

Ethnobotanical survey of medicinal wild plants in the Shouf Biosphere Reserve, Lebanon

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Abstract

Background: Medicinal plants and associated traditional knowledge play a vital role in supporting the livelihoods and resilience of indigenous communities. This ethnobotanical survey aims to identify medicinal plants used by the local communities of the Shouf Biosphere Reserve (SBR) and document the associated traditional knowledge.

Methodology: Focusgroups and personal interviews with 133 informants of community members of 22 villages of SBR were performed during 2019-2022. Informants were selected using purposive sampling techniques based on their knowledge of medicinal plants and experience in traditional herbal medicine. Interviews were conducted using a semi-structured questionnaire through field visits.

Results: Informants were equally represented by females and males, had different demographic characteristics, and the main source of knowledge was ancestral.

A total of 184 medicinal plant species belonging to 57 families were documented. The predominant families were Asteraceae (31 spp.), Lamiaceae (14 spp.), and Rosaceae (14 spp.). Leaves (23%) were the plant part most used. Decoction (45%) was the predominant preparation method, while internal (oral) use (47%) was the most frequent administration mean. *Berberis libanotica*, *Dittrichia viscosa*, and *Daucus carota* achieved the highest scores of Frequency of Citation (FC), Relative frequency of citation (RFC), Use value (UV), and Fidelity level (FL). Furthermore, the gastrointestinal tract was the most treated system.

Conclusions: Findings revealed a rich and diverse list of medicinal plants with associated traditional knowledge still actively used to treat a wide range of diseases. Future phytochemical and pharmacological studies are recommended to determine the efficacy and safety of plant species used. The management body of the SBR and all related authorities are invited to continue their conservation efforts to protect such rich biocultural heritage.

Introduction

Since antiquity, the use of medicinal wild plants has been globally practiced as one of the fundamental bases of traditional health care systems of indigenous communities (Sadiku et al., 2022). Today, medicinal wild plants continue to provide a wide range of therapeutic benefits for many diseases and act as an important source of novel drugs and natural products (FAO, 2022). The WHO Traditional Medicine Strategy 2014–2023 aims to strengthen the role of traditional medicine and emphasizes that traditional treatments, herbal medicines and traditional practitioners are a primary source if not the only source, of health care for millions of people (WHO, 2013). This intimate interaction between man and plants has led to the accumulation of a wealth of traditional knowledge presently recognized as relevant to preserving plant biodiversity and understanding the dynamic relationships between wild plants, social, and cultural systems (CBD, 1993). Yet, this traditional knowledge is under the threat of erosion being mostly orally transmitted between generations and traditional practitioners (Martin, 1995). Thus, documentation of this traditional knowledge through ethnopharmacology surveys is important to preserve this valuable knowledge and valorize priority medicinal plants of high therapeutic potential towards new drug discovery and contribution to livelihoods of indigenous community worldwide.

Situated in the Eastern Mediterranean, Lebanon represents a rich repository of medicinal plants and associated traditional (Arnold-Apostolides, 1991). The country hosts 360 species believed to have medicinal properties (GEF-UNDP-LARI, 2013). Many of these plants are extensively used in the preparation of herbal remedies that are used alone or in combination with conventional modern medications. These plants also serve as important raw materials for many natural products. Like many societies, it is becoming trendy in modern Lebanese societies to use combinations of traditional medicinal plants with conventional drug therapy (Afifi et al., 2013). This renewed interest may be seen in the context of changes in the lifestyle, that values the concept of natural products. This leads consumers to perceive the use of medicinal plants as a healthy option for treatments (Baydoun et al., 2015). Previous research on medicinal plants in some localities of Lebanon has documented some unique species such as *Salvia fruticosa*, *Achillea fragrantissima*, *Artemisia herba-alba* and *Peganum harmala*, that have a high potential therapeutic value in the treatment of many diseases such as diabetes, cardiovascular diseases, asthma, and rheumatism. Such studies provide the rationale for the selection and scientific investigation of priority species (El Beyrouthy et al., 2013; Arnold et al., 2014; and Nasser et al., 2018). Nevertheless, research on this topic in Lebanon is very limited compared to other countries and still very restricted to specific areas. It is highly likely that many potential medicinal plants are still not explored yet and are waiting to be identified. Therefore, more research is needed to explore this potential in other regions in the country especially in forests given their richness of flora biodiversity and proven profitability of sustainable exploitation of medicinal plants (Lebanon CBD, 2015).

In this respect, the forest of Shouf Biosphere Reserve (SBR) stands as a potentially rich resource of wild plants being one of the valuable ecosystem services of the Reserve. Estimated in the range of 16.7 to 21.3 million US dollars/ year, SBR provides a variety of ecosystem services (ECODIT, 2015) including the direct use of plants of which medicinal plants continue to play a major role. Vegetation of SBR have a high diversity due to the altitudinal gradient, continentality gradient, lithological variability, and the historical interactions between people and nature (Regato et al., 2018). Supra-Mediterranean (1000–1500 m.a.s.l.) and Oro-Mediterranean (1500–2000 m.a.s.l.) bio-climatic zones are represented in SBR and each zone corresponds to a series of plant communities. While the higher parts of SBR are rich in species that accompany the *Cedrus libani*

forests such as *Prunus prostrata* and *Berberis libanotica* and the lower parts, where the communities live, are very rich in the medicinal species that accompany the agricultural lands such as *Ruscus aculeatus*, *Salvia sclarea* and *Hypericum triquetrifolium*. The recent list of plant species in SBR identified 1054 different species.

The SBR includes three zones (core, buffer, and development) (Fig. 1) and is home to more than 170,057 inhabitants, living in the 22 villages of the development zone. Security issues, political instability, Syria crisis, COVID 19 and the current economic situation have had a marked impact on the social fabric of SBR that hosts now approximately 58,000 Syrian refugees, mostly in its eastern side (Regato et al., 2018).

The health care system of communities of SBR includes primary care centers, dispensaries, private clinics, and a few hospitals in addition to the herbalists and home care traditional treatment. In which medicinal plants present a major contributor. Due to the current economic crises, governmental social security services cover only a little percentage of the medical cost of the individuals. Adding to that, the big number of refugees residing in the region has added extra pressure on the health care system. Such circumstances have encouraged communities to revive their ethnobotanical medical system. It is observed that herbalists and local healers now receive more locals for traditional consultations and treatments.

In this direction, SBR has recently established the commercial production of the hydrolates and essential oils of several important medicinal plants such as *Eryngium creticum*, *Origanum syriacum*, *Salvia fruticosa*, *Dirichia viscosa*, and *Urtica dioica* / *U. urens*. Also, a Zaatar House (Oregano House) was established at one of Reserve's villages, (Maasser el Shouf), where the waters and essential oils of *O. syriacum* and *Lavandula angustifolia* are commercially produced and sold. Despite these important initiatives, there is still a need to have a good understanding of the medicinal plant species and associated traditional knowledge of SBR. This is especially important today as current economic situation has urged many individuals including youth of SBR communities to come back to their rural areas and revive their cultural practices including the use of medicinal plants.

This ethnobotanical survey aims to identify medicinal plants used by the local communities of SBR and document related traditional knowledge. The following questions are addressed: What are the plant species local communities of SBR use in their traditional health care system? What are the associated practices? What are the disease categories treated by the identified plants? Findings could contribute to the scientific understanding of traditional medicine and identification of priority species of high potential for drug discovery, economic valorisation, and livelihood development of local communities.

Materials And Methods

Study area

The study area of this ethnobotanical survey is SBR (Fig. 1). SBR lies between longitude 35° 28'–35° 47' East and latitude 33° 32'–35° 48' North at an altitude of 800 to 1950 m. a.s.l. occupying an area of approximately 539 km² equivalent to 5% of the total area of Lebanon, making it the largest protected area in the Mediterranean area of the Middle East. Designated by UNESCO in 2005, SBR consists of the Al-Shouf Cedar Nature Reserve that was established by the Lebanese Government in 1996 under the authority of the Ministry of Environment (MoE) and 22 surrounding villages located in the Shouf, Aley and West Bekaa districts (Abu-Izzeddine, 2018). The SBR is home to more than 170,057 inhabitants, spreading over villages located in the development zone of the Reserve that surrounds the core and buffer areas. On average 30% of the population are civil servants, 30% are engaged in agriculture activities, 25% in private businesses, and 15% are unemployed.

Climate of SBR is characterized by a bio-climatic gradient from the Supra Mediterranean type at the lower altitudes, with fresh to cold temperatures and sub-humid conditions (annual rainfall between 600 and 1,300 mm), to the Oro-Mediterranean type at higher altitudes, with subhumid to humid conditions (annual rainfall between 1,000 and 1,600 mm) and cold to very cold temperatures. The eastern slopes have drier conditions with annual rainfall lower than 600 mm (Hani et al., 2017).

Ethnobotanical survey and data collection

The data collection was performed during 2019–2021 following the different flowering seasons in the 22 villages of SBR by focus groups and personal interviews organised with key informants of community members. Informants were selected by purposive sampling method based on the knowledge of informants about medicinal plants and experience in traditional herbal medicine. A semi-structured questionnaire was used in the interviews covering informant personal information (age, sex, and education.) and source of knowledge, vernacular name of plant species, ailments and diseases treated, and preparation and administration methods.

Data collection followed the code of ethics of the International Society of Ethnobotany (ISE, 2006) and respected by the Convention of Biological Diversity (CBD, 1993) and the CBD Nagoya protocol on Access and Benefit Sharing (CBD, 2018). Prior the implementation of the study, the approval of SBR committee in terms of objectives, design and approach and a verbal consent of each informant post providing a clear explanation of the study's objectives were obtained.

The interviews with the informants were mainly conducted during repetitive field walks mainly during the flowering season to ensure capturing the seasonal differences and the whole floral cycle. Alternatively, fresh specimens and photos of plant species were shown to informants in case of limiting conditions. Photos of cited species were taken, and some interviews were recorded using a mobile phone or filmed using a professional videographer. Voucher fresh floristic specimens were collected, pressed, and labeled immediately in the field and deposited at the SBR herbarium. These specimens were later scanned and saved online in a special database on the SBR website (Bridson and Forman, 2013, Weckerle et al, 2018).

Plant identification was conducted based on the taxonomic keys of the New Flora of Lebanon and Syria (Mouterde, 1966; 1970; 1983) and confirmed by the Botany, Pharmacognosy and Pharmacology Professor Dr. Dr. Nelly Arnold Apostolides. New species naming and botanical family delimitation were based on Plants of the World Online (POWO, 2022). Species ID was presented on the nomenclature of the International Plant Names Index (IPNI Plant, 2022).

Ailment and disease categories

All ailments and diseases cited by informants were classified into categories according to the International Classification of Primary Care (ICPC-2) (<https://www.icpc-3.info/>), post some modifications (Table 4). Indications such as headache, toothache, poisoning (as antidote), scurvy, cancer, eye infections, allergy, and fatigue, that did not match with any of the categories were grouped in the "Others category".

Data analysis

Quantitative analysis of collected data was performed based on computing the following indices:

- Frequency of Citation (FC)

Number of times a particular species was mentioned/total number of times that all species are cited $\times 100$.

- Relative frequency of citation (RFC)

Number of informants mentioning the use of a species divided by total number of informants participating in the survey (Tardío and Pardo-de-Santayana, 2008). The RFC index ranges from "0" when no citation of a plant species as useful to "1" when all informants refer to the plant as useful.

- Use value (UV)

This index quantifies the relative importance of cited plants (Phillips et al., 1994; Andrade-Cetto & Heinrich, 2011). It is calculated by the formula $UV = \sum U/N$, Where, "U" refers to the number of uses mentioned by the informants for a species and "N" refers to the total number of informants interviewed. A high UV score indicates there are many use reports for that plant, while a low score indicates fewer use reports cited by the informants.

- Factor of informant consensus (FIC)

This index reflects the level of homogeneity between information provided by different informants. It was calculated as $FIC = (Nur - Nt) / (Nur - 1)$ (Heinrich et al., 1998). Where Nur is the number of use reports from informants for a particular disease category and Nt is the total number of species used for that category.

- Fidelity level (FL)

Fidelity level (FL) is the percentage of informants who mention the use(s) of a certain plant species to treat a particular ailment or disease. It quantifies the informants' choice for a potential plant species to treat a given ailment, thus reflecting its therapeutic importance (ref). It is calculated using the formula: $FL (\%) = Np/N \times 100$ where Np is the number of informants that claimed use of a particular plant species for a particular ailment or disease and N is the total number of informants citing the species for any ailment or disease. The maximum FL illustrates the frequency and high use of the species for treating a particular ailment by the informants in the area under study.

Results

Demographic features of informants and source of knowledge

A total of 133 informants of different demographic groups were interviewed on the therapeutic properties of medicinal plants throughout the 22 villages under study (Table 1). As indicated in the Table, informants were almost of equal shares of women (51%) and men (49%). They constituted five age groups falling in the range of 19 to 97 years old with the majority being of 40–80 years old. Informants were also of different educational backgrounds with 52 (39%), 40 (30%) and 25 (19%) persons of them having intermediate, secondary and university education,

respectively. The remaining informants were of either primary education or had no schooling. Farmers were 60 represented (44%) and housewives were 54 (41%), together representing the majority of informants' profession, whereas other professions were exemplified by a few persons only.

Table 1
Informants' demographic data and the percentage of data provided this can go the supplementary

Gender	Number	%	Data %	Educational level	Number	%	Data %
Men	65	49	58	University	25	19	10
Women	68	51	42	Secondary	40	30	21
Knowledge	Ancestral	Self-Training	TP	Intermediate	52	39	43
Informants %	65	26	9	Primary	4	3	18
				No schooling	12	9	10
Age group	Number	%	Data %	Profession	Number	%	%
Less than 20	1	1	0.5	Farmers	60	44	44
more than 20–40	4	3	1	Shepherds	3	2	1
More than 40–60	55	41	39	Housewives	54	41	38
more than 60–80	58	44	52	Shopkeepers	5	4	2
more than 80	15	11	7	Traditional practitioners (TP)	5	4	13
				Health care professionals (dentist, pharmacist, nurse)	7	5	2

Table 1 also shows the number of cited plants per informant group. While males provided 58% of the cited species, females presented the remaining number (42%). Older age groups cited more plants than younger age groups with most plants (89%) being cited by informants of the 40–80 years old. Moreover, 71% of cited plants was provided by informants who had lower level of education (i.e. no schooling, primary and intermediate levels). As for profession aspect, farmers and housewives representing 85% of the total number of informants, provided 82% of the cited plants. Despite their small number (4 informants, 4%), traditional practitioners provided 13% of the cited plants.

As for the main source of informant's knowledge, oral transmission of ancestors (65%) was reported as the main approach through which informants acquired their knowledge about the medicinal properties of plants and means to use them. Whereas, self-training using traditional manuscripts, modern online means and contemporary books represented 26% and learning from fellow herbalists and traditional practitioners formed 9% only.

Cited Species Diversity

The floristic analysis of cited species reveals a list of 184 plant species of medicinal properties used for the treatment of a wide range of diseases. Table S1 (Quantitative and qualitative ethnobotanical data of wild medicinal plants in the Shouf Biosphere Reserve, Lebanon) presents the scientific and common names, botanical families, and life forms of these species. It also presents plant parts used, therapeutic indications, preparations and administrations, dosages, along with quantitative analysis values (FC, RFC, UV, RI and FL) used as a tool for the prioritisation of certain species for future pharmacological research and development projects. Remarks provided by informants such as other uses, toxicity and endemism are also included.

The cited species belonged to 57 families with Asteraceae (31 spp.) having the predominant representation followed by Lamiaceae (14 spp.), Rosaceae (14 spp.), Fabaceae (7 spp.), Apiaceae (7 spp.), Caryophyllaceae (6 spp.) and Brassicaceae (6 spp.). Other families were represented by no more than 4 species only.

Based on the New Flora of Lebanon and Syria (Mouterde, 1966; 1970; 1983), all the 184 cited species were native. Among them, two species, i.e. *Berberis libanotica* and *Pseudopodospermum libanoticum*, were endemic to Lebanon-Syria, and another two, i.e. *Arum palaestinum* and *Onopordum cynarocephalum* were endemic to Lebanon-Syria-Palestine. Whereas, 15 other species were endemic to the region including Turkey, Cyprus, Greece and Iraq, i.e. *Acanthus hirsutus subsp. syriacus*, *Achillea falcata*, *Crocus graveolens*, *Ferulago trachycarpa* and *Valeriana erotica*.

Herbaceous species constituted the highest contribution (156 species) of the cited species, while climbers, shrubs and trees contributed 2, 11 and 15 species, respectively. The Raunkiar's (1934) life form classification system was used to classify the plants in this survey into herbs, climbers, shrubs, and trees.

Mode Of Preparation, Administration Methods And Dosage Of Application (Dup: Abstract ?)

Most plant species were cited for the treatment of more than one ailment and disease, for instance, *Matricaria aurea* treated 24 conditions, *Taraxacum officinale* 23 conditions and *Urtica urens* 19 conditions (Table S1).

Leaves represented the plant parts most used (23%), followed by aerial parts (15%), flowers / inflorescences (14%), roots/bulbs/rhizome/tubers (14%) and fruits (10%) (Table 2). Other parts such as whole plant, seeds, bark, wood, latex, and stem were also cited. For most plants, more than one plant part was used.

Table 2 Number of plants and percentage of plant parts used												
	Whole plant	Aerial	Flowers/ inflorescences	Leaves	Fruits	Seeds	Bark	Resin /Gum	Roots/ Bulb/ Rhizome/Tubers	Wood	Latex	Stem/young shoot
Sub-total	36	61	56	91	39	28	8	6	58	3	3	15
%	9	15	14	23	10	7	2	1	14	1	1	4

Preparation methods were diverse with decoction being most common (45%), followed by infusion (25%), maceration (9%) and latex/fresh juice (9%) (Table 3). Informants also reported the use of excipients (water, alcohol, oil, honey, and eggs) and some additives (salt and sugar).

While most preparations were based on the use of a single species, some mixtures for treating respiratory and gastrointestinal conditions, in particular, were also commonly reported. For example, a mixture of *Micromeria myrtifolia*, *Myrtus communis*, *Matricaria aurea*, *Salvia fruticosa*, *Alcea setosa*, and *Mentha longifolia* was used to treat common cold, cough, flu and sore throat. Another common mixture was made of *Salvia fruticosa*, *Origanum syriacum* and *Foeniculum vulgare*. This mixture is used for stomachache and colic conditions. In the case of diarrhoea, some peels of pomegranate (*Punica granatum*) is added.

Table 3 Number plants and percentage of preparation									
	Decoction	Infusion	Maceration	Latex/ Fresh juice/ Syrup	Hydro-distillation	Fumigation	Steaming	Powder	
Sub-total	123	67	25	25	11	5	4	12	
%	45	25	9	9	4	2	1	4	

The majority of remedies were prepared from fresh materials soonest after collection (60%), and some were prepared from either dried or fresh materials (31%) while a few were only used from dried materials (9%).

Medicinal formulations were administered orally (internally) (47%) in ailment categories other than dermatological problems, 8% is administered externally in dermatological ailments, while both usages internally and externally were used in 45% of cited plants.

Informants used different measuring units such as Arabic coffee cup (70 ml), glass (200 ml), soup bowl (350 ml), tea spoon (6 ml) or table spoon (12ml), pinch of three fingers (5 grams), and handful (20 grams), in addition to traditional and contemporary weighing measures such as oz (28 grams), dirham (3 grams), etc. Formulations were taken till recovery.

Interestingly, dosage of detailed formulations was particularly provided by some traditional portioners. For example, one coffee cup per day for 15 days of the decoction of *Daucus carota* seeds was recommended for cystitis, diuretic, laxative, diabetes, spasms, etc (Table S1). Also, two cups per day (morning and evening) for two days only of the decoction of the seeds mixed with cherry peduncles and palm dates was cited as highly efficient in the treatment of kidney stones (Table S1).

Nevertheless, informants expressed concern about side effects of some species in cases of overuse (Table S1). Among the most toxic species were such as *Arum palaestinum*, *Arum hygrophilum*, *Eupatorium cannabinum*, *Ruscus aculeatus*, *Dittrichia graveolen*, *Ricinus communis*, *Tussilago farfara*, *Lonicera etrusca*, *Ecballium elaterium*, *Hyoscyamus aureus*, and *Prunus cocomilia*. In particular, ingestion of a high dose of *E. cannabinum*, a species cited for the treatment of liver and gallbladder disorders, skin infections, colds, and fever causes tremor, delirium, and even death. Also, a relatively more frequent smoking of *T. farfara* leaves was perceived as a seriously harmful practice. Likewise, *E. elaterium* was considered highly toxic if a dose greater than one drop/day is administered as a nasal instillation. Such doses cause serious side effects such as

uvular edema, nasal and tongue edema, and other adverse effects on the voice of users. Also, a high dose of *P. cocomilia* seeds and young shoots used for diarrhea, skin diseases, liver cirrhosis, and diuretic was cited as toxic. With this particular example, informants reported the use of the level of bitterness as an indicator of toxicity. While the berries of the *L. etrusca* were cited among the mildly poisonous.

Further, informants highlighted the multiuse of several cited species (Table S1). The diverse uses reported were: edible for human, ritual and spiritual use, ornamental and decoration, source of natural materials (cosmetics, insect repellent and pesticide, dyes), fire wood, forage, and melliferous. *Gundelia tournefortii*, *Pseudopodospermum molle*, *Eryngium creticum*, *Rhus coriaria*, and *Cichorium intybus* among others (n=84 species) were cited as edible plants. Further, *Anchusa hybrida*, *Calicotome villosa* and *Cedrus libani* were among the most frequently cited as melliferous plants (n=33). Also, *Cistus creticus* and *Chrozophora tinctoria* were among species cited for forage. Informants also reported that treatment was done by oneself in common ailments such as common cold, indigestion, mosquito bite, abdominal pain, etc).

Ethnobotanical Indices

Quantitative indices presented in Table S1 revealed that species of highest FC values were *Berberis libanotica*, *Hyoscyamus reticulatus*, *Dittrichia viscosa*, *Echinops spinosissimus* and *Urtica dioica*.

Table S1 also shows that RFC ranged between 0.05 and 0.48 with *Dittrichia viscosa* scoring the top value. Other high RFC values were achieved by *Capparis spinosa* (0.44), *Micromeria myrtifolia* (0.41), *Centaurea iberica* (0.40) and *Daucus carota* (0.38). Species of low RFC included *Blitum virgatum* and *Aristolochia sempervirens* having the value of 0.05.

Values of UV ranged between 0.10 and 3.86 with *Dittrichia viscosa* achieving the highest score (UV 3.86). The plant was cited to treat wide range of diseases and ailments including skin diseases (wounds and infections), respiratory (bronchitis), gastrointestinal and liver (stomach ulcers), diabetes and rheumatism. *Daucus carota* followed with a score of UV 3.85 used to treat less number of ailments (Table 4). On the other hand, *Centranthus ruber* and *Ficaria vicioides* achieved the lowest values (UV 0.10).

Wide diversity of diseases and ailments was recorded and grouped into 14 use categories (Table 4). Gastrointestinal system and liver diseases were treated by 16% of the cited plants. This was followed by skin and related symptoms (13%), respiratory system diseases (9%), central nervous system (7%) and blood-hematopoietic system (7%) (Table 4). Accordingly, the FIC values reflecting the agreement between informants of the use of a species in the treatment of specific disease category fell in the 0.62 to 0.02 range.

Table 4
The categories of diseases and ailments treated by medicinal plants of SBR and relevant FIC values.

Category	Number of Plants	FIC
1. Respiratory system: Cold, sinusitis, sore throat, cough and asthma, catarrhs, etc	83	0.58
2. Gastro intestinal system and liver disease: Diarrhea, intestinal worms, abdominal cramps, gastric ulcers, aerocoly, hemorrhoids, etc	142	0.62
3. Renal system: Kidney stones, renal infections, renal insufficiency, Edema,....	34	0.39
4. Genital system: Impotency and sterility, menstrual disorders, prostate disorders, uterine infections, etc	50	0.26
5. Fever	28	0.1
6. Blood-hematopoietic system: Gout, blood neoplasms, anemia, hypercholesterolemia,	64	0.33
7. Diabetes	48	0.02
8. Skin and related symptoms: Ecchymosis, wounds, skin diseases, vitiligo, warts, insect stings, headlice, etc	118	0.56
9. Rheumatism	37	0.05
10. Central nervous system: Insomnia, epilepsy, sciatica, etc	64	0.43
11. Infectious and urinary diseases: Infections	74	0.26
12. Cardiovascular system: Hypertension, palpitation,	24	0.26
13. Inflammation	50	0.21
14. Others: Headache, toothache, poisoning (as antidote), scurvy, cancer, eye infections, allergy and fatigue,	91	0.36

The highest fidelity level (100%) was recoded with *Berberis libanotica*, *Hyoscyamus reticulatus*, and *Dittrichia viscosa* which are frequently cited to treat specific ailments and diseases including respiratory, skin, gastrointestinal, blood-hematopoietic system, diabetes and rheumatism, and

ranged between 90–95% for the rest of highly cited plants (Table S1)

Discussion

In this study, a rich list of 185 medicinal plant species belonging to 59 botanical families was reported by 133 informants from the local communities of the SBR for use in the treatment of 14 categories of ailments and diseases. The rich list of medicinal plants highlights the importance of the provision of ecosystem services of SBR that support health care systems and the well-being of communities in the 22 villages of the SBR. This high number of cited species and associated traditional knowledge clearly reflects that medicinal plants continue to play a critical role in the healthcare systems of these communities and present a potential resource for resilience and sustainability. This is especially relevant in the times of the economic crises Lebanon is presently facing and the growing need for national production for health and pharmaceutical industries in the country.

Demographic Feature Of Informants And Source Of Knowledge

The results presented in Table 1 suggest that the demographic variables of informants influence the traditional botanical knowledge of cited medicinal plants. Despite their nearly equal numbers in the inquiry under study, men seem to have more knowledge as they provided 58% of the collected data compared to women. This pattern may be related to the broader exposure men have while practicing their professions and communicating with community members and fellows of the same professions. It may be indicated in the fact that a significant share of reported knowledge was provided by farmers being all males who can acquire good botanical knowledge about the healing effects of plants through their observations of the animals' responses to plants consumption and detection of the side effects and properties different plant species to control several pests that attack crops. Nevertheless, housewives also provide a high share of knowledge (38%) that can be attributed to their role in taking care of their families and their high tendency to develop a cohesive social network with other women and share knowledge with their ancestors. Data on age groups clearly shows that older people had much experience, skills and knowledge on therapeutic properties, preparation and administration of remedies related to cited plants. The drop of knowledge noted among younger generations may be due to changing lifestyles and transitions in traditional medicine interests. Data also shows that education seems to have an inverse relationship with knowledge as many educated people don't have interest to learn and practice traditional use of medicinal plants probably because time invested in schooling deflects them from acquiring botanical knowledge of medicinal plants. The aforementioned influence of demographic characteristics on botanical knowledge is commonly reported in the literature (Taïbi et al., 2014). Findings varied between communities and regions as the acquisition of traditional knowledge on medicinal plants is a complex and dynamic social process that can be influenced by multiple socioeconomic and cultural drivers that mostly do not act independently (Bencheikh et al., 2021).

Further, the dominance of oral transmission of ancestors as the main sources of ethnobotanical knowledge (65%) may be associated with the fact that communities in SBR villages are characterised by deep traditional customs and that information about herbal medicines are often considered secret, and therefore, only transmitted to descendant by elders. This indicates a high risk of loss of such important cultural heritage, the need is to devise reliable means to avoid this risk.

Ethnobotanical Diversity

This study recorded 184 medicinal plant species belonging to 57 families that were used to treat wide range of diseases (Table S1). This indicates high diversity in terms of total number and representative families that may be mostly due to the high diversity and abundance of members of this family in Lebanon and neighbouring countries in the Eastern Mediterranean (Güler et al., 2015; Sadat-Hosseini et al., 2017; Hosseini et al., 2021). Also, the effectiveness of members of these families may be of a high relevance. Literature shows that many members of these families have antioxidant, anti-inflammatory, antimicrobial, antioxidant, anti-hyperlipidemia, vasorelaxant, antithrombotic, hepatoprotective and diuretic effects. These bioactivities are attributed to the phytochemical components of relevant species (Achika et al., 2014; Koc et al., 2015; Rolnik et al., 2021). For example, the chemical composition of *Matricaria aurea* of Asteraceae is dominated by terpenoids and phenolic compounds, phenolic acid, flavonoids, and coumarins (El Mihyaoui et al., 2022). Another example of Asteraceae is *Dittrichia viscosa* which is rich in sesquiterpenes, flavonoids and caffeic acids among others (Grauso et al., 2019). Also, the high diuretic activity of *Taraxacum officinale* may be attributed to its high potassium content (Jedrejek et al., 2017). The astringent properties of tannins being a major constituent in Rosaceae species promote rapid healing and the formation of new tissues on wounds and inflamed mucosa (Jarić et al., 2017). Tannins are effective in the treatment of diarrhea, intestinal catarrh, varicose ulcers, hemorrhoids, minor burns, frostbite, as well as inflammation of gums and as an antidote. Moreover, tannins are recently found to demonstrate antiviral activities for treatment of viral diseases including AIDS (Nonaka et al., 1990).

The most widely used species were of herbaceous life form constituting the highest category of 156 species (85%). This may be attributed to their relatively higher abundance in Mediterranean forest ecosystems being subjected to intense human transformation (Mouterde, 1966; 1970; 1983). Also, collection of herbaceous plant material may be relatively less time and effort consuming. Similar findings were reported by other studies throughout the world (Khan et al., 2013; Munir et al., 2022).

Most species were used in monotherapies based on preparations from a single plant to treat more than one condition. This may be attributed to the presence of several active components in the composition of one particular plant and also the fact that such components can be active against several pathogens. In the other occasions where mixtures of two or more species were used as efficient treatment of certain conditions indicate a potential synergistic effect of such plants.

Some of the medicinal plant species identified in the study area are reported in other regions of Lebanon (Radwan et al., 2020; Arnold et al., 2015; Baydoun et al., 2017), other Eastern Mediterranean (Tsioutsou, 2017; Khatib et al., 2021) and Middle East countries (Al-douri, 2011) to treat the same or different ailments. Such wide ethnomedicinal uses of these species for similar or different conditions in many countries is a well-founded indication of high therapeutic potential of these species. A comparison between the findings of current study and those of Hermon Mountain, a recently announced reserve, in the Southeast of the country shows a rich uniqueness in medicinal species and associated knowledge of SBR. Examples of unique uses are the decoction of flowers and fruits of *Crataegus azarolus* for diabetes as well as seeds and roots of *Sarcopoterium spinosum*, fresh leaves of *Dittrichia viscosa* for wounds healing, decoction of aerial parts of *Daucus carota* for kidney stones, uterine and urinary infections, and whole plant of *Eryngium creticum* for snake /insect bites and skin diseases. On the other hand, the similarity observed can be explained by vegetation resemblance as well as the high cultural exchange between the local communities of SBR and Hermon Mountain.

The high utilisation of leaves is in line with previous research in Lebanon (Baydoun et al., 2015) and also in other countries (Gurdal et al., 2012). Leaves are favoured parts in the preparation of herbal formulation because of their easy handling and sustainability. Leaves also contain diverse plant secondary metabolites. However, other plant parts such as whole plants and roots were also frequently cited. This practice can cause a decline in the plant populations and affect its natural regeneration, especially that the majority of cited plants were of herbaceous nature. On the other hand, removing leaves within reasonable limits doesn't interfere with the plant life compared to collecting other parts that may risk plant lives.

Mode Of Preparation, Administration Methods And Dosage Of Application

The frequent use of decoction might be due to the belief that heat is effective in the destruction of plant tissues leading to the release of many active compounds in water (Jaradat et al, 2016). Compared to infusion, decoction is particularly very effective in extracting non-aromatic plants, and it at the same time preserves the herbal remedies for a longer period than fresh preparations. However, both decoction and infusion don't offer long shelf life for the preparations. Therefore, users would need to continuously harvest medicinal plants putting them under increased pressure of over harvesting.

Oral application as the main administration route is commonly used in many herbal remedies as reported in the literature (Getachew et al, 2022). It offers a large effective surface area for absorption of formulations' active components. This choice may be associated with the use of some solvents such as water, olive oil, almond oil, and honey. Such solvents and additives are commonly believed to serve as an efficient vehicle to transport remedies, enhance extraction of bioactive molecules, improve taste and diminish adverse effects such as vomiting and diarrhoea.

A lack of consistency regarding the dosage of formulations was apparent among informants. It was apparent that the traditional practitioners were more confident to provide more information about doses. However, informants reported that the use of plant species depends on several factors such as the nature of the plant, the user's age, health, and several other conditions. Other informants expressed high uncertainty. For example, few informants mentioned dosage and detailed formulation on the use of *Daucus carota* which is one of the most cited plants by informants for kidney stones and intestinal infections.

Noteworthy the general awareness of informants on the risk of some side effects and health complications to happen causing both short term and long-term problems for patients. The literature provides many examples of cases about toxicity and safety implications of herbal medicines (Mensah et al., 2019) attributed to many toxins. For example, *Tussilago farfara* contains toxic compounds among which pyrrolizidine alkaloids and *Prunus cocomilia* contains cyanogenic glycosides, especially amygdalin and prunasin (Seremet et al, 2018). Also, *Eupatorium cannabinum* contains hepatotoxic pyrrolizidine alkaloids which may block blood flow in the veins and cause liver damage, cancer, and breath defects (Al-Snafi et al., 2017). Even when applied to broken skin, dangerous chemicals can be absorbed and can lead to dangerous body wide toxicity. Obviously, external use is relatively of less risk as compared to internal/oral applications. Under any condition, there is a high chance of the patient to be victim of the side effects of the medicinal plant. thus, there is a need to develop standardised traditional treatment guidelines for medicinal plants and to always keep in mind that natural products are not always necessarily safe.

Moreover, findings also indicated that several of the cited plants serve for various purposes such as food, bee forage and pesticides increasing their potential for community livelihood.

Quantitative Indices

Species with the highest FC and RFC values and those of high UV specify the usefulness of these species and their potential as priority species that merit future comprehensive phytochemical and pharmacological studies (Chaachouay et al., 2021). Some of these species such as *Dittrichia viscosa*, *Daucus carota*, *Capparis spinosa* and *Micromeria myrtifolia* scored high FC and RFC values in previous reports from different parts of the world (Katiri et al, 2017, Meddour et al, 2022). This confirms the high therapeutic potential of such species as an important alternative source to provide people with formulations to prevent disease, maintain health or cure ailments. On the other hand, some of the herein cited species are unique being narrow endemics to Lebanon and Syria or the region. Among these are, *Pseudopodospermum libanoticum*, locally named as Dabeh Lebnan, *Arum palaestinum* (Loof) and *Berberis libanotica* (Berbaris loubnani) (Ali-Shtayeh. et al, 2008, El-Merahbi et al, 2014).

The maximum FIC value reported for gastrointestinal disorders may reflect the widespread prevalence of these disease in the sites under study as well as the efficacy of cited plants in the treatment of such diseases. Similar results for gastrointestinal disorders were also reported by other studies in the country (Baydoun et al., 2015).

The plant species with 100% FL of *Dittrichia viscosa* has been reported by other authors confirming the potential of this plant to treat a particular ailment (Chaachouay et al, 2021). Richness in several metabolites such as sesquiterpenes, flavonoids and caffeic acids (Grauso, 2019), explain the wide range of usage of *D. viscosa* for several ailments under many categories. Such plant should be considered for further phytopharmacological investigation.

Conclusion And Recommendations

The results of this ethnobotanical survey in the SBR show that a high diversity of medicinal plants and a wealth of traditional knowledge continue to play a significant role in the traditional health care system and the treatment of a wide range of diseases in the region.

The high dependency on medicinal plants for primary healthcare and the perception of people of their declining trend call for preserving these resources and the associated traditional knowledge, while minimizing the threats, and protecting the medicinal plants as an integral part of the SBR management plan.

Despite community awareness of toxic side effects, careful attention must be given to the use of many species. Most medicinal plant species used belong to Asteraceae, Lamiaceae and Rosaceae, frequently used to manage serious diseases worldwide. There was a general consensus on the plant species used to manage diseases of the gastrointestinal system. This is a clear indication that such plants are effective and merit further studies for phytochemical screening and identification of bioactive constituents and their associated pharmacological activities.

There is a need to develop training programs on the sustainable use of medicinal plants for the SBR local communities and incorporate regulations to safeguard the diversity of medicinal plants as an important source of ecosystem services. This approach is critical to balance demand for medicinal plants and promote social well-being while maintaining the vitality of SBR ecosystem services.

The importance of traditional knowledge of medicinal plants was highly perceived by informants owing to the substantial role of culture in inspiring the conservation of medicinal plants. Therefore, SBR managers and authorities are invited to incorporate traditional knowledge into the Reserve's biodiversity conservation plan and management strategy.

Declarations

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

This work is part of Nizar Hani PhD (the main and corresponding author of the manuscript), Prof. Nelly Arnold-Apostolides is the PhD director and supervisor, who guided, revised, and corrected the manuscript. Dr. Safaa Baydoun helped to carefully revise the text of the manuscript, Dr. Hatem Nasser collected the data related to chemical characteristics of many plant species and Dr. Tiziana Ulian from Kew Gardens helped to revise and correct the data mainly related to the edible and other characteristics of the plant species. All the authors read and approved the final manuscript.

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Ethical Approval and Consent to participate

A verbal approval was gotten from every informant as well as approval to get photos, records and videos following the code of ethics of the International Society of Ethnobotany

Consent for publication

A written approval was delivered by SBR committee

Availability of supporting data

All raw data is available, filled questionnaires, herbarium specimens, photos, videos, scanned herbarium specimens, etc

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Figures

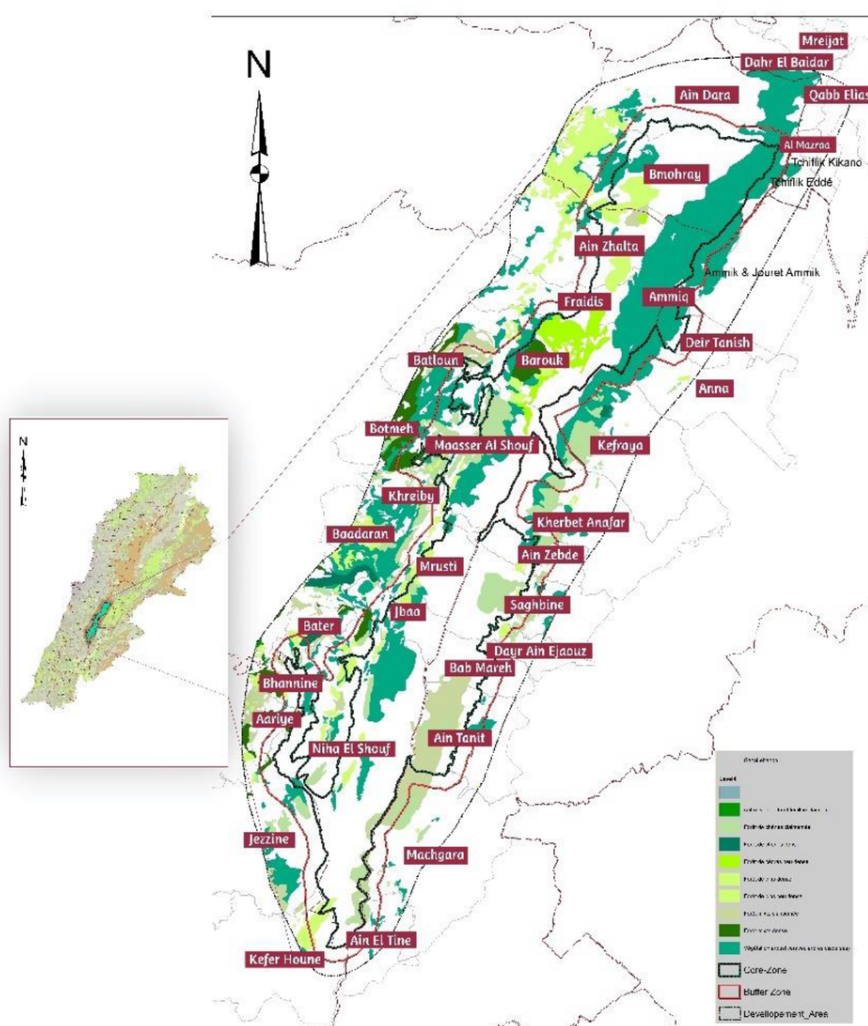


Figure 1

The map of the study area (villages of Ain Dara, Bmohray, Ain Zhalta, Barouk, Fraidiss, Batloun, Maasser, Khraibeh, Baadaran, Mrusti, Jbaa, Niha, Aitanit, Bab Marea, Ain Zebdi, Saghbine, Kherbet Kanafar, Kefraya, Ana, Ammiq, Qebelias)

Supplementary Files

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- [TableS1QuantitativeandqualitativeethnobotanicaldataofwildmedicinalplantsintheShoufBiosphereReserveLebanon.xlsx](#)