observed in *Crassula ovata* and *Pothos* sp., these species nonetheless made a significant contribution to the overall soil remediation process.

Moreover, *Chlorophytum comosum*, thanks to its particularly well-developed tuberous root system, could play a key role in stimulating microbial activity responsible for the degradation of PAHs in the rhizosphere. Indeed, it is well recognized that the phytoremediation of soils contaminated with PAHs is closely dependent on the plants' tolerance to high pollutant concentrations, as well as on the morphology and extent of the root system, which promote interactions between roots and degrading microorganisms (Rezek et al., 2008; Yousaf et al., 2011).

5.1. Benefits and Challenges

The use of ornamental plants for phytoremediation in Algeria provides several benefits, including:

- Green-Sustainable: Leveraging the natural process of phytoremediation makes it a sustainable and noninvasive approach for cleaning up contaminated land and water. It is unique in that it does not generate secondary pollution, disrupt or otherwise harm the ecosystem, unlike chemical treatment methods.
- Cheap labour: Phytoremediation is a more economical option than traditional remediation processes such as excavation and chemical

treatments. It takes less energy and you can work on large patches, you don´t have to baby them all day long.

- Aesthetic Value of Plant used in Phytoremediation: The plant used in the process of phytoremediation takes care of the contamination and beautify contaminated sites. The greenery is not only part of environmental restoration but also part of wildlife shelter.
- Soil Conservation: Again, rather than employing excavation which disturbs the soil profile, phytoremediation aids in the stabilization and healing of the soil even while remediating it.
- Applications are numerous: Phytoremediation may be used to treat a broad range of contaminants such as heavy metals, pesticides, hydrocarbons and excess nutrients in marine life.
- Carbon Sequestration: Phytoremediation plants not only remove contaminants but they also contribute to carbon sequestration and climate change mitigation.

However, challenges remain, such as:

- Time-Consuming Process: The slow pace is one of the main limitations of phytoremediation. It is based on natural plant growth and the biochemistry of plants and their associated microbes, which can be a lengthy process of multiple months or years before reaching meaningful outcomes.
- Limited Depth of Contaminant Removal: Phytoremediation works best for contaminants in the root zone usually shallow soil). For contaminants that are deeply buried underground, or in inaccessible locations, this technique may not be feasible.
- Challenges in Plant Selection: Phytoremediation is not suitable for all plants. This approach requires picking species that can survive and function in polluted environments, and apply pollutants efficiently (for cleaning) or metabolize them (for degradation).
- Possible Bioaccumulation Risks: At times phytoremediation plants can absorb toxic substances within their tissues. And, if these are not handled properly, it could be dangerous for wildlife or people who might touch or eat these plants.
- Limitations Due to Site Specificity: Environmental conditions, such as soil type and climate and contaminant concentration, strongly

influence phytoremediation. Extremely contaminated or otherwise unsuitable sites may not be compatible with this approach.

- Increased Maintenance Needs: Phytoremediation is a monitoring-intensive, maintenance-intensive procedure. This involves watering, pest management and harvesting of contaminated plant matter.
- Not efficient for cleaning some contaminants: Although phytoremediation is effective for many organic contaminants and certain heavy metals, it is the least effective against very toxic chemicals such as arsenic or mercury that do not readily associate with plant tissues.

6. CONCLUSION

Phytoremediation with ornamental plants is a good alternative for soil and water pollution abatement in Algeria. Although challenges do remain, the benefits to the environment restoration, economic development and community participation could outweigh this and make it an acceptable option for sustainable practices in the country. Ornamental plants could increasingly play a critical role in worldwide endeavors to combat environmental pollution and repair ecosystems. In Algeria, if the shortcomings of Phytoremediation with ornamental plants can be addressed properly, and the positive aspects exploited fully, this novel approach can help contribute to a cleaner, healthier environment for our future generations.

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