



Ethnobotanical Survey of Medicinal Plants Widely Used in the Sidi Bel Abbès Region (North-West Algeria)

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Abstract:

This ethnobotanical study was conducted in the region of Sidi Bel Abbès (north-western Algeria), an area characterized by a diversity of ecosystems ranging from semi-arid zones to wetlands and forests. The main objective was to identify the medicinal plants most commonly used by the local population in herbal medicine. A questionnaire survey was conducted among 26 herbalists in several municipalities. The results show that herbalists are exclusively male, mostly aged between 40 and 70, with no academic training, but with in-depth knowledge of medicinal plants, acquired either through family heritage or professional experience. The study identified 48 medicinal species belonging to 25 botanical families, with a predominance of Lamiaceae (31.25%) followed by Apiaceae (12.5%). The species most sought after by the population are *Thymus vulgaris* and *Ammoides verticillata*, mainly used against infectious disorders such as flu and colds. Depending on the species, the leaves are the most commonly used part (50% of cases), followed by the stems and seeds (16%). The calculation of the degree of consensus (ICF) revealed generally low values, ranging from 0 to 0.41, with a higher consensus for infectious and digestive disorders. A comparison between traditional uses and scientific data was carried out for several major species, including *Thymus vulgaris*, *Ammoides verticillata*, *Aquilaria malaccensis*, *Bunium bulbocastanum* and *Punica granatum*, partially confirming the therapeutic efficacy reported by herbalists. The study concludes that there is a need to raise awareness of the need for rational use of plant resources in order to preserve biodiversity in the face of intensive and uncontrolled exploitation.

1. Introduction

Ethnobotany is an interpretative and associative discipline that researches, uses, links and interprets the interrelationships between human societies and plants in order to understand and explain the birth and progress of civilisations, from their vegan beginnings to the use and transformation of plants themselves in primitive or advanced societies [1]. Ethnobotanical surveys have been of interest to botanists around the world for several decades. As examples, we cite some recent work, including an ethnopharmacological and pharmacognosic study of the medicinal drugs most commonly used by herbalists in Lebanon [2], and a study of medicinal plants sold in markets in the city of Douala (Cameroon) [3]. In France, an ethnobotanical survey entitled 'Women's evils' examined whether plants are used to treat gynaecological conditions [4]. An ethnobotanical survey examined the use of medicinal plants in the treatment of oral and dental conditions in the municipality of Kindia in the Republic of Guinea [5]. In Ivory Coast, an ethnobotanical survey examined medicinal plants used in the treatment of COVID-19 [6]. A review of plants and other natural substances in the traditional pharmacopoeia of French Polynesia was based on an in-depth bibliographic study of sources published between 1858 and 2023 [7]. The richness of Algeria's flora is undeniable, with around 4300 species and subspecies of vascular plants [8]. A published article reported that the DGF (Directorate General of Forests) had identified 289 fairly rare species, 647 rare species, 640 very rare species and 35 extremely rare species [9]. Due to its climate (Mediterranean, arid) and the nature of its soils, Algeria has a particularly rich flora of medicinal and aromatic plants, most of which grow wild [10]. Depending on the region of the country, ethnobotanical surveys have always been an area of interest for ecologists and naturalists. Examples include ethnobotanical studies conducted in the Kabylie region (province of Tizi Ouzou) [11], M'sila in eastern Algeria [12], Touat (province of Adrar) in southern Algeria [13], and Naâma [14]. Several other researchers have conducted ethnobotanical surveys among herbalists or the local population on the medicinal value of a number of species, or on the plants used to treat a given disease. An ethnobotanical study examined antilithiasic plants used in traditional medicine in the city of Oran [15]. An ethnobotanical study examined *Pistacia lentiscus* in the province of El Taraf (eastern Algeria) [16]. An ethnobotanical survey and inventory concerned medicinal plants used in the treatment of dermatological diseases in the city of Aïn-Temouchent (north-western Algeria) [17]. Ethnobotanical surveys on medicinal plants used to combat COVID-19 were conducted among

the population of the Tebessa region in eastern Algeria [18] and the province of Souk Ahras [19]. In addition, some botanical and phytochemical research has been conducted on a few species of medicinal plants in the Sidi Bel Abbès region. Recent studies include a survey on the phytotherapeutic use of 11 medicinal plants growing in Tessala, north of the wilaya [20], an ethno-veterinary approach to medicinal plants used in the Sidi Bel Abbes region [21], and an ethnobotanical study of medicinal plants used in the traditional treatment of urinary tract infections in western Algeria [22]. An ethnobotanical survey of patients in northwestern Algeria, including the city of Sidi Bel Abbes, examined ethnobotanical knowledge and practices related to the use of medicinal plants for the management of urinary lithiasis [23]. Many medicinal species native to the Sidi Bel Abbès region have been studied from an ecological and phytochemical perspective, including: *Daphne gnidium* L. (Thymelaeaceae) [24], *Rhamnus alaternus* L. (Rhamnaceae) [25], *Ballota hirsuta* Benth., 1834 (Lamiaceae) [26], *Arbutus unedo* L. (Ericaceae) [27], *Gleditsia triacanthos* L. (Fabaceae) [28], *Peganum harmala* L. (Nitrariaceae) [29]. Ethnobotanical surveys in the Sidi Bel Abbès region remain rare. This study is part of this framework and aims to determine the most sought-after and most widely used wild plant species by the local population for therapeutic purposes and to deduce their status in terms of threats. It will therefore provide an overview of the current situation regarding local phytotherapeutic uses, and identify and classify plants in order of importance in terms of their use by the population and herbalists. This approach will highlight the importance of implementing a specific programme for the protection and conservation of these species, as they are at risk of disappearing over time due to their irrational use and unregulated harvesting by herbalists, qualified or otherwise, who are only interested in meeting the needs of their customers and who believe in the indispensability of phytotherapy, especially at a time when patients are advised to use traditional therapy methods.

2. Material and Methods

2.1 Study area

The Sidi Bel Abbes plain covers an area of 92000 hectares, with cereals dominating more than 50000 hectares. Surrounded by the Tessala Mountains to the north (1060 m), the Dhaya Mountains to the south (1450 m), the Beni Chougrane Mountains to the east (850 m) and the Tlemcen Mountains to the west (1400 m), the plain has an altitude ranging

from 450 to 700 m. [30] (Figure 1). Administratively, it comprises 52 municipalities grouped into 15 Dairas, with a total population of 713377 [31]. The Sidi Bel Abbès region encompasses different types of ecosystems, including:

-Semi-arid steppe areas: A large part of the southern region of the wilaya of Sidi Bel Abbès, particularly around Ras El Ma, is dominated by esparto grass steppes. These areas, although undergoing desertification due to climate change and human activities, are characteristic of Algerian steppe flora. In addition to the dominant species *Stipa tenacissima* L. (Poaceae), which is very important for grazing, there are other steppe species of ecological and forage importance such as *Artemisia herba alba* Asso. (Asteraceae) (White sagebrush steppe), *Lygeum spartum* L. (Poaceae), and *Aristida pungens* (Desf.) De Winter (Poaceae) [32].

-Wetlands: Wetlands, such as wadis, dams and lakes in the Sidi Bel Abbès region, play a crucial role in the ecological balance of these areas. The Mekerra wadi watershed, for example, is a dynamic ecosystem with rich plant biodiversity, particularly in flood reception and transfer areas. According to floristic inventories [33], the Mekerra wadi station is home to various medicinal plants on its banks, such as *Inula montana* L. [34], *Plantago major* L. [35], and *Scolymus grandiflorus* Defs. [36].

- Forest areas: The Sidi Bel Abbès region is known for its forest heritage, which makes it a heavily wooded province. Its forest massif occupies an important place with a forest cover rate of 22% and a forest area of 209489 ha encompassing 20 state-owned forests [37]. These forests, dominated by Aleppo pine (*Pinus halepensis* Mill., Cupressaceae), are among the largest and most diverse in western Algeria [38], in addition to holm oak (*Quercus ilex* L., Fagaceae) and thuja (*Tetraclinis articulata* Vahl., Cupressaceae), which together cover an area of 41897 ha, as well as low-lying formations such as alfatière grasslands [39].

From a bioclimatic perspective, the monthly averages for temperature and precipitation recorded between 2010 and 2020 indicate a cold season that lasts from October to April. The highest temperatures (38.1°C) are reached in July, while the lowest (0.6°C) occur in January. The maximum rainfall is observed in December (46.5 mm), and the minimum in July (1.5 mm). The average annual rainfall is 350 mm [40].

2.2 Ethnobotanical survey

The objective of this study is to conduct a survey using a questionnaire designed to collect general data on the plants most commonly used in herbal medicine by the local population. To this end, the questionnaire included the following questions (Figures A1 and A2):

- Which plants are most commonly used in herbal medicine by the local population?
- Which gender and age group is interested in traditional medicine?
- Which part of the plant is sold?
- In what condition is it packaged?
- Where do the plants mentioned come from?
- What remedies are they used for?

The survey was conducted among 26 herbalists spread across the wilaya of Sidi Bel Abbès, located in six municipalities of the wilaya of Sidi Bel Abbès (Table 1). It began with herbalists in the city's most popular neighbourhood, where the largest number of herbalists are concentrated. Other herbalists' shops, spread across several other popular neighbourhoods, as well as other municipalities in the north of the province, were included in the survey (Figure 1, Table 1).

2.3 Data collection and analysis

The information collected from herbalists concerning the part used in herbal medicine and its use was compiled in Table 2. For each species, the scientific name, common name, family and biological type were mentioned. The frequency of citation by the 26 herbalists surveyed was also calculated for each species using the following formula [41]:

$$FC = \text{number of citations} / \text{number of herbalists}$$

According to herbalists, the health problems to be treated with the medicinal plants mentioned have been classified into 16 groups according to their medicinal use (Table 3). The following formula was adopted for calculating the degree of consensus on the use of the plant, or informing consensus factor (ICF) [42]:

$$ICF = (NUR - NT) / (NUR - 1)$$

where NUR is the number of use reports in each category and NT is the number of taxa used.

The purpose of calculating this factor is to assess the variability in the use of medicinal plants and to determine whether plants from certain groups are of particular interest in the search for bioactive compounds [43]. ICF values range from 0 to 1,

where 1 indicates the highest level of agreement among informants.

3. Results and Discussions

3.1 Herbalist profile

The information collected on the information sheets concerning the herbalists who participated in the survey revealed the following:

- They are all male;
- Most are between 40 and 70 years old;
- None of them have any formal education, but they all claim to have good to very good knowledge of medicinal plants.
- 50% of herbalists inherited this profession from their ancestors;
- Others admit that they have made this trade a means of earning a living;

The categories of people most interested in traditional medicine are women and the elderly.

3.2 Medicinal species cited by herbalists

This survey enabled the compilation of a list of 48 species used in herbal medicine by the local population. These species are: *Ajuga reptans* L. (1753), *Aloysia citrodora* Palau (1784), *Ammoides verticillata* (Desf.) Briq. (1914), *Aquilaria malaccensis* Lam (1783), *Artemisia herba alba* Asso (1779), *Atriplex hortensis* L. (1753), *Bunium bulbocastanum* L. (1753), *Carum carvi* L. (1753), *Centaurium erythraea* Rafn. (1800), *Chamaemelum nobile* L. (1785), *Cuminum cyminum* L. (1753), *Daphne gnidium* L. (1753), *Ephedra alata* Decne. (1834), *Eucalyptus globulus* Labill. (1799), *Foeniculum vulgare* Mill. (1768), *Haloxylon scoparium* Pomel. (1875), *Hibiscus sabdariffa* L. (1753), *Juniperus communis* L. (1753), *Laurus nobilis* L. (1753), *Lavandula angustifolia* Mill. (1768), *Lepidium sativum* L. (1753), *Linum usitatissimum* L. (1753), *Marrubium vulgare* L. (1753), *Melissa officinalis* L. (1753), *Mentha pulegium* L. (1753), *Nigella sativa* L. (1753), *Ocimum basilicum* L. (1753), *Origanum majorana* L. (1753), *Origanum vulgare* L. (1753), *Peganum harmala* L. (1753), *Pimpinella anisum* L. (1753), *Pinus pinaster* Aiton. (1789), *Pistacia lentiscus* L. (1753), *Punica granatum* L. (1753), *Rosmarinus officinalis* L. (1753), *Rubia tinctorum* L. (1753), *Ruta graveolens* L. (1753), *Salvia argentea* L. (1762), *Salvia officinalis* L. (1753), *Satureja calamintha* (L.) Kuntze (1891), *Senna alexandrina* Mill. (1768), *Thymus algeriensis* Boiss. & Reut. (1850), *Thymus serpyllum* L. (1753), *Thymus vulgaris* L. (1753), *Trigonella foenum-graecum* L. (1753), *Zea mays* L. (1753), *Zingiber officinale*

Roscoe. (1807), *Ziziphus spina-christi* L. (1798). These species, belonging to 25 different botanical families, are presented with different frequencies of use by the local population of the wilaya in Table 2, dominated by the Lamiaceae family (31.25%) followed by the Apiaceae (12.5%) and other families (Thymeleaceae, Asteraceae, Cupressaceae, Fabaceae, Chenopodiaceae, Amaranthaceae, Gentianaceae, Punicaceae, Rutaceae, Zygophyllaceae, Verbenaceae, Rubiaceae, Malvaceae, Rhamnaceae, Anacardiaceae, Zingiberaceae, Linaceae, Myrtaceae, Poaceae, Ephedraceae, Brassicaceae, Ranunculaceae, Lauraceae) are represented by only one or two species (Figure 2). The species most frequently cited by herbalists are *Thymus vulgaris* and *Ammoides verticillata*, with respective frequencies of citation of 80% and 76%, followed by *Mentha pulegium* with a frequency of 42%, then *Artemisia herba alba*, *Rosmarinus officinalis*, and *Rubia tinctorum* with a frequency of 30%, and other species with FC values below 30% (Table 2, Figure 3). The results of the survey showed that the species in high demand among the local population are *Thymus vulgaris* and *Ammoides verticillata*. According to herbalists, these species are indicated in the treatment of infectious disorders caused by seasonal flu (Table 2, Figure 3).

3.3 Plant parts used

The active ingredient in the drug can be found in different parts of the plant, depending on the species: leaves, flowers, stems, roots, seeds, etc. According to the herbalists surveyed, leaves are by far the most commonly used part of the plant in phytotherapeutic preparations, accounting for 50% of reported uses, followed by stems and seeds at 16%, flowers at 11%, roots account for only 3% of observed practices, while other parts such as bristles, rhizomes and rhytidomes account for only 3% (Table 2, Figure 4).

3.4 Biological types

The species listed belong to five biological types, the most commonly mentioned by herbalists being phanerophytes, hemikryptophytes and therophytes (Figure 5).

3.5 Informant consensus factor

The calculation of ICF rates revealed low consensus values. All indices are below average (0.5), with variations ranging from 0 to 0.41 (Table 3, Figure 6). The highest consensus rate among herbalists was observed for infectious disorders, followed by digestive and stomach disorders.

3.6 Discussion

The information gathered from herbalists on the gender and age group most interested in herbal medicine at the local level is similar to that obtained in other surveys conducted in certain regions of Algeria. Comparable findings have been reported in Tizi Ouzou, northern Algeria [44], Tiaret [45] and Tlemcen [46] in western Algeria, Adrar in the south [13], and Guelma in the east [47]. These studies showed that women and older people were more interested in herbal therapy. There is strong demand for remedies made from the leaves and stems of the species most frequently cited in this research (*Thymus vulgaris* and *Ammoides verticillata*), which are used to treat seasonal flu. The same result was reported in another study [48], contrary to an ethnobotanical study of medicinal plants in the Jijel region [49], which identified two plant species as the most widely used by the population: *Calamintha baborensis* Batt., of the Lamiaceae family, whose aerial parts are used in the treatment of gastrointestinal problems, particularly diarrhoea, and *Arum maculatum* L., the araceae family, used to lower cholesterol levels and for hypoglycaemia. The dominant families to which the species listed in this study belong are comparable to those found in an ethnobotanical survey in the wilaya of Tizi Ouzou, which noted the dominance of Lamiaceae among the families of species requested by traditional practitioners [50]. This is also evident in an ethnobotanical survey conducted in Fez, Morocco, which showed the dominance of this family [51]. However, another study conducted in the Middle Moulouya region of the province of Boulamne (north-eastern Morocco) counted 144 species belonging to 44 families, with a predominance of Asteraceae (17.94%), followed by Lamiaceae (7.69%), Amaranthaceae (5.98%) and Brassicaceae (5.12%) [52]. According to the information gathered in this study, the leaves are the part of the plant most commonly used in herbal medicine. This predominance of leaves is corroborated by ethnobotanical studies conducted in Tizi Ouzou (Algeria) [11], the Oum Ali forest in El Taraf [53], Settlat (Morocco) [54], other regions of Morocco [51,55], Oran (Algeria) [15], Ivory Coast [56], Tunisia [57], and the Democratic Republic of Congo [58]. These results therefore confirm a common trend in many regions that favour leaves for traditional healthcare. The local species of the Sidi Bel Abbès region, mentioned by herbalists for their traditional uses, are each of particular interest. Knowing their biological type can contribute to the promotion of this local knowledge and to understanding their ecological

behaviour. According to the classification [59], the biological types of plants reflect their strategy for adapting to unfavourable seasons, mainly through the position of their regeneration buds. Knowledge of these biological types makes it possible to develop an ecological interpretation of plant communities by identifying the dominant life forms and assessing the degree to which species are adapted to the climatic constraints of the environment. Following the results obtained, a critical analysis is required to better understand the meaning of the data collected. The low consensus index (ICF) values observed for most pathological categories suggest significant diversity in the therapeutic uses reported by herbalists. This low level of agreement can be interpreted as reflecting several realities in the field. The lack of structured phytotherapeutic training and the oral transmission of knowledge between generations encourage subjectivity and variability in practices.

3.6.1 Comparison of traditional knowledge with scientific evidence

Research has been conducted to assess whether herbalists' prescriptions are part of a coherent phytotherapeutic approach, or whether they are simply a commercial activity motivated by daily profit. To verify the validity of their claims, a comparison was made between a few frequently cited species and the available scientific data on their medicinal properties. This comparative analysis helps to promote local knowledge while comparing it with scientific data, which meets the objective of the study. *Thymus vulgaris* L.: belongs to the aromatic plant species of the Lamiaceae family and is commonly known as 'thyme'. This important medicinal herb is found in various regions of the world, particularly in the Mediterranean [60]. In traditional medicine, this species is cultivated in many countries by local populations, particularly in rural areas, where medicinal plants are used to treat a wide range of ailments [61]. During the ethnobotanical survey, herbalists interviewed in the Sidi Bel Abbès region mentioned *Thymus vulgaris* as one of the most widely used and sought-after plants for treating respiratory conditions, particularly flu-like symptoms. These traditional uses are corroborated by scientific literature. Thus, among medicinal plants used to treat influenza, particular attention is paid to those that have inhibitory effects on neuraminidase or haemagglutinin, two key proteins of the influenza virus [62]. Extracts from several plants have been tested for this purpose, and *Thymus vulgaris* is one of those cited for its antiviral potential. The antiviral activity of *Thymus*

vulgaris may be linked to its high flavonoid content, some of which are known to inhibit the action of neuraminidase, thereby helping to slow the spread of the virus in the body [63]. We believe that these scientific data are consistent with the empirical knowledge reported by local herbalists. In addition to its use in respiratory conditions, *Thymus vulgaris* is also mentioned by herbalists in Sidi Bel Abbès as a remedy for food poisoning. Several studies have been conducted in this regard. One study on the antimicrobial effect of thyme extracts from the Sidi Bel Abbès region [64] demonstrated the inhibition of the growth of several pathogens responsible for digestive disorders and food poisoning, in particular *Escherichia coli* and *Bacillus cereus*, recognised as causes of food poisoning [65]. These data help to prove that the antimicrobial properties of *Thymus vulgaris* are based on tangible scientific evidence, beyond traditional local knowledge. The ethnobotanical survey conducted among local herbalists reveals partial knowledge of the therapeutic uses of *Thymus vulgaris*. Although its digestive properties and its use against winter illnesses are well known and practised, other scientifically recognised applications are not mentioned by local practitioners. For example, the external uses of thyme in the form of aromatic baths, compresses or solutions to treat superficial wounds, oral infections [66-68] or pruritus are not mentioned. The high antiviral efficacy of *Thymus vulgaris* aqueous extract against both types of herpes simplex virus (HSV), which is resistant to acyclovir, has been demonstrated [69], indicating that the extracts exert their antiviral effect on free HSV and offer an opportunity for topical therapeutic application against recurrent herpes infections. Furthermore, according to published data [70], thyme is considered to be antiseptic, antimicrobial, astringent, vermifuge, carminative, disinfectant and tonic, extremely useful in cases of various intestinal infections and infestations, such as hookworms, roundworms, Gram-positive and Gram-negative bacteria, fungi and yeasts such as *Candida albicans*. Its active ingredient, thymol, is effective against enterobacteria and cocci. Thyme can also improve liver function and stimulate appetite. It is used in the treatment of bronchial and urinary tract infections. As a gargle, thyme is useful in the treatment of laryngitis and inflammation. This gap suggests a need to pass on and enrich traditional knowledge in order to incorporate practices that have been validated by recent scientific research. *Ammoides verticillata* (Desf.) Briq: Known as Carambole and Ajwain in several countries, it is called Noukha in Algeria [71]. It is a herbaceous plant 30 to 70 cm tall that grows wild in

Europe, the Mediterranean region, North Africa, Egypt, Iran and India. During this ethnobotanical survey, herbalists in the Sidi Bel Abbès region reported that the aerial parts of *Ammoides verticillata* are commonly used in infusions to treat colds, flu and fever. This traditional use is partly confirmed at the local level by studies [72,73], which showed that the aqueous extract of this plant contains flavonoids, tannins, coumarins and saponosides, known for their antiviral, anti-inflammatory and expectorant effects. A study of the phytochemical screening and antimicrobial evaluation of aqueous extracts of *Ammoides verticillata* [74] showed that the infusion of stems and flowers was very active against *Escherichia coli*, *Citrobacter*, *Enterobacter*, *Staphylococcus aureus* and *Staphylococcus epidermidis*. These scientific results therefore corroborate the popular uses reported by herbalists. *Aquilaria malaccensis* Lam: called "Oud Gheris" by local herbalists, is a species of tropical plants in the Thymelaeaceae family, known as an agarwood-producing species. This species is native to South and Southeast Asia, with Indonesia and Malaysia being the two main sources of agarwood. This species was cited by herbalists during the present survey for the therapeutic virtues of its stems, particularly in the traditional treatment of cancer and diabetes. The latter was cited during an ethnobotanical study on medicinal plants reputed to be anticancer in two oncological hospitals in Tiaret (Algeria) [75] and Tlemcen (Northwest Algeria) [76] as a therapeutic treatment for this disease. It was also mentioned during an ethnobotanical approach on medicinal plants presumed to be antidiabetic used in traditional medicine in the city of Ghardaïa, in the northern Algerian Sahara [77]. This information was also reported in a study of the effect of this species on insulin resistance in Wistar rats [78], which revealed that this species has the ability to control lipid peroxidation and biochemical disturbances associated with insulin resistance, the methanolic extract of Agarwood is an effective therapeutic system against insulin resistance, hyperlipidemia which helps limit the development of diseases such as diabetes and its complications. The available scientific data remains limited. This limited number of studies does not allow us to reliably validate the claims made by herbalists regarding the effectiveness of this plant for the treatment of cancer and diabetes. *Bunium bulbocastanum* L.: Groundnut or ground chestnut, known in Algeria by the vernacular name of Talghouda or Terghouda. This species is native to the Balearic Islands, western Central Europe (northwestern former Yugoslavia). Its fruits are used as a flavoring, the leaves and roots are eaten as

vegetables [79]. This species was mentioned by herbalists in the treatment of the thyroid gland (Goiter) and respiratory allergies during our ethnobotanical survey carried out in the region of Sidi Bel Abbès. An ethnobotanical study on medicinal plants for therapeutic use listed this species for the treatment of goiter [80]. Some studies have helped confirm the effectiveness of groundnut in correcting thyroid function. A study examined its impact on testicular function in mice made hypothyroid by carbimazole for two months, then treated with groundnut [81]. The results showed that this plant acts rather on the restoration of thyroid function while other studies have confirmed that treatment with groundnut allows the restoration of alterations caused by carbimazole almost similarly to treatment with levothyroxine [82]. A study on the therapeutic potential of the Algerian peanut (*Bunium bulbocastanum*) food supplement in the treatment of thyroid dysfunction in rabbits [83] highlighted that this species is a viable natural intervention for managing thyroid dysfunction. *Punica granatum* L.: Belonging to the Punicaceae family, it is known by its vernacular name of "pomegranate" and by its local name of "Romane". Its fruit is used empirically in traditional medicines. Spread by Arab nomads, then introduced to China at the beginning of the 2nd century BC, the pomegranate was imported to Rome by the Romans returning from the Punic Wars. Later, the pomegranate was introduced to the Iberian Peninsula, where the name of its fruit, the pomegranate, was given to one of the largest cities in Spain [84]. According to the herbalists interviewed during this study, the skin of the fruit of *Punica granatum* is used against inflammations

of the stomach and colon as well as for hair loss. In the region of Bougous (El Kala National Park, northeastern Algeria), the pomegranate tree was inventoried among 164 species used in herbal medicine by the population, the survey indicated that the species is used as an anti-diarrheal, against intestinal worms (antiparasitic), against stomach aches, high blood pressure, as an antiseptic and healing agent for irritated skin. The parts used of the plant are the leaves and the skin of the fruit, generally prepared in the form of an infusion, decoction or dried and then reduced to powder before administration [85]. In Rabat (Western Morocco), some ethnobotanical research among the populations noted that the species was used against diarrhea and gastrointestinal diseases [86]. In the region of Jijel and the Chr  a National Park, an ethnobotanical study on the pharmacological effects of *Punica granatum* selected from seven species used in traditional medicine, concluded that this species has an antiulcer effect which was compared and verified with a reference drug [87]. A recent study targeted pomegranate by evaluating its anti-inflammatory activity and the in vitro toxicity of pomegranate peel extracts concluded that different fruit peel extracts have significant antiinflammatory capacity by preventing lysosomal membrane lysis [17]. Although the herbalists interviewed attributed various therapeutic properties to the 48 species mentioned, only five were randomly selected for comparison with scientific data. This work allowed traditional knowledge to be compared with existing scientific evidence. However, further investigations are necessary to validate the pharmacological effects of the other species identified.

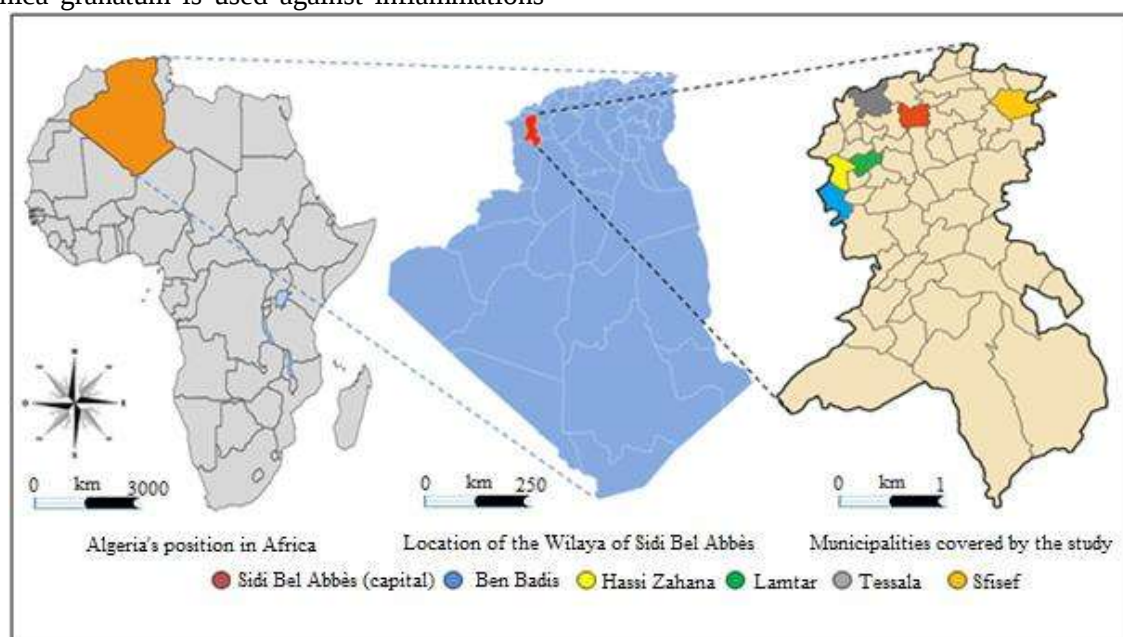


Figure 1. Geographical location of the study area and municipalities surveyed in the Wilaya of Sidi Bel Abb  s (north-west Algeria).

Table 1. Characteristics of the sites covered by the survey.

Survey municipality	Coordinates (Lambert)	Inhabitants (2019)	Active herbalists (2021)	Herbalists surveyed
Sidi Bel Abbès (capital)	35°11'38" N; 0°38'29" W	245,441	44	18
Lamtar	35°04'14" N; 0°47'53" W	7,530	1	1
Hassi Zahana	35°01'33" N; 0°53'25" W	8,500	2	2
Ben Badis	34°57'06" N; 0°54'50" W	20,346	4	3
Tessala	35°14'35" N; 0°46'23" W	7,499	1	1
Sfisef	35°14'04" N; 0°14'36" W	29,696	5	1

Table 2. Medicinal species identified during the ethnobotanical survey and their main characteristics.

No.	Species	Family	Biological type	Part used	Use/application	Use importance	FC (%)
01	<i>Ajuga reptans</i> L.	Lamiaceae	Hemikryptophytes	Leaves	- Gynaecology, obstetrics and urology - Digestive and stomach, - Rheumatology	+++	3%
02	<i>Aloysia citrodora</i> Palau.	Verbenaceae	Phanerophytes	Leaves	- Infectious disorders	+++	19%
03	<i>Ammoides verticillata</i> (Desf.) Briq.	Apiaceae	Therophytes	Leaves Stems	- Infectious disorders	+++	76%
04	<i>Aquilaria malaccensis</i> Lam	Thymelaeaceae	Phanerophytes	Stems	- Oncological, - Endocrine-metabolic	+++	7%
05	<i>Artemisia herba alba</i> Asso	Asteraceae	Chamephytes	Stems Leaves	- Digestive and stomach, - Paediatric, - Cardiovascular	+++	30%
06	<i>Atriplex hortensis</i> L.	Chenopodiaceae	Therophytes	Leaves	- Endocrine- metabolic, - Gynaecology, obstetrics and urology - Oncological	+++	23%
07	<i>Bunium bulbocastanum</i> L.	Apiaceae	Geophytes	Roots	- Dermatological, - Endocrine-metabolic - Pulmonary- Respiratory	+++	11%
08	<i>Carum carvi</i> L.	Apiaceae	Hemikryptophytes	Seeds	- Paediatric, - Digestive and stomach	+++	7%
09	<i>Centaurium erythraea</i> Rafn.	Gentianaceae	Therophytes	Leaves Flowers	- Digestive and stomach, - Aesthetics, - Dermatological	++	3%
10	<i>Chamaemelum nobile</i> L.	Asteraceae	Hemikryptophytes	Flowers	- Neurological,- Cardiovascular	+++	19%
11	<i>Cuminum cyminum</i> L.	Apiaceae	Therophytes	Seeds	- Digestive and stomach	++	3%
12	<i>Daphne gnidium</i> L.	Thymelaeaceae	Phanerophytes	Leaves	- Gynaecology, obstetrics and urology -E.N.T- Aesthetics	+++	7%
13	<i>Ephedra alata</i> Decne.	Ephedraceae	Phanerophytes	Leaves	- Oncological	+	3%
14	<i>Eucalyptus globulus</i> Labill.	Myrtaceae	Phanerophytes	Leaves	- Aesthetics, - Infectious disorders	+++	3%
15	<i>Foeniculum vulgare</i> Mill.	Apiaceae	Hemikryptophytes	Seeds	- Digestive and stomach	++	15%
16	<i>Haloxylon scoparium</i> Pomel.	Chenopodiaceae	Chamephytes	Leaves	- Endocrine- metabolic, - Dermatological, - Infectious disorders	++	11%
17	<i>Hibiscus sabdariffa</i> L.	Malvaceae	Phanerophytes	Flowers	- Psychological disorder	++	7%
18	<i>Juniperus communis</i> L.	Cupressaceae	Phanerophytes	Leaves	- Digestive and stomach,	+++	19%
19	<i>Laurus nobilis</i> L.	Lauraceae	Phanerophytes	Leaves	- Cardiovascular	+++	3%
20	<i>Lavandula angustifolia</i> Mill.	Lamiaceae	Chamephytes	Leaves Flowers Stems	- Infectious disorders	++	26%

No.	Species	Family	Biological type	Part used	Use/application	Use importance	FC (%)
21	<i>Lepidum sativum</i> L.	Brassicaceae	Therophytes	Seeds	- Endocrine- metabolic, - Cardiovascular, - Digestive and stomach,	++	3%
22	<i>Linum usitatissimum</i> L.	Linaceae	Therophytes	Seeds	- Aesthetics, - dietetics	+++	15%
23	<i>Marrubium vulgare</i> L.	Lamiaceae	Hemikryptophytes	Leaves Stems	- Gynaecology, obstetrics and urology	+++	11%
24	<i>Melissa officinalis</i> L.	Lamiaceae	Hemikryptophytes	Leaves Flowers	- Digestive and stomach	+	7%
25	<i>Mentha pulegium</i> L.	Lamiaceae	Hemikryptophytes	Leaves Flowers Stems	- Pulmonary- Respiratory, - Neurological	+++	42%
26	<i>Nigella sativa</i> L.	Ranunculaceae	Therophytes	Seeds	- Pulmonary- Respiratory, - dietetics	+++	3%
27	<i>Ocimum basilicum</i> L.	Lamiaceae	Therophytes	Leaves	- Digestive and stomach	++	15%
28	<i>Origanum majorana</i> L.	Lamiaceae	Therophytes	Leaves Flowers	- Psychological disorder, - Endocrine- metabolic, - dietetics	++	15%
29	<i>Origanum vulgare</i> L.	Lamiaceae	Hemikryptophytes	Leaves	- Cardiovascular	++	7%
30	<i>Peganum harmala</i> L.	Zygophyllaceae	Chamephytes	Seeds	- Dermatological, - Aesthetics	+++	7%
31	<i>Pimpinella anisum</i> L.	Apiaceae	Therophytes	Seeds	- Digestive and stomach,	+++	15%
32	<i>Pinus pinaster</i> Aiton	Pinaceae	Phanerophytes	Rhytidome	- Digestive and stomach, - Dermatological	++	3%
33	<i>Pistacia lentiscus</i> L.	Anacardiaceae	Phanerophytes	Leaves	- Digestive and stomach,	+++	7%
34	<i>Punica granatum</i> L.	Punicaceae	Phanerophytes	Leaves Fruit	- Digestive and stomach, - Aesthetics, - Dermatological	+++	11%
35	<i>Rosmarinus officinalis</i> L.	Lamiaceae	Chamephytes	Stems Leaves	- Oncological, - Neurological, - Endocrine- metabolic, - Pulmonary- Respiratory	+++	30%
36	<i>Rubia tinctorum</i> L.	Rubiaceae	Hemikryptophytes	Stems	- Haematological, - Oncological, - Endocrine- metabolic, - Digestive and stomach	++	30%
37	<i>Ruta graveolens</i> L.	Rutaceae	Hemikryptophytes	Stems Leaves	- Digestive and stomach,	+++	15%
38	<i>Salvia argentea</i> L.	Lamiaceae	Hemikryptophytes	Leaves	- Pulmonary- Respiratory	+++	3%
39	<i>Salvia officinalis</i> L.	Lamiaceae	Chamephytes	Leaves	- Haematological, - Cardiovascular	+++	19%
40	<i>Satureja calamintha</i> (L.) Kuntze	Lamiaceae	Hemikryptophytes	Leaves Stems	- Gynaecology, obstetrics and urology - Neurological, - Infectious disorders	+++	23%
41	<i>Senna alexandrina</i> Mill.	Fabaceae	Phanerophytes	Leaves	- Digestive and stomach	+++	11%
42	<i>Thymus algeriensis</i> Boiss. & Reut.	Lamiaceae	Hemikryptophytes	Leaves	- Cardiovascular	+++	3%
43	<i>Thymus serpyllum</i> L.	Lamiaceae	Chamephytes	Leaves	- Infectious disorders, - Pulmonary- Respiratory, - Cardiovascular	++	7%
44	<i>Thymus vulgaris</i> L.	Lamiaceae	Chamephytes	Leaves	- Infectious disorders, - Digestive and stomach,	+++	80%
45	<i>Trigonella foenum-graecum</i> L.	Fabaceae	Therophytes	Seeds	- Aesthetics, - Dermatological, - dietetics, - Cardiovascular, - Endocrine- metabolic, -	+++	11%

No.	Species	Family	Biological type	Part used	Use/application	Use importance	FC (%)
					Gynaecology, obstetrics and urology		
46	<i>Zea mays</i> L.	Poaceae	Therophytes	Silks	- Gynaecology, obstetrics and urology, - Digestive and stomach	+ +	7%
47	<i>Zingiber officinale</i> Roscoe.	Zingiberaceae	Geophytes	Rhizome	- Digestive and stomach,	+ + +	7%
48	<i>Ziziphus spina-christi</i> L.	Rhamnaceae	Phanerophytes	Leaves Seeds Roots	- Rheumatology, - Digestive and stomach,, - Aesthetics, - Dermatological	+ +	23%

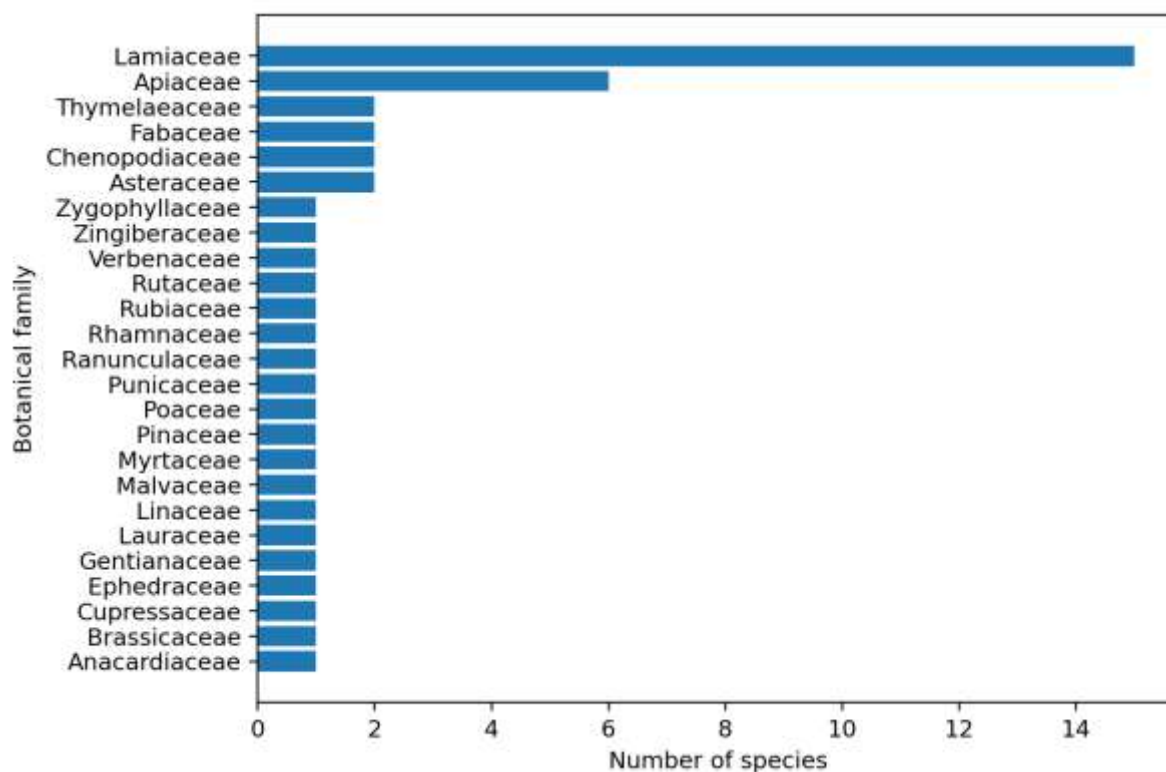


Figure 2. Number of species cited by herbalists in each botanical family.

Table 3. Disease categories, conditions treated, number of species and informant consensus factor (ICF).

Disease category	Conditions affected	No. species	ICF
Infectious disorders (ID)	Fever, urinary tract infections, influenza, pharyngitis	8	0.41
Neurological (NE)	Migraine	4	0
Cardiovascular (CAV)	Heart disease, blood circulation, high/low blood pressure, cholesterol	9	0
Digestive and stomach (DS)	Hepatitis, intestinal worms, colic, food poisoning, liver, colon, constipation, diarrhoea, nausea, intestinal gas, pancreas	20	0.34
Pulmonary-respiratory (PNR)	Respiratory allergy, cough, asthma, bronchitis	6	0.16
Gynaecology, obstetrics and urology (GOU)	Ovarian cysts, fibroids, hormones, pregnancy, urinary tract infections, bladder, kidneys, breastfeeding	7	0.33
Rheumatological (RHU)	Rheumatological disorders	2	0
Dermatological (DER)	Skin injuries, fungal infections, irritation, hair loss	8	0
Endocrine-metabolic (EM)	Diabetes, goitre	8	0
Paediatric (PED)	Intestinal gas and sleep disorders in babies	2	0
Aesthetics (AST)	Hair and lice	8	0.12
Oncological (ONC)	Cancer	5	0
Haematological (HEM)	Anaemia, cholesterol, immunity	3	0

Disease category	Conditions affected	No. species	ICF
Psychological disorders (PD)	Insomnia, nervousness, stress	2	0
ENT	Sinusitis	1	0
Nutrition (NUT)	Cholesterol, loss of appetite, thinness, obesity	5	0.33

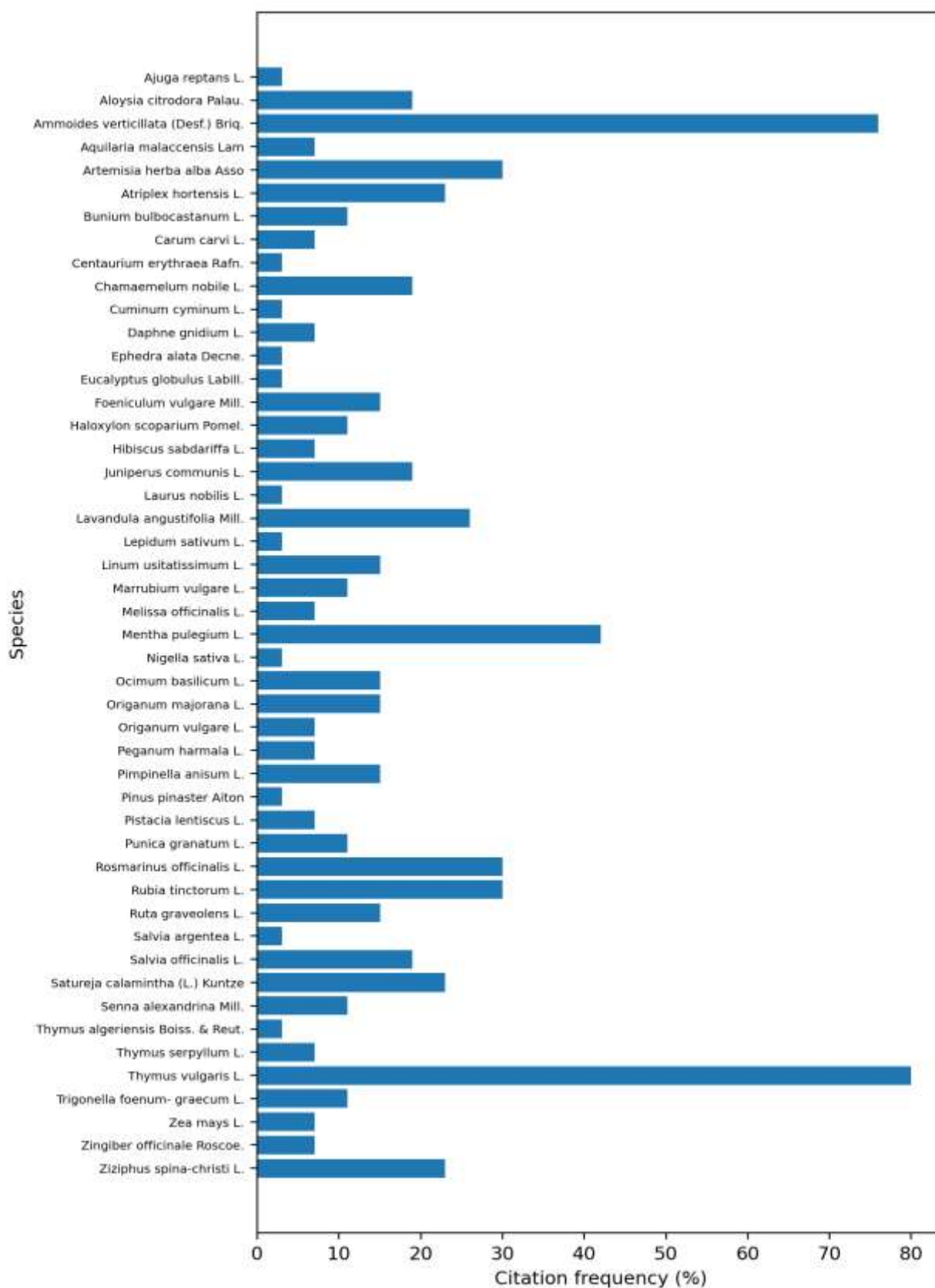


Figure 3. Citation frequency of medicinal species recorded in herbalist shops in the selected municipalities.

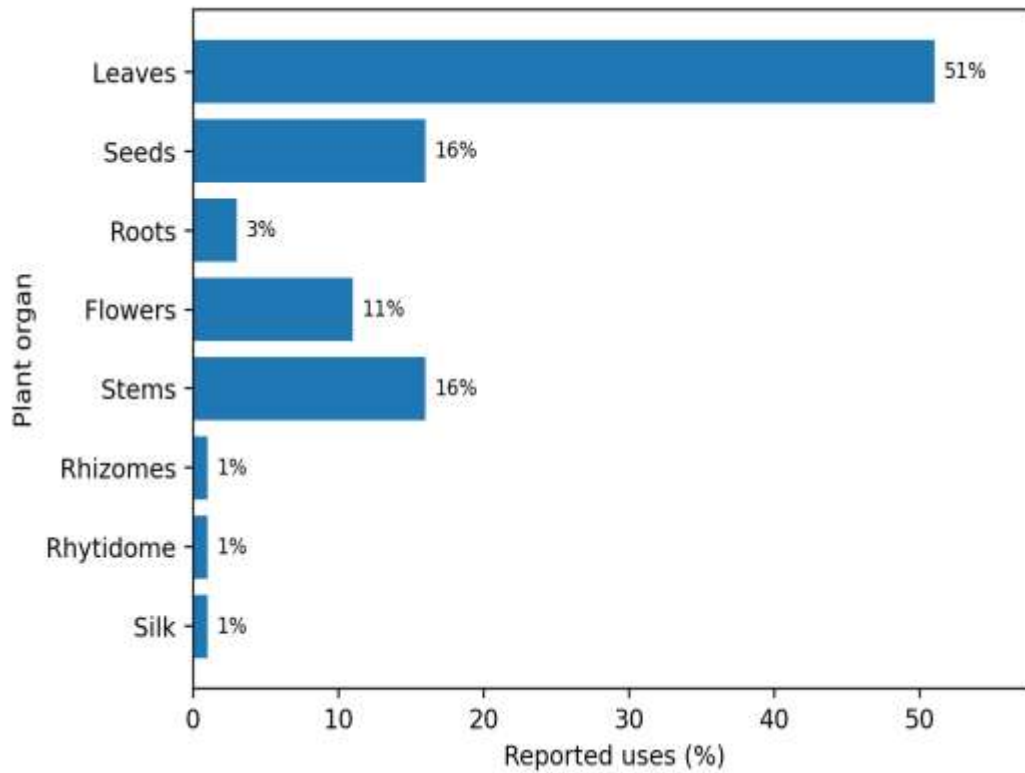


Figure 4. Percentage distribution of plant organs used in herbal medicine.

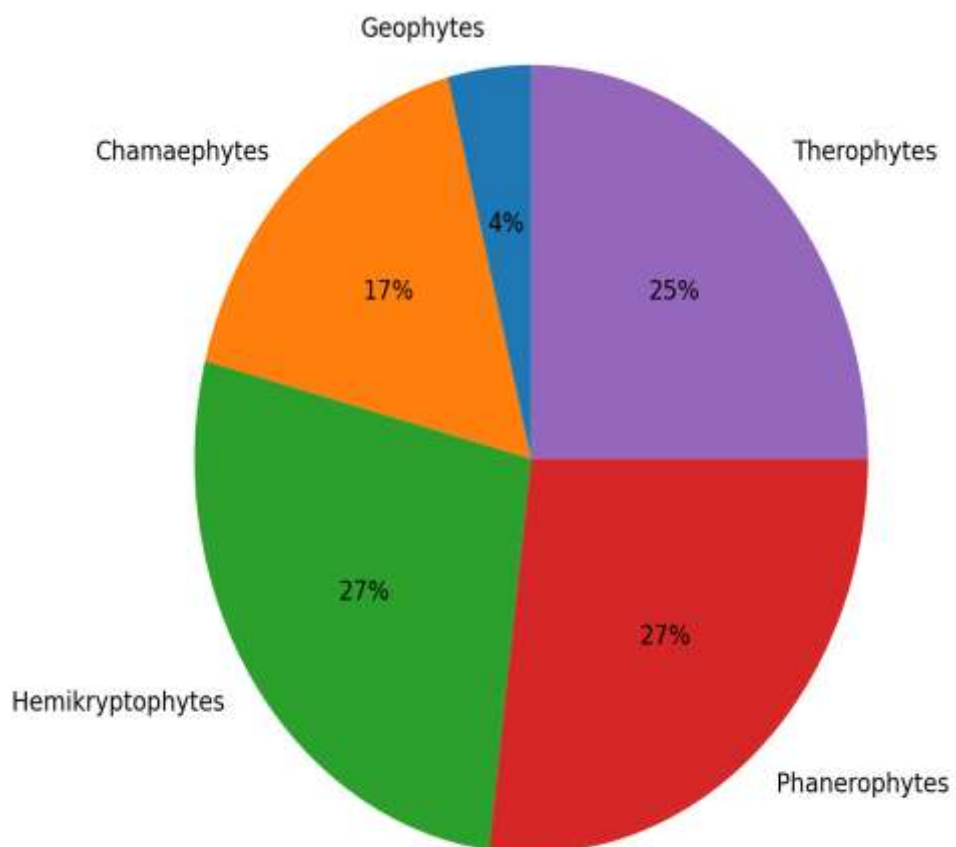


Figure 5. Biological spectrum of the medicinal species recorded during the survey.

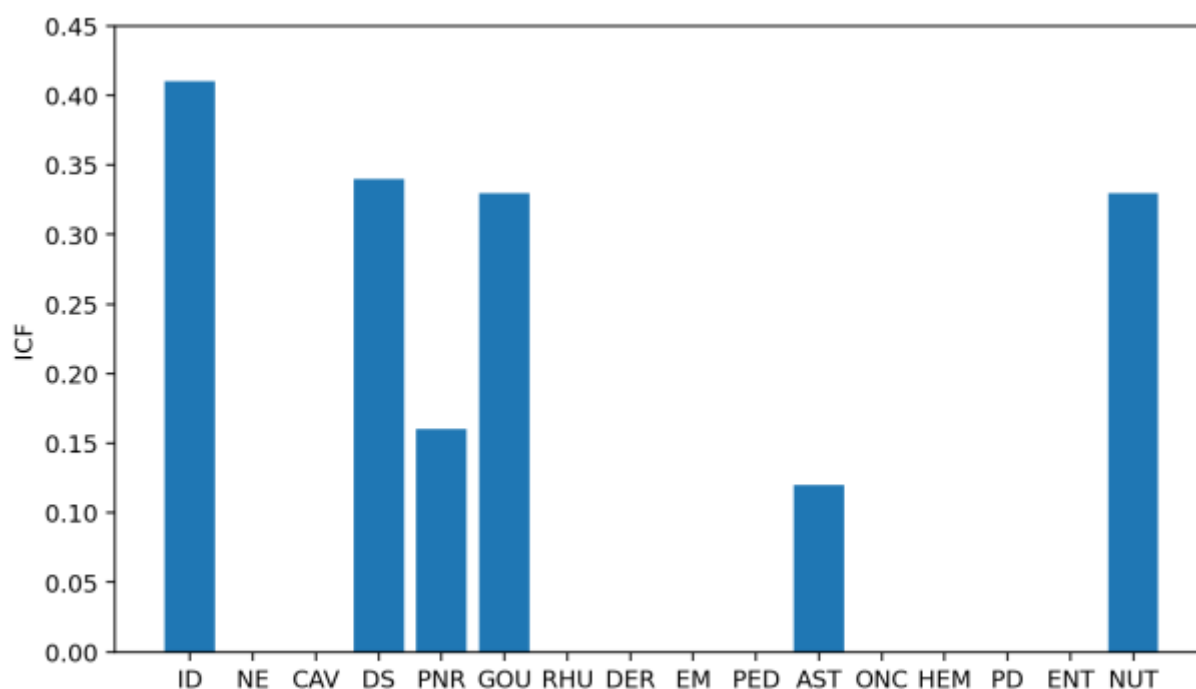


Figure 6. Informant consensus factor (ICF) for health problems treated with the recorded species. Abbreviations are defined in Table 3

4. Conclusions

This ethnobotanical study, conducted among herbalists in the Sidi Bel Abbès region, revealed that a wide range of medicinal plants are sought after by the local population for the treatment of various health problems. The survey identified 48 species belonging to 25 families, dominated by the Lamiaceae family (31.25%), followed by the Apiaceae (12.5%). The other families are represented by only one or two species. Among the species listed, *Thymus vulgaris* and *Ammoides verticillata* are the most sought-after, with a frequency of citation of 80% and 76%, indicated for the treatment of infectious disorders, followed by other species with varying frequencies of citation. The exchange of information between herbalists is very limited, as confirmed by the ICF calculation. Studies on the therapeutic effects of many species listed in this survey, for which scientific evidence is lacking, are needed to scientifically validate their use.

Despite the evolution of the chemical industry and the availability of treatments capable of addressing most health problems, herbal medicine continues to play an important role among the local population. However, the origin of certain medicinal species, particularly indigenous, wild and uncultivated species, raises concerns, notably due to harvesting difficulties and scarcity or unavailability as a result of the absence of protection protocols. This situation highlights the need to implement strategies for the conservation and protection of

these plant resources, as well as to carry out in-depth scientific studies to support and validate the applications of these plant resources in traditional folk therapy. The intensive use and uncontrolled harvesting of the most sought-after medicinal plants in the region pose a real risk to the sustainability of these species. This pressure is exacerbated by the fact that the herbalists surveyed have no training or education, which limits their knowledge of good practices for harvesting and sustainable resource management. It is therefore essential to implement awareness-raising activities and appropriate conservation programmes to ensure the preservation of local plant heritage while maintaining traditional knowledge.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.
- **Use of AI Tools:** The author(s) declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

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Appendix A. Survey Forms

ETHNOBOTANICAL SURVEY QUESTIONNAIRE (Appendix 01)

File No

Date :

1. Location code:

2. Herbalist code:

3. Age : 20-40 years old ☐ 40-60 years old ☐ +60 years old ☐

4. Length of service in the field:
-10 years ☐ 10-20 years ☐ +20 years ☐

5. Level of education: graduate ☐ No ☐

6. Niveau de connaissance des plantes médicinales :
Low ☐ average ☐ good ☐ very good ☐

7. Learning environment:
Vocation ☐ Legacy ☐ Chance ☐ Field of study ☐ Other ☐

8. Total number of medicinal plants for sale:
-10 ☐ 10 - 30 ☐ 30 - 50 ☐ +50 ☐

9. Number of plants requested during the year (approximate number) :

10. Number of the most popular or well-known plants:

11. Number of least requested or least known plants :

12. Category of population interested in plants for sale
Men ☐ Women ☐
Elderly ☐ Young ☐

Figure A1. Questionnaire used to collect information about the herbalists interviewed.

ETHNOBOTANICAL SURVEY QUESTIONNAIRE (Appendix 02)

File No :....

Date :.....

1. Location code:.....

2. Herbalist code:.....

Plant code	Plant names			Part used (organ)	packaging (dry/fresh)	Origin (wild/cultivated)	Harvest season / harvesting method	Use/application	Frequency of demand/sales (estimate)
	Arabic	vernacular French	scientific						

Figure A2. Questionnaire used to record the medicinal species cited by herbalists.