Herbal Medicine Used in the Treatment of Human Diseases in the Rif, Northern Morocco

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Abstract

Since the beginning of time, the Moroccan people have used many medicinal plants as a popular medicine to cure many human and livestock health problems. Yet, few studies have been carried in the past to properly document and promote traditional ethnomedicinal knowledge. This study was conducted out from July 1st, 2016 to July 30th, 2018 in the Rif; it was aimed to establish the list of medicinal plants, together with the association of ethnomedicinal knowledge. The ethnomedicinal data obtained were from 1000 traditional healers using semi-structured discussions, free listing, and focus groups. Family importance value, plant part value, fidelity level, the relative frequency of citation, and informant consensus factor were applied in data interpretation. Plant species were accumulated, and deposited at the Plant, Animal Productions and agro-industry laboratory, Ibn Tofail University. A total of 280 medicinal plants belong to 204 genera and 70 families were documented. Asteraceae with 29 species was the most used family in this study area. *Rosmarinus officinalis* L. (RFC = 0.189) was the species the most commonly prescribed by local traditional healers. Similarly, the leaf was the most useful part of the plant (PPV = 0.364), the most frequent affections were osteoarticular affections (ICF = 0.983), and the majority of herbal remedies were prepared from a decoction (38.6%). The results of the present investigation confirmed the presence of indigenous ethnomedicinal information of plant species in the Rif's area to treat various disorders. More investigation on phytochemical, pharmacological, and toxicological should be considered to determine new drugs from these reported plants.

Keywords Ethnopharmacology · Human diseases · Medicinal plants · Moroccan Rif · Traditional healers

1 Introduction

Medicinal plants have been prescribed and used extensively for thousands of years to treat various disorders and ailments in traditional herbal medicine systems all over the world [1]. In all ancient civilizations and on all continents, we find traces of this use. Thus, even today, despite advances in pharmacology, the therapeutic use of plants is very present in some countries, especially in developing countries [2]. The World Health Organization (WHO) estimates that unevenly, 80% of the people from developed and developing nations depend on traditional medicines, especially on plant-based medicine in primary healthcare [3].

The use of plant species for healing purposes is a matter of culture and tradition in Morocco. It should be noted that for the primary health needs, a large portion of Moroccan people utilizes traditional methods of medicine to treat their diseases [3–6]. The inability of many developing countries to supply contemporary pharmaceutical medications [7–12], and the high cost of many drugs, has forced local communities to search for alternative products, such as medicinal plants, that have proven effectiveness and safety and are culturally acceptable.

The Rif region is one of the most biologically diverse regions in the Mediterranean, with some of the rarest biogeographical areas in the world and biodiversity of primary importance with many plants of therapeutic interest [13]. For this reason, this region is the source of many medicinal plants marketed throughout Morocco and abroad and the use of plants in herbal medicine is still very present in this region. On the opposite, data on medicinal plants in this

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region are rare and insufficient. To complete partial and fragmentary studies those have been carried out throughout the Rif [13, 14], Talassemtane National Park [15], and Tingitane Peninsula [16]. It is, therefore, necessary to undertake them to identify the local uses of plant species.

It is in this context that an ethnopharmacological study was carried out in the Rif, which has a lithological diversity, structural and floristic plants important enough to establish the catalog of medicinal plants used in the traditional treatment of diseases, especially herbal medicine, as an alternative to enhance, preserve and rationally use them.

2 Materials and Methods

2.1 Description of the Study Area

The current study was conducted out in the Tangier-Tetouan-Al Hoceima region (North of Morocco) where the Rif's area was located. It extends between 34° and 36° of latitude in the North and 4° to 6° of longitude in the East. It is bounded in the North by the Strait of Gibraltar and the Mediterranean Sea, in the South by the Rabat-Sale-Kenitra region and Fez-Meknes region, in the East by the Eastern Region, and in the West by the Atlantic Ocean (Fig. 1). The total geographical area of the Rif is 11,570 km^2 and the population of the city is about 3,549,512 inhabitants with an average population density of 222.2/km^2 [17]. The population is mixed between Arabic and Amazigh ethnicity.

The Rif is marked by Mediterranean weather with the highest temperature up to 45 °C during summer (July–August) and below 0 °C during winter (December–January) and the average annual rainfall ranges from 700 to 1300 mm which falls mainly between October and February [18]. It is mountainous with elevations ranging from 145 to 2456 (Jbel Tidirhine) meters above mean sea level and the area dominated by species such as *Abies marocana* Trab., *Pinus halepensis* Mill., *Cannabis sativa* L., *Cedrus atlantica* (Endl.) *Quercus suber* L., *Quercus ilex* L., and *Quercus canariensis* Willd. Principally families of Rif
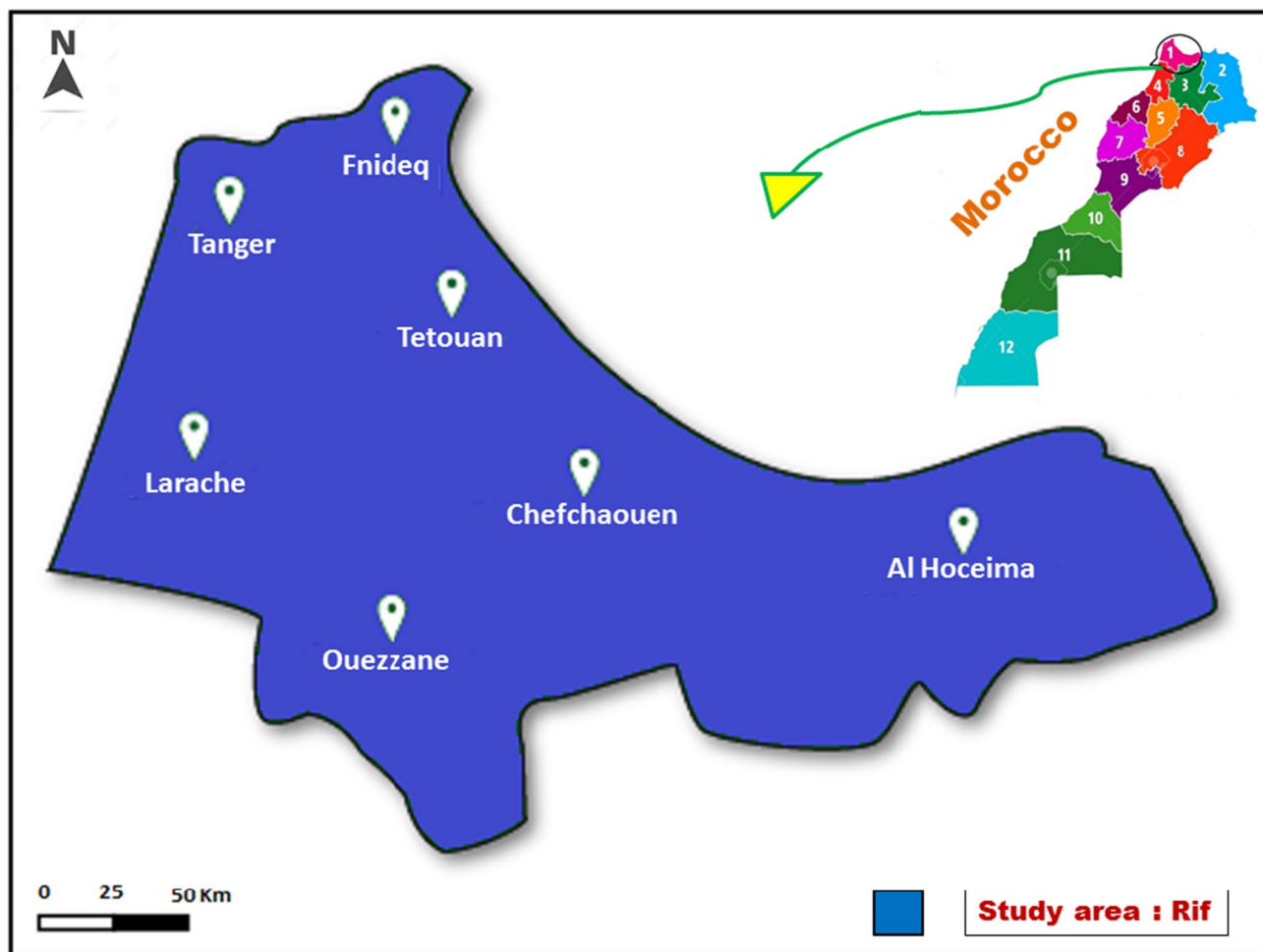

Fig. 1 The geographical position of the Rif region

are very much dependent on subsistence farming, livestock, and to a more secondary space, from forest resources for their livelihood.

2.2 Methodology

2.2.1 Ethnopharmacological Survey

Ethnopharmacological investigations were carried out from July 2016 to July 2018 to collect information on medicinal plants utilized to treat multiple human sicknesses in the Rif region. In this work, the sample has been developed through a mode of probabilistic sampling random stratified [19, 20] non-proportional, it is divided into 28 strata, having concerned the cities, villages, douars, and souks weekly in the area of study. It is based on environmental factors (climate, soil, and altitude), vegetation, and the distribution of the population. The techniques employed for data collection were semi-structured interviews [21], open-ended, group discussion, free listing, and noted and recorded with a digital voice recorder. 1000 informants within aged 17–95 were randomly selected for interviews (cautery installer, farmers, elder people, bonesetters, herbalists, and therapists) in Rif (weekly markets, pharmacies, hospitals, houses, and mosques). By conducting a stratified random sampling [22], samples are then formed in each of the 28 strata, including seven urban communes: [S_1: Al Hoceim (40), S_{12}: Chefchaouen (40), S_{15}: Tétouan (40), S_{19}: Martil (40), S_{20}: Md'q (40), S_{21}: Fnideq (40), S_{26}: Tanger (41)] and twenty-one rural communes: [S_2: Ajdir (35), S_3: Izefzafen (30), S_4: Bni Hadifa (30), S_5: Targuist (40), S_6: Tizi n Tchin (30), S_7: Issaguen (34), S_8: Bab Berred (35), S_9: Cherrafate (30), S_{10}: Bab Taza (30), S_{11}: Derdara (29), S_{13}: Akchour (35), S_{14}: Fifi (30), S_{16}: Bni Karrich (40), S_{17}: Mallalyène (35), S_{18}: Zinat (36), S_{22}: Belyounich (35), S_{23}: Melloussa (39), S_{24}: Ksar Esghir (34), S_{25}: Bni Ouassin (36), S_{27}: Al Bahraouiyne (39), S_{28}: Jouamaa (39)] and they are put together to make up the overall sample of 1000 informants. Knowing that the number of people surveyed varies from one stratum to another depending on the abundance of medicinal plants sought (Fig. 2).

The time spent on each interview was approximately 20 min to one hour. The information collected concerning the profile of the interviewee (age, gender, level of study, monthly income, family situation, and locality) and the ethnopharmacological data for each plant include the common local name, the route of administration, the method of preparation, the dosage, the part used, the condition of the plant used and the diseases treated "Appendix A". The people in the Rif region speak Amazigh, Arabic dialects and therefore, interviews were conducted in Amazigh or Arabic dialects. All the documented data were later translated into English.

2.2.2 Vegetation data collection

Fertile specimens for the present study were collected in the field (197 plant species), in herbal stores (50 plant species), and at the homes of traditional healers (33 plant species) in the Rif. The informants were always provided with fresh plant material, either collected with them, by them, or available at their market stands (Fig. 3). Field observations were also used to record the habitat of each plant species with the assistance of local guides and interviewed informants.

2.2.3 Plant species identification, and deposition in Herbarium

Based on ethnopharmacological knowledge provided by our informants, plant specimens with their exact taxonomy were ordered alphabetically by ethnomedicinal uses, vernacular name, and family name. The identification and nomenclature of the collected material vegetal were done first in the field and completed at the *Plant, Animal Productions, and Agro-industry Laboratory* (Fig. 4). These plant species mentioned by the informants were taxonomically identified using floristic and taxonomic references, especially "The medicinal plants of the Morocco" [23], "List of vascular plants of Morocco tomes I and II" [24], and "Practical vegetation of Morocco" [25–27]. All voucher specimens have been preserved during documentation and deposited in the Ibn Tofail University, Morocco Herbarium for future reference.

2.2.4 Statistical Analysis

Ethnopharmacological data collected are recorded on questionnaire sheets to be analyzed, studied, and confirmed or overturned at the end. Then these data were registered and interpreted by Microsoft Excel 2010 and IBM-SPSS Statistics Base 21. A representative and the quantitative scientific method was applied to examine the socio-demographic data of the informants (ANOVA One-way and Independent Samples T-Test). Further, the recorded data were analyzed by various quantitative indices like family importance value (FIV), the relative frequency of citation (RFC), plant part value (PPV), fidelity level (FL), and informant consensus factor (ICF).

2.2.4.1 Family Importance Value (FIV) The FIV identifies the significance of plant families. It is an indication of therapeutic importance that can be utilized in ethnobotany to assess the value of natural plant species. To determine family importance value, we adopt the following method: $FIV = \frac{FC_{family}}{N_S}$, where FC_{family} is the number of
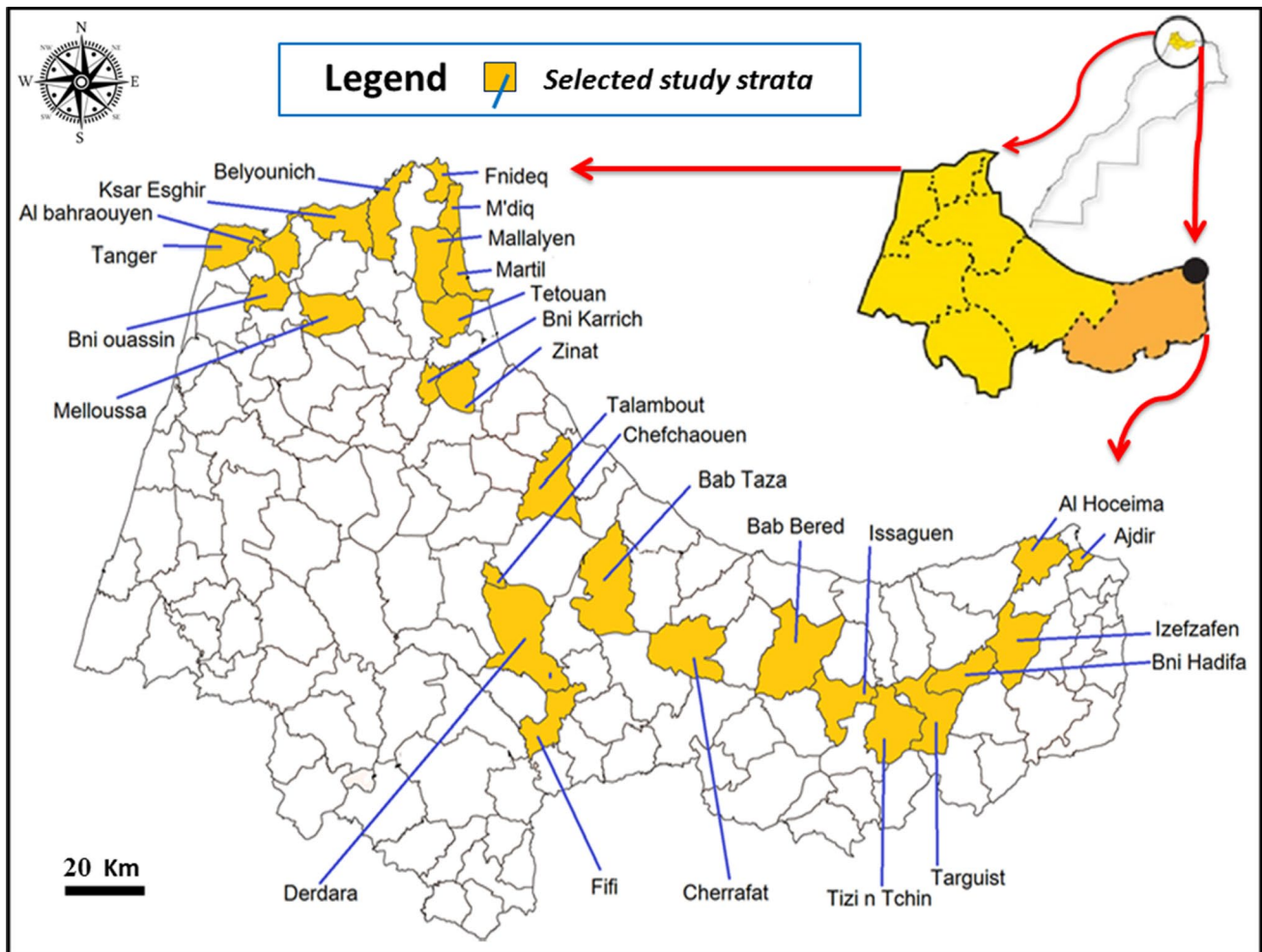
Fig. 2 Distribution of survey points at the study area level

informants mentioning the family and N_s = Total number of species within each family [28].

2.2.4.2 Relative Frequency of Citation (RFC) and Frequency (FC) RFC is calculated by dividing FC by an entire number of interviewees in the research (N). The value of RFC for plant species is based on the citing portion of interviewees for every species. Relative Frequency of Citation was determined by applying the following formula [29]: $\text{RFC} = \frac{\text{FC}}{N}$ with (0 < RFC < 1).

2.2.4.3 Plant Part Value (PPV) PPV was determined by applying this equation [30]: $\text{PPV} = \frac{\text{RU}_{\text{Plant part}}}{\text{RU}}$, where RU is the number of applications notified of total portions of the medicinal plant and $\text{RU}_{\text{plant part}}$ is the number of uses reported per part of the medicinal plant. The part among the most important PPV is the most used by the informants.

2.2.4.4 Fidelity Level (FL) Fidelity level is the rate of interviewees who mentioned the uses of certain medicinal plants

to treat a particular disease in the study region. The FL ratio is determined using this equation [31]: $\text{FL}(\%) = \frac{N_p}{N} \times 100$, where N_p is the number of interviewees that require the application of a plant species to cure a special affection and N is the sum of interviewees that use the medicinal species as a drug to treat any given illness.

2.2.4.5 Informant Consensus Factor (ICF) Informant consensus factor (ICF) was determined to investigate an agreement between the interviewees on the related remedies for each group of diseases [32] $\text{ICF} = \frac{N_{\text{ur}} - N_t}{N_{\text{ur}} - 1}$, where N_{ur} is the number of use-reports in each disease category and N_t is many species used. The values for the Informant Consensus Factor range from 0 to 1.

Fig. 3 Type of sachets used to preserve collected plant species

3 Results

3.1 Socio-demographic Data

A total of 1000 respondents were interviewed. Based on socio-demography, these participants were categorized into different classes as given in Table 1. Among the participants, 52.7% were females and the remaining were males 47.3%, with a sex ratio female/male of 1.11. From the total respondents, 76% were married, 10.8% divorced, 9.2% widowed, and 4% unmarried. In terms of age, the age groups of 40–60 were very high compared to other groups (47.6%). Just 30.6% were more than 60 years old, 21.4% were 20–40 years old, and 0.4% of informants were below 20 years old. Regarding educational status, the majority of respondents (69.1%) were illiterate, while (23%) and (6.7%) respondents attended primary and secondary school, respectively. Only 1.2% of respondents were attended higher education. Considering the income/month, most of the informants were unemployed (41.6%), while (38.6%) of these informants had low income/month level, (17%) with average level income/month, and (2.8%) with higher-level income/month.

3.2 Most Represented Botanical Family and Their Family Importance Value (FIV)

The floristic analysis of the results obtained identified 280 medicinal species and subspecies belonging to 204 genera and 70 plant families were reported as having rich ethnopharmacological uses in the Rif to treat different human ailments. In terms of the number of species, it appears that the Asteraceae family is the most represented with 29 species or 10.36% of the catalog developed, followed by Lamiaceae (22 species), Fabaceae and Poaceae (21 species each), Apiaceae (17 species), Solanaceae (12 species), Brassicaceae (11 species), Asparagaaceae (10 species), Amaranthaceae and Cucurbitaceae (8 species for each), Rutaceae (6 species), Myrtaceae and Rosaceae with 5 species each. Besides, Anacardiaceae, Caryophyllaceae, Cupressaceae, Euphorbiaceae, Lauraceae, and Zingiberaceae are each represented by 4 plant species. The Apocynaceae, Malvaceae, Moraceae, Oleaceae, Papaveraceae, Pinaceae, Rubiaceae, and Tamaricaceae are represented by 3 medicinal species each, whereas the other families are those with at most one or two medicinal plant species. Based on the family importance value (FIV), the families most cited by informants are Amaryllidaceae (FIV = 0.104), Lythraceae (FIV = 0.103) Caryophyllaceae (FIV = 0.084), Apocynaceae (FIV = 0.079), Capparaceae (FIV = 0.073), Linaceae (FIV = 0.065), Rubiaceae (FIV = 0.063), Nitrariaceae, Rhamnaceae and Verbenaceae (FIV = 0.053), Rutaceae (FIV = 0.052) and Arecaceae (FIV = 0.049). The vernacular names, scientific names of documented species, their families, used parts, methods of preparations, FL, FC, RFC, and FIV were illustrated in Tables 2, 3, 4, 5, 6, 7, 8, 9.
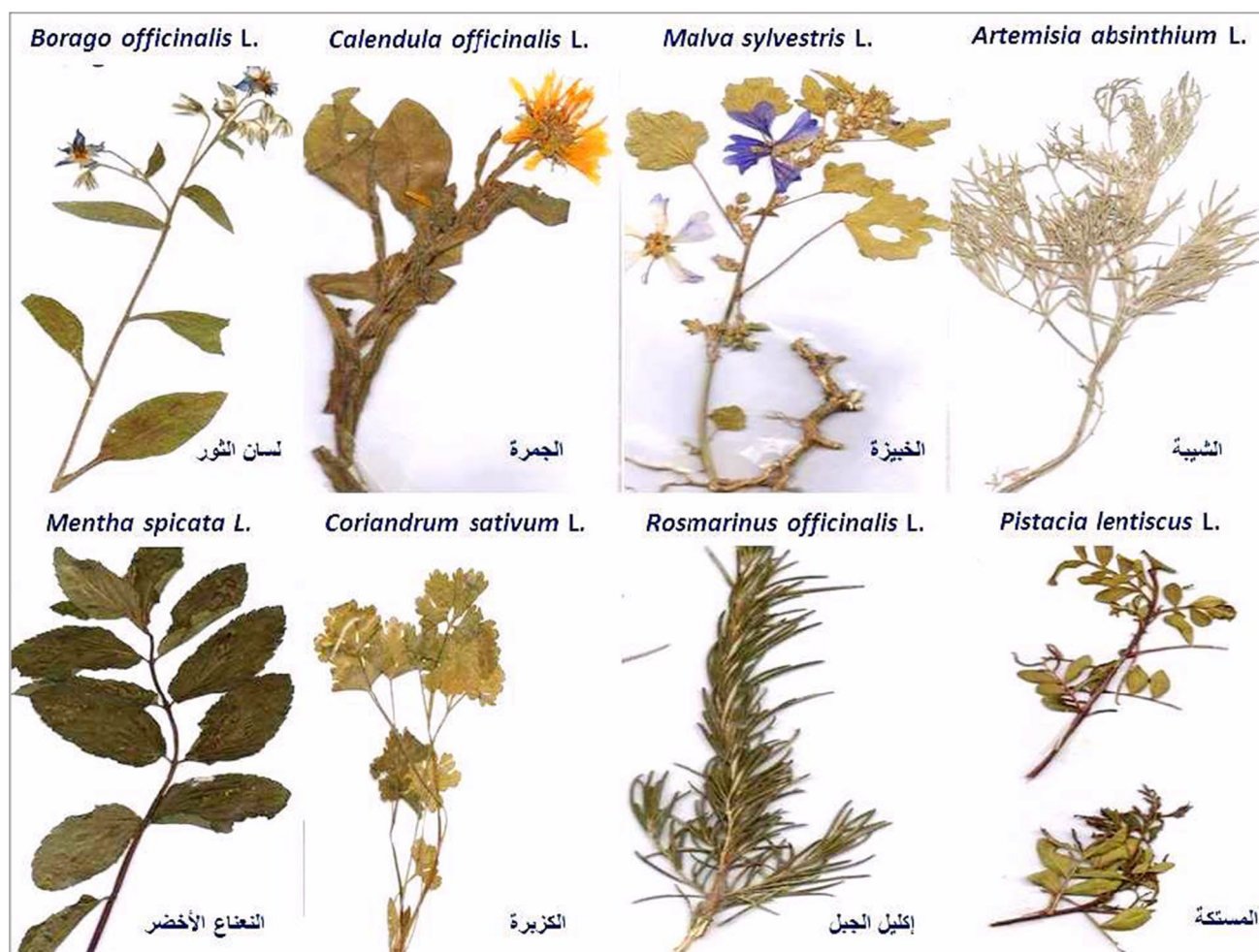
Fig. 4 Plant samples collected in the field and kept in papers with their scientific and local name

3.3 Diversity of Medicinal Plants

To assess the relative importance of the reported plant species, the relative frequency of citation (RFC) was calculated from the informants' citations. In the present study, the highest value reported was 0.189, and the lowest value was 0.001 for each species as given in Tables 2, 3, 4, 5, 6, 7, 8, 9. In the current investigation, the highest RFC value was reported for *Rosmarinus officinalis* L. (RFC = 0.189), *Thymus satureioides* Coss. (RFC = 0.176), *Dittrichia viscosa* (L.) Greuter. (RFC = 0.165), *Lawsonia inermis* L. (RFC = 0.154), *Arenaria rubra* L. (RFC = 0.153), and *Nerium oleander* L. (RFC = 0.146). Meanwhile, 60 medicinal plant species scored the least RFC value, which is 0.001.

3.4 Habitat of Medicinal Plants

The present study showed that 165 medicinal plant species (59%) used by the Moroccan pharmaceutical medicines today are collected from the agriculture (cultivated) (Fig. 5),

101 species 36% were collected from wasteland (Fig. 6) (All lands affected by water erosion, wind erosion, floods, waterlogging, soil salinization, and soil alkalization) and only 14 species (5%) were introduced by marketing in other regions.

3.5 Medicinal Formulations Used During the COVID-19 Lockdown for Improving the Immune System

Medicinal plant species have a fundamental unit for use as alternative medicines systems in Morocco and are the basis for the discovery of natural ingredients for the development of therapeutic agents in pharmacology. The study conducted in the Salé region [33] shows that the local population uses some plants to prevent and treat the COVID-19, which was mentioned by the Moroccan Rif community. In Moroccan Rif, the uses of medicinal species have increased during the COVID-19 pandemic as a preventive behavior. *Citrus limon* (L.) Burm. f. has been used to relieve cough, and as an expectorant in bronchitis. *Allium sativum* L. *Allium cepa*

Table 1 Demographic profile of informants interviewed

Categories	Number of informants	Percent (%)	Average ± E.T	F-Value	p-Value
Gender				5.753	0.02
Female	527	52.7	18.82 ± 2.842		
Male	473	47.3	16.89 ± 3.166		
Age ranges				306.208	0.000
< 20 years	22	0.4	0.78 ± 0.832		
20–40 years	214	21.4	7.64 ± 1.889		
40–60 years	476	47.6	17.00 ± 3.042		
> 60 years	306	30.6	10.92 ± 1.783		
Family status				441.234	0.000
Married	760	76	2.32 ± 4.784		
Divorced	108	10.8	3.85 ± 1.580		
Widower	92	9.2	3.28 ± 1.629		
Single	40	4	27.14 ± 2.927		
Educational level				673.173	0.000
Illiterate	691	69.1	24.67 ± 3.464		
Primary school	230	23	8.21 ± 2.166		
Secondary school	67	6.7	2.39 ± 1.749		
Universitaire	12	1.2	0.42 ± 0.634		
Income/month				359.350	0.000
Unemployed	416	41.6	14.85 ± 1.432		
250–1500 MAD	386	38.6	13.78 ± 2.024		
1500–5000 MAD	170	17	6.07 ± 2.508		
> 5000 MAD	28	2.8	1.00 ± 1.018		
Locality				246.861	0.000
Rural area	497	49.7	17.75 ± 3.122		
Urban area	251	25.1	8.96 ± 1.990		
Village	229	22.9	8.17 ± 2.695		
Nomadic	23	2.3	0.82 ± 0.904		

L. and *Zingiber officinale* Roscoe are indicated for respiratory disease (cold and cough), and other symptoms related to influenza. *Eucalyptus globulus* Labill. is indicated for symptoms of respiratory disease (bronchitis, rhinitis), due to the presence of 1–8-cineol [34]. Indications of respiratory conditions: *Foeniculum vulgare* Mill. *Plantago lanceolata* L., *Pimpinella anisum* L., *Silybum marianum* L., *Laurus nobilis* L., *Malva sylvestris* L., *Thymus vulgaris* L., and *Glycyrrhiza glabra* L. are indicated by informants for cough associated with a cold, sore throat, fever laryngitis, and tonsilitis. *Hedera helix* L. is indicated as antispasmodic, other indications are anti-inflammatory, and in the treatment of flu and fever. Black seeds of *Nigella sativa* L. are globally known as a spice and as such as a food item.

3.6 The Fidelity Level (FL) of Medicinal Plants Reported

Fidelity level (FL) designates the choice for medicinal plants to be better for other species in the treatment of a particular ailment. The plant species that are extensively used by the indigenous inhabitants have more important FL values than those that are few popular. In this study, the FL ranged from 45.5% to 100% for medicinal plant use age. The study determined 240 medicinal plant species (85.71%) achieve the greatest fidelity level (FL = 100%) and the remaining 40 plant species achieve reasonable FL.

3.7 Disease treated and their ICF values

The results of the ICF calculation show that the value in our study ranges from 0.944 to 0.983 per uses categories (Table 10). Results revealed that the very best ICF (0.983) value was obtained for osteoarticular diseases with 867 use-reports for 16 plant species. It's followed by dermatological diseases (ICF = 0.981), neurological diseases (ICF = 0.974), genitourinary diseases (ICF = 0.973), metabolic diseases (ICF = 0.972), cardiovascular diseases (ICF = 0.968), digestive system diseases (ICF = 0.945), and respiratory system diseases (ICF = 0.944).

Table 2 Inventory of plant species used to treat digestive system disorders by indigenous people of Rif

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Amaranthaceae							0.024
Chenopodium album L.	Labda, Baremren	Leaf	Infusion	71	07	0.007	
Chenopodium murale L.	Talekutta	Other combination	Infusion	100	01	0.001	
Salsola kali L.	El Herd	Whole plant	Infusion	100	01	0.001	
Anacardiaceae							0.048
Pistacia atlantica Desf	Btem	Leaf	Decoction	100	17	0.017	
Apiaceae							0.032
Ammi majus L.	Tlillane	Fruit	Other	100	32	0.032	
Ammi visnaga (L.) Lam	Bechnikha	Fruit	Infusion	91	22	0.022	
Ammodaucus leucotrichus Coss	Camoun Soufi	Seed	Cooked	100	41	0.041	
Apium graveolens L.	Lkrafess	Leaf	Decoction	100	04	0.004	
Carum carvi L.	Karwiya	Seed	Infusion	100	26	0.026	
Coriandrum sativum L.	Alkazbour	Seed	Raw	100	04	0.004	
Cuminum cyminum L.	Camoun	Seed	Infusion	100	03	0.003	
Eryngium ilicifolium Lam.	El Asfour, Chkour	Flower	Raw	100	15	0.015	
Foeniculum vulgare Mill.	Lbesbas	Seed	Decoction	100	68	0.068	
Smyrnium olusatrum L.	Lheyyâr	Leaf	Infusion	100	43	0.043	
Apocynaceae							0.079
Vinca minor L.	El Innakia	Whole plant	Cooked	100	01	0.001	
Arecaceae							0.049
Chamaerops humilis L.	Doum, El Ghaz	Fruit	Infusion	100	51	0.051	
Asparagaceae							0.013
Asparagus acutifolius L.	Sekkom, Tazzut	Leaf	Decoction	100	01	0.001	
Asparagus densiflora Kunth.	Sekkom, Tazzut	Whole plant	Other	100	01	0.001	
Asparagus officinalis L.	Sakkum, Tazzut	Other combination	Decoction	100	02	0.002	
Asparagus plumosus Baker	Sekkom, Tazzut	Stem	Infusion	100	01	0.001	
Asparagus stipularis Forssk	Sekkom, Tazzut	Rhizome	Other	100	01	0.001	
Drimia maritima (L.) Stearn	Ansal	Bulb	Decoction	100	04	0.004	
Muscari comosum (L.) Mill.	Bsyla	Bulb	Decoction	100	02	0.002	
Asteraceae							0.038
Artemisia absinthium L.	Chiba	Other combination	Decoction	100	75	0.075	
Cynara humilis L.	Khorchef, Timta	Stem	Raw	94	31	0.031	
Helichrysum italicum (Roth) G.Don	Dahab Eshams	Whole plant	Infusion	100	01	0.001	
Matricaria chamomilla L.	Babunj	Whole plant	Decoction	100	48	0.048	
Ormenis mixta (L.) Dumort	Hellâla	Other combination	Infusion	100	19	0.019	
Scolymus hispanicus L.	Garnina	Rhizome	Infusion	100	50	0.050	
Brassicaceae							0.012
Brassica oleracea f. *alba* DC	Melfouf, Krunb	Leaf	Other	100	07	0.007	
Raphanus sativus L.	Fjel	Whole plant	Decoction	100	46	0.046	
Caryophyllaceae							0.084
Silene vulgaris (Moench) Garcke	Tigheghet	Leaf	Decoction	100	08	0.008	
Crassulaceae							0.001
Umbilicus rupestris (Salisb.) Dandy	Sorrat El Ard	Whole plant	Infusion	100	01	0.001	
Cucurbitaceae							0.013
Bryonia dioica Jacq	Aineb Edib	Root	Decoction	60	05	0.005	
Cucurbita maxima Duchesne	Elgraa Hamra	Flower	Infusion	100	15	0.015	
Cupressaceae							0.043
Cupressus sempervirens L.	Zembale, Sarw	Leaf	Infusion	100	01	0.001	
Cyperaceae							0.001
Cyperus rotundus L.	Tara	Whole plant	Decoction	100	01	0.001	

Table 2 (continued)

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Fabaceae							0.023
Lupinus angustifolius L.	Shenqala, Bozghiba	Whole plant	Decoction	100	01	0.001	
Cassia senna L.	Sna Mekki	Leaf	Decoction	100	05	0.005	
Ceratonia siliqua L.	Salghwa, Kharroub	Fruit	Decoction	100	67	0.067	
Glycyrrhiza glabra L	Arq Sûs	Root	Infusion	83	36	0.036	
Trigonella foenum-graecum L.	Helba	Seed	Cooked	100	54	0.054	
Vicia benghalensis L.	Jelbanet Lehnouch	Leaf	Decoction	100	01	0.001	
Vicia tenuifolia Roth	Bykya	Whole plant	Infusion	100	01	0.001	
Fagaceae							0.038
Quercus rotundifolia Lam.	Kerrush, Tasaft	Bark	Infusion	100	06	0.006	
Geraniaceae							0.015
Pelargonium capitatum (L.) L'Hér	Laatercha	Leaf	Decoction	100	27	0.027	
Iridaceae							0.001
Iris × germanica L.	Sawsan Almani	Leaf	Other	100	01	0.001	
Juglandaceae							0.005
Juglans regia L.	Guergaâ	Bark	Other	80	05	0.005	
Lamiaceae							0.056
Ocimum basilicum L.	Lhbak	Leaf	Infusion	71	07	0.007	
Origanum majorana L.	Mard'douch	Whole plant	Infusion	65	46	0.046	
Origanum vulgare L.	Zaatr Elma	Leaf	Infusion	100	80	0.080	
Thymus satureioides Coss.	Z'îtra, Tazuknit	Leaf	Infusion	100	176	0.176	
Lauraceae							0.035
Cinnamomum zeylanicum Blume	Qarfa	Bark	Infusion	100	11	0.011	
Lythraceae							0.103
Punica granatum L.	Remman	Bark	Decoction	100	53	0.053	
Malvaceae							0.004
Malva hispanica L.	Khobbeyza	Leaf	Decoction	100	04	0.004	
Malva silvestris L.	Bakkula	Leaf	Cooked	100	06	0.006	
Myristicaceae							0.003
Myristica fragrans Houtt	Bsibissa	Fruit	Cooked	67	03	0.003	
Myrtaceae							0.028
Eugenia caryophyllata Thunb.	Qronfel	Flower	Infusion	100	05	0.005	
Oleaceae							0.020
Olea europea L.	Zaytoun	Leaf	Decoction	100	51	0.051	
Olea europea var. *sylvestris* (Mill.) Lehr	Zabbouj	Leaf	Decoction	100	03	0.003	
Piperaceae							0.005
Piper nigrum L.	Ibzar	Seed	Cooked	100	05	0.005	
Plantaginaceae							0.006
Plantago lanceolata L.	Lssan lhamel	Leaf	Cooked	100	06	0.006	
Poaceae							0.015
Cymbopogon citratus (DC.) Stapf	Aoshb Elhamed	Stem	Decoction	100	01	0.001	
Hordeum vulgare L.	Châir, Timzine	Seed	Cooked	100	05	0.005	
Phalaris canariensis L.	Hchicht Lkanari	Seed	Decoction	100	01	0.001	
Polygonaceae							0.005
Emex spinosa (L.) Campd.	Houmida	Whole plant	Cooked	100	01	0.001	
Rumex acetosa L.	Houmida	Leaf	Infusion	67	09	0.009	
Rhamnaceae							0.053
Ziziphus lotus (L.) Lam.	Nbeg, Tazart	Seed	Other	62	53	0.053	
Rosaceae							0.026
Prunus armeniaca L.	Mechmach	Leaf	Infusion	100	01	0.001	

Table 2 (continued)

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Prunus persica (L.) Batsch	Khokh	Leaf	Other	100	02	0.002	
Rutaceae							0.052
Ruta montana (L.) L.	Fijel, Iwermi	Root	Decoction	58	12	0.012	
Salicaceae							0.007
Populus alba L.	Sefsaf	Leaf	Decoction	100	13	0.013	
Populus nigra L.	Sefsaf	Leaf	Decoction	100	01	0.001	
Schisandraceae							0.004
Illicium verum Hook.f	Badiana	Fruit	Infusion	100	04	0.004	
Scrophulariaceae							0.001
Verbascum sinuatum L.	Torah	Flower	Infusion	100	01	0.001	
Solanaceae							0.025
Solanum lycopersicum L.	Maticha	Fruit	Cooked	71	14	0.014	
Solanum melongena L.	Denjal	Fruit	Cooked	60	05	0.005	
Solanum nigrum L.	Buqnîna	Leaf	Infusion	100	01	0.001	
Tamaricaceae							0.001
Tamarix aphylla (L.) H.Karst	Adba	Flower	Infusion	100	02	0.002	
Tamarix gallica L.	Tamimayt	Leaf	Decoction	100	01	0.001	
Tamarix ramosissima Ledeb.	Athel	Other combination	Infusion	100	01	0.001	
Theaceae							0.042
Camellia sinensis (L.) Kuntze	Atây	Leaf	Infusion	100	42	0.042	
Thymelaeaceae							0.032
Thymelaea virgata (Desf.) Endl	Matnane	Whole plant	Infusion	100	32	0.032	
Verbenaceae							0.053
Lantana camara L.	Nabat Oum Kaltoum	Leaf	Decoction	100	01	0.001	
Vitaceae							0.017
Vitis vinifera L.	Aneb, Dalya	Leaf	Infusion	100	17	0.017	
Zingiberaceae							0.031
Curcuma Longa L.	Kharqûm	Rhizome	Decoction	100	16	0.016	

3.8 Plant Parts Used in the Study Area

In classical pharmacopeia, various parts of medicinal plants identified particularly the seeds, the leaves, the flowers, the fruits, the roots, or maybe the entire plant are exploited by the indigenous people of Rif. supported the plant structure value (PPV) index, the leaf has been reported because the dominant party within the preparation of the herbal remedy within the study area (PPV = 0.364), followed by seed (PPV = 0.226), whole plant (PPV = 0.097), flower (PPV = 0.073), fruit (PPV = 0.060), root (PPV = 0.051), bulb (PPV = 0.044), other combinations (PPV = 0.034), rhizome (PPV = 0.026), bark (PPV = 0.021), and stem (PPV = 0.006), respectively.

3.9 Method of Preparation and Administration of Plants

Indigenous people in the study area used many methods of preparation. The results showed that the majority of remedies

were prepared from decoction (38.6%) and infusion (34%), followed by cataplasm (11.3%) cooked (7.6%) and raw (2.3%). The percentage of the other methods of preparation grouped (maceration, inhalation, fumigation) doesn't exceed 6.2%. The main solvent with the plant was water, but milk, butter, tea, and honey, cereal oils were also widely used ingredients. The route of administration in this study varies with the type of disease treated and the actual sites of the ailments. The result revealed that herbal medicine was administered through different routes. Generally, the majority of informants prepared remedies were applied mostly by oral (82.4%) followed by massage (6.3%), swabbing (5.2%), other modes of administration (3.4%), and rinsing (2.7%).

4 Discussion

As part of this study, our investigations identified 280 species and subspecies used for medicinal purposes. These medicinal species belong to 204 genera and 70 botanical

Table 3 Inventory of plant species used to treat respiratory diseases by indigenous people of Rif

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Aizoaceae							0.001
Mesembryanthemum acinaciforme L.	Bousbayeaa	Leaf	Other	100	01	0.001	
Anacardiaceae							0.048
Schinus molle L.	Foulfol kadib	Fruit	Decoction	100	01	0.001	
Apiaceae							0.032
Thapsia garganica L.	Deryas	Whole plant	Cataplasm	100	02	0.002	
Araliaceae							0.002
Hedera helix L.	Louwaya	Leaf	Cooked	100	02	0.002	
Asteraceae							0.038
Carthamus rhiphaeus Font Quer & Pau	EL Kertam	Whole plant	Decoction	100	05	0.005	
Sonchus oleraceus (L.) L.	Tilfaf	Whole plant	Cooked	100	01	0.001	
Brassicaceae							0.012
Brassica fruticulosa Cirillo	Harchae	Seed	Decoction	100	01	0.001	
Brassica nigra (L.) K.Koch	Khrdal, Bohamo	Leaf	Infusion	100	06	0.006	
Brassica rapa L. Brassicaceae	Left Lbeldi	Root	Raw	100	06	0.006	
Brassica rapa var. *annua* W.D.J.Koch	Left	Leaf	Raw	100	07	0.007	
Lepidium sativum L.	Habb Rchad	Seed	Cooked	100	21	0.021	
Sinapis alba L.	Karkaz	Seed	Cooked	100	01	0.001	
Sinapis arvensis L.	Khardal	Leaf	Cooked	100	01	0.001	
Cupressaceae							0.043
Juniperus oxycedrus L.	Taqqa	Leaf	Infusion	100	12	0.012	
Convolvulaceae							0.032
Cuscuta approximata Bab	Lhamoul	Whole plant	Infusion	100	01	0.001	
Cyperaceae							0.001
Cyperus alternifolius L.	Saad	Whole plant	Infusion	100	01	0.001	
Fabaceae							0.023
Medicago sativa L.	Fessa	Leaf	Decoction	100	05	0.005	
Vicia faba L.	Elfûl, Ibaouèn	Seed	Cooked	100	51	0.051	
Lamiaceae							0.056
Lavandula dentata L.	Lakhzama	Other combination	Infusion	75.5	53	0.053	
Lavandula multifida L.	Kohhyla, Tiguizte	Leaf	Decoction	100	23	0.023	
Lavandula pedunculata (Mill.) Cav	Lakhzama	Leaf	Decoction	100	03	0.003	
Lavandula stoechas L.	Halhal	Leaf	Decoction	100	56	0.056	
Mentha cervina L.	Menta, Nadgh	Whole plant	Infusion	100	11	0.011	
Mentha × citrata Ehrh.	Nana Elmeska	Whole plant	Infusion	100	04	0.004	
Mentha × rotundifolia (L.) Huds	Mchichtrou	Leaf	Infusion	49.3	67	0.067	
Mentha suaveolens Ehrh.	Marseta, Timersad	Leaf	Decoction	89	46	0.046	
Lauraceae							0.035
Cinnamomum camphora (L.) J.Presl.	Kafour	Leaf	Infusion	100	02	0.002	
Myrtaceae							0.028
Eucalyptus camaldulensis Dehnh.	Kalitûs	Leaf	Decoction	60	05	0.005	
Eucalyptus globulus Labill.	Kalitûs	Leaf	Cataplasm	93.8	65	0.065	
Oleaceae							0.020
Fraxinus angustifolia Vahl.	Lsan Ettir	Other combination	Infusion	100	06	0.006	
Platanaceae							0.001
Platanus orientalis L.	Delb Machriqi	Bark	Infusion	100	01	0.001	
Poaceae							0.015
Avena sativa L.	Khortal	Seed	Decoction	100	02	0.002	

Table 3 (continued)

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Cynodon dactylon (L.) Pers.	N'jem	Rhizome	Infusion	100	02	0.002	
Pontederiaceae							0.016
Eichhornia crassipes (Mart.) Solms.	Sounbel	Whole plant	Cooked	100	16	0.016	
Ranunculaceae							0.040
Nigella sativa L.	Sanûj	Seed	Infusion	100	78	0.078	
Rutaceae							0.052
Citrus sinensis (L.) Osbeck	Limoun	Fruit	Other	100	02	0.002	
Solanaceae							0.025
Mandragora autumnalis Mill.	Bid Al Ghol, Taryâla	Leaf	Other	100	36	0.036	
Styracaceae							0.005
Styrax officinalis L.	Jawi	Bark	Other	100	05	0.005	
Zingiberaceae							0.031
Alpinia officinarum Hance	khodenjal	Rhizome	Decoction	100	02	0.002	
Elettaria cardamomum (L.) Maton	Qaaqella	Seed	Decoction	100	01	0.001	
Zingiber officinale Roscoe	Skinjbir	Rhizome	Infusion	89.6	106	0.106	

families that have been used to treat different ailments in the study area. Among plant families, Asteraceae had the greatest number of species (29) followed by Lamiaceae (22 species), Fabaceae, and Poaceae (22 species each). The dominance of Asteraceae and Lamiaceae might reflect a wide variety of active ingredients in the species taxa belonging to these families and their availability, wider distribution, abundance, and richness in the study area. Besides, people of the area have a piece of high knowledge about plants from these families, i.e. they have been using these plants for many generations and hence the members of these plant families are well known to them. families groups with high species richness most likely contain a great diversity of morphological and chemical properties [35] (flavonoids, alkaloids, saponins, terpenes, coumarins, organosulfur compounds, glycosides, steroids, tannin, mucus, lignans, anthraquinones, aromatic constituents, phenolic lipids, carotenoids, steroids, and), from which potential multiple uses can be derived. These results are in general agreement with previous ethnobotanical inventories which indicated that the most prominent families were Asteraceae Lamiaceae, Fabaceae Poaceae, Apiaceae, and Solanaceae [2, 11, 12, 36–40].

Our quantitative analysis showed that the highest RFC was calculated for *Rosmarinus officinalis* L. (RFC = 0.189), *Thymus satureioides* Coss. (RFC = 0.176), and *Dittrichia viscosa* (L.) Greuter. (RFC = 0.165). Several studies about *Rosmarinus officinalis* L., with biological, pharmacological, and phytochemical approaches have been conducted and indicate anti-proliferative, anti-inflammatory, anti-bacterial, and anti-oxidant healing properties [41–43]. As this plant species is widely distributed in almost all Moroccan regions, including the study area, and is easily spread, it is frequently used and a widely available raw material. According to these

results, it is recommended that medicinal species having high RFC values should be further screened in pharmacological, toxicological, phytochemical, and biological activities for any novel molecules or chemicals for treating various ailments. Moreover, these species should also be prioritized for conservation as their preferred uses may place their populations under threat due to over-harvesting. Furthermore, the ethnopharmacological plants with greater values of RFC confirm the fact that these plant species were well accepted to the largest of the autochthonous people [44]. Among the 280 medicinal plants, 86 species were used for the treatment of digestive system diseases, whereas 41 species were used to treat respiratory system diseases, 30 species neurological diseases, 29 species cardiovascular diseases, 29 species metabolic diseases, 27 species genitourinary diseases, 22 species dermatological diseases, and 16 species were used to treat osteoarticular diseases.

The fidelity level (FL) of each species is also evaluated from the available information. It indicates the informant's choice for each ailment and the potential of the species related to the diseases as well. FL values in this study varied from 45.5% to 100%. The study determined 240 species of plants with an FL of 100%, even without considering plants that were mentioned only once for better accuracy, whereas below FL values are obtained for plant species that are employed for several purposes. This result means that the indigenous people tended to rely on one specific medicinal plant for treating one certain disease than for several illnesses. Consequently, plant species not previously studied and have maximum FL should be recommended for further study related to clinical practice [45].

The diseases treated in the Rif region were classified into 8 ailment categories. The highest ICF values were recorded

Table 4 Inventory of plant species used to treat cardiovascular diseases by indigenous people of Rif

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Amaranthaceae							0.024
Spinacia oleracea L	Sabanikh, Selq	Leaf	Raw	100	56	0.056	
Amaryllidaceae							0.104
Allium porrum L	Borro	Bulb	Infusion	100	72	0.072	
Allium sativum L	Touma, Tishert	Bulb	Cooked	100	118	0.118	
Apiaceae							0.032
Daucus carota L	Khizou	Leaf	Decoction	100	102	0.102	
Arecaceae							0.049
Phoenix dactylifera L	Tmar, Tazdayet	Fruit	Other	78	46	0.046	
Asteraceae							0.038
Carduus getulus Pomel	Lssan Maghribi	Leaf	Other	100	01	0.001	
Cynara scolymus L	Lqoq	Whole plant	Decoction	100	09	0.009	
Cactaceae							0.001
Opuntia ficus indica (L.) Mill	Sbar, Zaâboul	Fruit	Infusion	100	01	0.001	
Cannabaceae							0.011
Cannabis sativa L	Lkif	Seed	Cataplasm	100	11	0.011	
Dryopteridaceae							0.001
Dryopteris filix-mas (L.) Schott	Sarkhs Dakar	Leaf	Decoction	100	01	0.001	
Fabaceae							0.023
Lens culinaris Medik	Aaddes	Seed	Cooked	100	48	0.048	
Medicago polymorpha L	Fessa	Whole plant	Decoction	100	14	0.014	
Vicia sativa L	Guersana	Whole plant	Infusion	100	01	0.001	
Geraniaceae							0.015
Erodium cicutarium (L.) L'Hér	Rakma Chokrania	Leaf	Cooked	100	03	0.003	
Iridaceae							0.001
Gladiolus italicus Mill	Dalbout Itali	Leaf	Other	100	01	0.001	
Lauraceae							0.035
Laurus nobilis L	Wrak Sidnamossa, Rend	Leaf	Decoction	89	91	0.091	
Persea gratissima C.F.Gaertn	Avocat	Fruit	Cataplasm	100	35	0.035	
Malvaceae							0.004
Hibiscus sabdariffa L	Karkadé	Leaf	Decoction	100	01	0.001	
Poaceae							0.015
Avena barbata Pott ex Link	Chofan Barri	Whole plant	Raw	100	01	0.001	
Glyceria fluitans (L.) R.Br	Aaima	Whole plant	Other	100	01	0.001	
Hordeum murinum L	Chaair El Firan	Leaf	Infusion	100	01	0.001	
Pennisetum setaceum (Forssk.) Chiov	Dyl Ethaalab	Seed	Decoction	100	01	0.001	
Phragmites communis Trin	Kseb	Root	Infusion	100	74	0.074	
Zea mays L	Dra	Fruit	Decoction	100	08	0.008	
Ranunculaceae							0.040
Ranunculus bullatus L	Wden Elhallouf	Root	Decoction	100	02	0.002	
Rosaceae							0.026
Rubus ulmifolius Schott	Oualik, Tabgha	Leaf	Raw	100	49	0.049	
Rubiaceae							0.063
Galium aparine L	Lsak	Leaf	Infusion	100	01	0.001	
Rubia peregrina L	Fûwa, Tarubya	Root	Infusion	100	123	0.123	
Solanaceae							0.025
Solanum sodomaeum Dunal	Tfah Lfar	Fruit	Cataplasm	100	07	0.007	

Table 5 Inventory of plant species used to treat neurological diseases by indigenous people of Rif

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Asparagaceae							0.013
Agave sisalana Perrine	Aloe Vera	Leaf	Cataplasm	100	01	0.001	
Asteraceae							0.038
Anacyclus radiatus Loisel	Far Dahabya	Whole plant	Infusion	100	01	0.001	
Artemisia herba-alba Asso	Chih, Izri	Leaf	Decoction	97.9	95	0.095	
Artemisia mesatlantica Maire	Chih, Izri	Leaf	Decoction	100	01	0.001	
Chrysanthemum coronarium L	Lgahwân, Lgentus	Flower	Infusion	100	63	0.063	
Xanthium spinosum L	Lzik Chouki	Leaf	Decoction	100	01	0.001	
Cucurbitaceae							0.013
Citrullus vulgaris Schrad	Dlah	Leaf	Decoction	100	09	0.009	
Cucumis melo L	Btikh	Leaf	Infusion	100	13	0.013	
Ecballium elaterium (L.) A.Rich	Faggous El Hemar	Fruit	Other	100	02	0.002	
Lagenaria siceraria (Molina) Standl	El garâa-slâwiya	Fruit	Cataplasm	100	05	0.005	
Cupressaceae							0.043
Tetraclinis articulata (Vahl) Mast	El A'râr	Leaf	Infusion	100	81	0.081	
Fabaceae							0.023
Retama monosperma (L.) Boiss	Rtem	Stem	Decoction	100	32	0.032	
Retama raetam (Forssk.) Webb	Rtem	Root	Decoction	75.61	41	0.041	
Lamiaceae							0.056
Marrubium echinatum Ball	Mrywt, Ifzi	Other combination	Cataplasm	100	134	0.134	
Mentha x piperita L	Na'na El-Aabdi	Leaf	Infusion	100	06	0.006	
Mentha pulgium L	Fliyou	Whole plant	Infusion	100	67	0.067	
Mentha spicata L	Na'a Na'a	Whole plant	Infusion	100	23	0.023	
Vitex agnus-castus L	Kharwae	Seed	Infusion	100	15	0.015	
Amaryllidaceae							0.104
Allium cepa L	Bassla, Azalim	Bulb	Cataplasm	51.22	123	0.123	
Asparagaceae							0.013
Asphodelus microcarpus Salzm. & Viv	Lberwag, Inghri	Bulb	Decoction	100	36	0.036	
Nyctaginaceae							0.001
Mirabilis jalapa L	Chob Ellayl	Root	Decoction	100	01	0.001	
Pinaceae							0.048
Cedrus atlantica (Endl.)	Arz	Leaf	Other	100	96	0.096	
Poaceae							0.014
Dactyloctenium aegyptium (L.) Willd	Njem Rjel Djaja	Seed	Decoction	100	08	0.008	
Rubiaceae							0.063
Coffea arbica L	Qahwa	Seed	Decoction	100	65	0.065	
Solanaceae							0.025
Datura stramonium L	Chedak Jmal	Seed	Other	100	02	0.002	
Lycium europaeum L	Haded Europa	Leaf	Cataplasm	100	01	0.001	
Nicotiana glauca Graham	Tembak Berri	Flower	Decoction	100	23	0.023	
Solanum tuberosum L	Batâta	Leaf	Cataplasm	100	78	0.078	
Typhaceae							0.001
Typha angustifolia L	Bot, Kseb	Stem	Other	100	01	0.001	
Verbenaceae							0.053
Aloysia citrodora Palau	Lwiza	Leaf	Infusion	95.24	105	0.105	

for osteoarticular diseases (ICF = 0.983), followed by dermatological diseases (ICF = 0.981), and neurological diseases (ICF = 0.974). The least (0.944) ICF was associated with

Respiratory system diseases. Ethnopharmacological studies have shown that in some parts of the world, osteoarticular diseases are a first-use category [7, 46, 47]. Osteoarticular

Table 6 Inventory of plant species used to treat metabolic diseases by indigenous people of Rif

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Amaranthaceae							0.024
Beta vulgaris L.	Lbarba	Seed	Infusion	100	06	0.006	
Apiaceae							0.032
Ferula communis L.	Lkalkha	Leaf	Decoction	100	04	0.004	
Ridolfia segetum (L.) Moris	Slilo	Leaf	Cooked	70.6	17	0.017	
Asteraceae							0.038
Calendula arvensis M.Bieb	Jemra, Azwiwel	Flower	Infusion	100	96	0.096	
Helianthus annuus L.	Abbad Shems	Seed	Infusion	100	21	0.021	
Lactuca sativa L.	Elkhass	Leaf	Infusion	100	22	0.022	
Sonchus asper (L.) Hill	Tifaf	Whole plant	Decoction	100	01	0.001	
Sonchus tenerrimus L.	Tifaf	Leaf	Decoction	48	25	0.025	
Tanacetum vulgare L.	Lbalssem	Leaf	Infusion	52.4	42	0.042	
Brassicaceae							0.012
Anastatica hierochuntica L.	Kaff Mariam	Root	Decoction	80	25	0.025	
Brassica oleracea L.	Karnabite	Leaf	Other	77.8	09	0.009	
Cucurbitaceae							0.013
Citrullus colocynthis (L.) Schrad	Lhdej, Taferzizte	Seed	Infusion	100	09	0.009	
Cucurbita pepo L.	Garaa Khedra	Fruit	Cooked	100	43	0.043	
Cupressaceae							0.043
Juniperus phoenicea L.	Arar Finiqi	Leaf	Decoction	100	79	0.079	
Euphorbiaceae							0.030
Euphorbia peplus L.	Laaya, Haliba	Whole plant	Other	100	01	0.001	
Fabaceae							0.023
Acacia albida Delile	Chok Telh	Root	Decoction	100	02	0.002	
Lupinus pilosus L.	Rjel Djaja	Seed	Infusion	100	07	0.007	
Phaseolus aureus Roxb	Soja	Seed	Decoction	100	02	0.002	
Phaseolus vulgaris L.	Loubya	Seed	Cooked	100	36	0.036	
Lamiaceae							0.056
Marrubium vulgare L.	Merriwta Hara, Ifzi	Leaf	Infusion	100	01	0.001	
Rosmarinus officinalis L.	Azir, Yazir	Leaf	Infusion	100	189	0.189	
Salvia officinalis L.	Salmiya	Leaf	Infusion	100	119	0.119	
Linaceae							0.065
Linum usitatissimum L.	Zeri't El Kettan	Seed	Cooked	100	65	0.065	
Moraceae							0.030
Ficus carica L.	Karmous, Chriha	Leaf	Infusion	70	10	0.010	
Ficus carica var. dottato	Karmous, Chriha	Fruit	Other	100	11	0.011	
Morus alba L.	Ettout	Leaf	Infusion	58.8	68	0.068	
Papaveraceae							0.014
Fumaria officinalis L.	Hchicht Essibyan	Root	Decoction	100	01	0.001	
Portulacaceae							0.005
Portulaca oleracea L.	Rejla, Tasmamine	Leaf	Cooked	100	05	0.005	
Rosaceae							0.026
Malus domestica Borkh	Tûffah	Fruit	Other	100	76	0.076	

diseases were prevalent in the study area which can be attributed to the limited availability of hygienic food mineral salts (calcium, magnesium, phosphorus) and vitamins (Vitamin D). Higher rates meant that only a few medicinal plants are used by the interviewees to treat a particular disease.

The plants frequently used to treat these disorders might contain active ingredients and thus were well known by locals. It expresses the best consensus between medicinal plants and treated osteoarticular diseases because informants interviewed used specific plant species commonly for

Table 7 Inventory of plant species used to treat genitourinary diseases by indigenous people of Rif

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Amaranthaceae							0.024
Atriplex halimus L.	Legtef	Leaf	Infusion	100	03	0.003	
Anacardiaceae							0.048
Pistacia lentiscus L.	Drou	Leaf	Infusion	83.5	97	0.097	
Apiaceae							0.032
Conium maculatum L.	Choukran	Leaf	Cataplasm	100	13	0.013	
Petroselinum sativum Hoffm	Maâdnous	Leaf	Decoction	100	109	0.109	
Pimpinella anisum L.	Habbat Hlawa	Seed	Other	100	35	0.035	
Apocynaceae							0.079
Caralluma europaea (Guss.) N.E.Br	Daghmous	Leaf	Infusion	100	89	0.089	
Aristolochiaceae							0.043
Aristolochia baetica L.	Berztem	Leaf	Cataplasm	100	43	0.043	
Asteraceae							0.038
Silybum marianum (L.) Gaertn	Tawra	Seed	Decoction	100	76	0.076	
Boraginaceae							0.014
Borago officinalis L.	El Hamhem	Flower	Infusion	100	02	0.002	
Caryophyllaceae							0.084
Arenaria rubra L.	Herras Lehjar	Whole plant	Decoction	53	153	0.153	
Corrigiola telephiifolia Pourr	Sarghina	Whole plant	Decoction	100	71	0.071	
Euphorbiaceae							0.030
Mercurialis annua L.	Hrriyga Lmelsa	Whole plant	Decoction	100	05	0.005	
Fabaceae							0.023
Cicer arietinum L.	Hommes	Seed	Decoction	83.3	18	0.018	
Lamiaceae							0.056
Lavandula officinalis Chaix	Lkhzama	Flower	Infusion	45.5	112	0.112	
Marrubium heterocladum Emb. and Maire	Mriwta	Leaf	Decoction	100	01	0.001	
Myrtaceae							0.028
Myrtus communis L.	Rayhan	Leaf	Decoction	76.8	56	0.056	
Pimenta dioica (L.) Merr	Nwiwira	Fruit	Infusion	100	08	0.008	
Pedaliaceae							0.007
Sesamum indicum L.	Jenjlane	Seed	Infusion	100	07	0.007	
Poaceae							0.015
Eleusine indica (L.) Gaertn	Njem	Whole plant	Decoction	100	01	0.001	
Festuca arundinacea Schreb	Aguzmir	Seed	Infusion	100	05	0.005	
Rosaceae							0.026
Eriobotrya japonica (Thunb.) Lindl	Lemzah	Leaf	Infusion	100	02	0.002	
Rutaceae							0.052
Citrus × aurantium L.	Larnej	Flower	Cooked	100	25	0.025	
Citrus limetta Risso	Lhamed Beldi	Fruit	Cooked	100	06	0.006	
Citrus limon (L.) Osbeck	Lhamed	Fruit	Other	100	06	0.006	
Citrus reticulata Blanco	Lmandarine	Fruit	Cooked	100	01	0.001	
Urticaceae							0.028
Urtica urens L.	Lhurriga	Leaf	Decoction	100	14	0.014	
Zygophyllaceae							0.002
Tribulus terrestris L.	Ders Elajouz	Whole plant	Cooked	100	02	0.002	

osteoarticular diseases. Hence, species with high ICF values show that the plants traditionally used to treat these illnesses are worth exploring for bioactive compounds [48], while low values are associated with many plant species with an almost equal or high use reports suggesting a lower level of

Table 8 Inventory of plant species used to treat dermatological diseases by indigenous people of Rif

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Amaranthaceae							0.024
Chenopodium ambrosioides L.	Mkhinza	Leaf	Decoction	60.2	93	0.093	
Anacardiaceae							0.048
Rhus pentaphylla (Jacq.) Desf	Tizgha	Leaf	Decoction	60.5	76	0.076	
Araceae							0.014
Arisarum vulgare O.Targ.Tozz	Irni	Whole plant	Decoction	100	14	0.014	
Asparagaceae							0.013
Agave Americana L.	Sabra	Whole plant	Cataplasm	100	82	0.082	
Asteraceae							0.038
Atractylis gummifera Salzm. ex L.	Addad	Whole plant	Other	60	05	0.005	
Dittrichia viscosa (L.) Greuter	Magraman, Terrahla	Leaf	Other	100	165	0.165	
Lactuca virosa Habl	Ahchlaf Nssem	Leaf	Other	100	16	0.016	
Sonchus fragilis Ball	Tifaf	Leaf	Cataplasm	100	07	0.007	
Caryophyllaceae							0.084
Silene ibosii Emb. and Maire	Tigheghecht	Whole plant	Decoction	100	105	0.105	
Euphorbiaceae							0.030
Euphorbia falcata L.	Hayat Nofos	Whole plant	Infusion	84.1	63	0.063	
Ricinus communis L.	Kherouâ, Uwriwra Krank	Leaf	Infusion	90.2	51	0.051	
Fabaceae							0.023
Acacia raddiana Savi	Talh	Leaf	Decoction	100	19	0.019	
Fagaceae							0.038
Quercus suber L.	Dbagh, Fernan	Bark	Decoction	71.4	70	0.070	
Lythraceae							0.103
Lawsonia inermis L.	Henna	Leaf	Cataplasm	100	154	0.154	
Papaveraceae							0.014
Glaucium flavum Crantz	Merzak Halabi	Flower	Decoction	100	06	0.006	
Papaver rhoeas L.	Bela'man	Flower	Infusion	100	34	0.034	
Pinaceae							0.048
Pinus pinaster Aiton	Tayda	Bark	Decoction	100	04	0.004	
Pinus sylvestris L.	Sanouber	Bark	Decoction	100	45	0.045	
Poaceae							0.015
Triticum aestivum L.	Lgamh, Farina	Leaf	Infusion	100	14	0.014	
Triticum turgidum L.	Zraa, Irden	Whole plant	Decoction	60	05	0.005	
Solanaceae							0.025
Capsicum annuum L.	Tahmira	Fruit	Cataplasm	100	87	0.087	
Capsicum frutescens L.	Sudaniya, Flfel Har	Fruit	Decoction	100	05	0.005	

agreement among the informants on the use of these plant species to treat a particular disease category [39].

The Rifain people used many various plant parts for preparing remedies. In our investigation, leaves were the most commonly utilized plant part with PPV = 0.364 application in traditional medicinal remedies, followed by seed (PPV = 0.2263), and whole plant (PPV = 0.097). Many studies conducted elsewhere in other countries also showed the dominance of leaves in the preparation of remedies [1, 2, 4, 37, 49–51]. The reason why leaves and aerial parts were mostly used could be that they are most easily accessible and their richness in secondary metabolites produced by photosynthesis. From the conservation point of view, the use of leaves is sustainable, since, if the withdrawal of aerial parts is not excessive, will not prevent the development and/or reproduction of the plant [52]. In this context, the use of leaves in herbal preparations implies a more sustainable practice but the harvesting of roots (which oftentimes requires uprooting) may result to plant death [53]. On the other hand, collecting leaves has a less detrimental impact on plants compared to the harvesting of roots and stem barks especially where there are no sustainable harvesting strategies in place [54]. Besides, a collection of leaves would be

Table 9 Inventory of plant species used to treat osteoarticular diseases by indigenous people of Rif

Family and scientific name	Vernacular name	Used part	Method of preparation	FL %	FC	RFC	FIV
Apocynaceae							0.079
Nerium oleander L.	Defla, Alili	Leaf	Decoction	95.2	146	0.146	
Asteraceae							0.038
Anacyclus pyrethrum (L.) Lag	Tiguentest, Ginass	Root	Infusion	100	81	0.081	
Calendula eckerleinii Ohle	Jemra	Flower	Cataplasm	100	67	0.067	
Carduus martinezii Pau	Chok Mchaar	Leaf	Decoction	100	91	0.091	
Boraginaceae							0.014
Anchusa italica Retz	Lsan Etthawr	Flower	Infusion	100	26	0.026	
Capparaceae							0.073
Capparis spinosa L.	Kebbar, Taglulut	Seed	Infusion	100	73	0.073	
Convolvulaceae							0.032
Convolvulus althaeoides L.	Lablab El hokol	Flower	Decoction	100	63	0.063	
Fabaceae							0.023
Pisum sativum L.	Jelbana	Seed	Cataplasm	100	25	0.025	
Nitrariaceae							0.053
Peganum harmala L.	El Harmel	Seed	Cataplasm	100	53	0.053	
Poaceae							0.014
Agrostis reuteri Boiss	Ziwan Khachabi	Flower	Decoction	85.7	14	0.014	
Bromus squarrosus L.	Amlsikh, Chwiara	Leaf	Decoction	75	16	0.016	
Oryza sativa L.	Rûz	Seed	Cooked	94	101	0.101	
Poa annua L.	Kabaa Howli	Leaf	Decoction	100	08	0.008	
Setaria verticillata (L.) P. Beauv	Dayl Eddib	Flower	Cooked	100	17	0.017	
Solanaceae							0.025
Withania frutescens (L.) Pauquy	Ali Amlal, Tayrta	Leaf	Decoction	88.9	45	0.045	
Urticaceae							0.028
Urtica dioica L.	Hriga	Leaf	Cataplasm	100	41	0.041	

Fig. 5 Cultivation of *vicia faba* L. in Izefzafen region

Fig. 6 *Salsola kali* L. in a wasteland of Tizi n Tchin

Table 10 ICF values by categories for treating human ailments in the Rif region

Ailments treated	Nt	Nur	ICF
Osteoarticular diseases	16	867	0.983
Dermatological diseases	22	1080	0.981
Neurological diseases	30	1129	0.974
Genitourinary diseases	27	960	0.973
Metabolic diseases	29	992	0.972
Cardiovascular diseases	29	879	0.968
Digestive system diseases	86	1552	0.945
Respiratory system diseases	41	717	0.944

much easier and sustainable than that of roots or flowers [55].

Concerning the methods of preparation, decoction (38.6%), and infusion (34%). are the most common preparation methods that are used by indigenous people of Rif. The major solvent with the plant was water, but milk, butter, tea, and honey, oils were also extensively used as ingredients. Local people of Rif add honey, sugar, salt, orange peel, banana, or lemon to increase the palatability of a preparation. Moreover, honey is considered sacred to Muslims and occupies an important place in Islamic popular medicine [56, 57]. Indeed, honey is considered an instant energy source and is often used in all parts of the world to improve the acceptability of medicinal plants having a bitter taste unbearable. The decoction is a mostly used method for the preparation of indigenous herbal practices due to its easy preparation by mixing with water or tea [58]. However, the decoction provides assemble the greatest for the active constituents and attenuates or eliminates the toxic effect of some compounds. Decoction and infusion are very valued and often favored by popular healers in Morocco [4, 7, 15, 59, 60]. The predominance of decoction of the different plant species in the Rif is in total agreement with most of the carried out ethnobotanical studies [4, 50, 51, 61–64]. Generally, the main route of application for herbal therapies was oral (82.4%). Furthermore, the oral mode of administration is a preferred route all over the world [10, 14, 36, 38, 39, 65]. The predominance of oral treatment may be explained by a large incidence of internal illnesses in the Rif region. The administration of oral treatment may be defined by a high degree of internal illnesses in the region [66].

5 Conclusions

Our investigation revealed that the use of plant species is playing an essential purpose in satisfying the basic healthcare requirements of the indigenous people residing in the Rif, northern Morocco. In this study, an ethnopharmacological catalog constituted of 280 plant species, belonging to 204 genera in 70 families, has been developed, these results of the study showed that there is a great variety of medicinal plants. The number of medicinal plants recorded for the prevention and therapy of human ailments is a good indicator of the potential that exists locally so long as the scientific procedure is added to the indigenous knowledge in terms of traditional herbal medicine. In light of this, medicinal plants with the most important RFC and FL values were identified could be taken up for further phytochemical, pharmacological, and clinical studies that allow the development of new herbal preparations or formulation of novel drugs addressed to improve the quality of life for treating various human diseases.

Appendix A

Questionnaire sheets: Medicinal plants and herbal medicine

Date..

Region ....

Commune..

Survey number...

<u>Informant:</u>

Profession: ....

Sex: Male ☐   Female ☐

Age: { ≤ 20} ☐   {20 - 40} ☐   {40 - 60} ☐   { ≥ 60} ☐

Family situation: Single ☐   Divorced ☐   Widower ☐   Married ☐

Level of study: Illiterate ☐   Primary ☐   Secondary ☐   University ☐

Locality: Nomadic ☐   Town ☐   Village ☐   City ☐

Income / month (MAD): Unemployed ☐ {250 - 1500} ☐ {1500 - 5000} ☐   { ≥ 5000} ☐

<u>Therapeutic practices :</u>

When you feel sick, you address:

To traditional medicine, why?

        Effective ☐   Cheapest ☐   Acquisition ☐   Ineffective medication ☐

To modern medicine, why?   Effective ☐   More precise ☐   Toxicity of plants ☐

If it is two that it is the first: Traditional medicine ☐   Modern medicine ☐

<u>Vegetal material:</u>

Vernacular name:………………………………………………………………………...

Scientific Name: ....

Plant Type: Spontaneous ☐   Cultivated ☐   Introduced ☐

Use of the plant: Therapeutic ☐   Cosmetic ☐   Other ☐

Harvesting technique: Manual ☐   Mechanical ☐

Harvest Time: Summer ☐   Fall ☐   Winter ☐   Spring ☐   Any year ☐

Drug preparation: Plant alone ☐   Possible association (of plants) ☐

If association of plants, quote the recipe:…………………………………………………..

Use of the plant: Fresh ☐   Desiccated ☐   After treatment ☐

If desiccated, drying method: Sun exposure ☐   In the Shade ☐

Used part: Stem ☐   Flower ☐   Fruit ☐   Seed ☐   Bark ☐   Bulb ☐

Root ☐   Rhizome ☐   Leaf ☐   Whole plant ☐   Other combination ☐

Form of employment: Tisane ☐   Powder ☐   Essential oil ☐   Oily oil ☐   Tincture ☐

Method of preparation: Infusion ☐   Decoction ☐ Cataplasm ☐   Raw ☐   cooked ☐   Other ☐

The dose used: Pinch ☐   Handle ☐   Spoonful ☐

Precise Dose: Quantity in g / glass: ………...   Quantity in g / liter: ……....   Other: ……………..

Administration mode: Oral ☐   Massage ☐   Rinse ☐   Swabbing ☐   Other ☐

Dosage: number of doses per day:

For children: 1time / day ☐   2time / day ☐   3time / day ☐   Other ☐

For adults: 1time / day ☐   2time / day ☐   3time / day ☐   Other ☐

For older people: 1time / day ☐   2time / day ☐   3time / day ☐   Other ☐

Length of Use: One Day ☐   A Week ☐   One month ☐   Until healing ☐

Conservation method: Sheltered from the light ☐   Exposed to light ☐   Other ☐

Expiration date:………… …………………………………………………………………….……

<u>Use :</u>

Diagnosis By: Himself ☐   Doctor ☐   Herbalist ☐   Other ☐

Results: Healing ☐   Improvement ☐   Ineffective ☐

Side effect: ....

Toxicity: ....

Caution of use: …………………………………………………………………….....................

Declarations

Conflict of interest We declare that there is never a conflict of interest with any commercial business about the document.

Consent for publication Consent for publication was obtained from participants.

Ethical Approval and Consent to participate The study was authorized by the ethical committee of Ibn Tofail University. Before starting data collection, we obtained oral informed permission in each case on a site level and then individually before each interview. We also informed indigenous people that it was a student academic project and investigation was only for our research purposes, not for any financial or other benefits. Informants provided verbal informed consent to engage in this study; they were free to withdraw their information at any point in time. Those informants have accepted freely the idea and they have consented to have their names and personal data to be published.

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