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Neurological Phytotherapy by Indigenous People of Rif, Morocco

Noureddine Chaachouay and Lahcen Zidane

Abstract

The Rif region has a rich culture of popular medicine use and valuable medicinal plant practices. This study aimed to assess the potential concerning medicinal plants used in the treatment of neurological diseases. An ethnobotanical survey has been carried out in the Rif for two periods from June 2016 to June 2018. To gather information about indigenous medicinal plants, 520 indigenous people of Rif were interviewed. The data were gathered through semi-structured interviews and free listening, analyzed, and compared. A total of 42 plant species belonging to 37 genera and 23 families were mentioned to be used for treatment by the informants. Lamiaceae was the most commonly reported family in this study area. The most common ailment treated was epilepsy. The preponderance of the herbal remedies was prepared from infusion (53.4%). Leaf was the commonly used plant part (44.3%) and *Marrubium vulgare* L. (29.4%) was the species most commonly prescribed by indigenous healers. The results of this investigation revealed that indigenous communities living in the Rif are still reliant on plants to treat neurological diseases. These reported medicinal species can serve as a source for further investigations on these medicinal plant knowledge and future phytochemical, toxicological, and pharmacological studies.

Keywords: Phytotherapy, medicinal plants, Moroccan Rif, neurological diseases

1. Introduction

The World Health Organization (WHO) estimates that more than one billion people suffer from central and peripheral nervous system disorders globally [1]. The term neurological disorder (ND) applies to any condition that is caused by a dysfunction in part of the brain or nervous system, resulting in physical and/or psychological symptoms [1]. These diseases include Parkinson's disease, schizophrenia, brain tumors, bipolar disorder, epilepsy, neuro infections, Alzheimer's disease, and other dementias, traumatic disorders, and cerebrovascular diseases such as stroke and migraine [2].

Medicinal plants are an important source of active substances that are exploited in the treatment of several sicknesses. In all ancient civilizations and all continents, one finds traces of this use [3]. Thus, even today, despite the progress of pharmacology, the therapeutic use of plants is very present in some countries, especially in developing countries [4, 5].

Today, despite the development of chemical drugs to combat neurological diseases, there is often a return to plants as a source of active ingredients. Besides, an important part of the population, especially in rural areas, prefers medicinal plants, for economic reasons and sometimes because of difficulty in accessing medical care [6].

The rural region of Morocco holds a wide variety of plant species, still offering the possibility to discover very interesting new natural products with potential medicinal value. The Rif region is one of the richest Mediterranean regions in terms of plant diversity, owing to its unique geographical location with geomorphological structures and various climatic. The loss of important medicinal species due to community demand, farming expansion, and deforestation are widely documented by many researchers [7, 8]. This study aimed to investigate local people's use of medicinal plant species used for therapeutic purposes in response to the neurological diseases in the Rif.

2. Materials and methods

2.1 Study area

The research was taken out in the Rif (Northern Morocco) where the Tangier-Tetouan-Al Hoceima region was located. It extends between 34° to 36° of latitude in the North and 4° to 6° of longitude in the East. It is bordered 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 (**Figure 1**). The total geographical area of the Rif is 11 570 km² and the population of the city is about 3 549 512 people with a population density rate of 222.2/km² [9].

The study area is characterized by a Mediterranean climate with the highest temperature exceeding 45°C during summer (July–August) and under 0°C during winter (December–January) and the average yearly precipitation ranges from 700 to 1300 mm which falls mainly between October and February [10]. It is mountainous with elevations ranging from 145 to 2.456 (Jbel Tidirhine) meters above mean sea level. This area is dominated by species such as *Tetraclinis articulata* (Vahl)

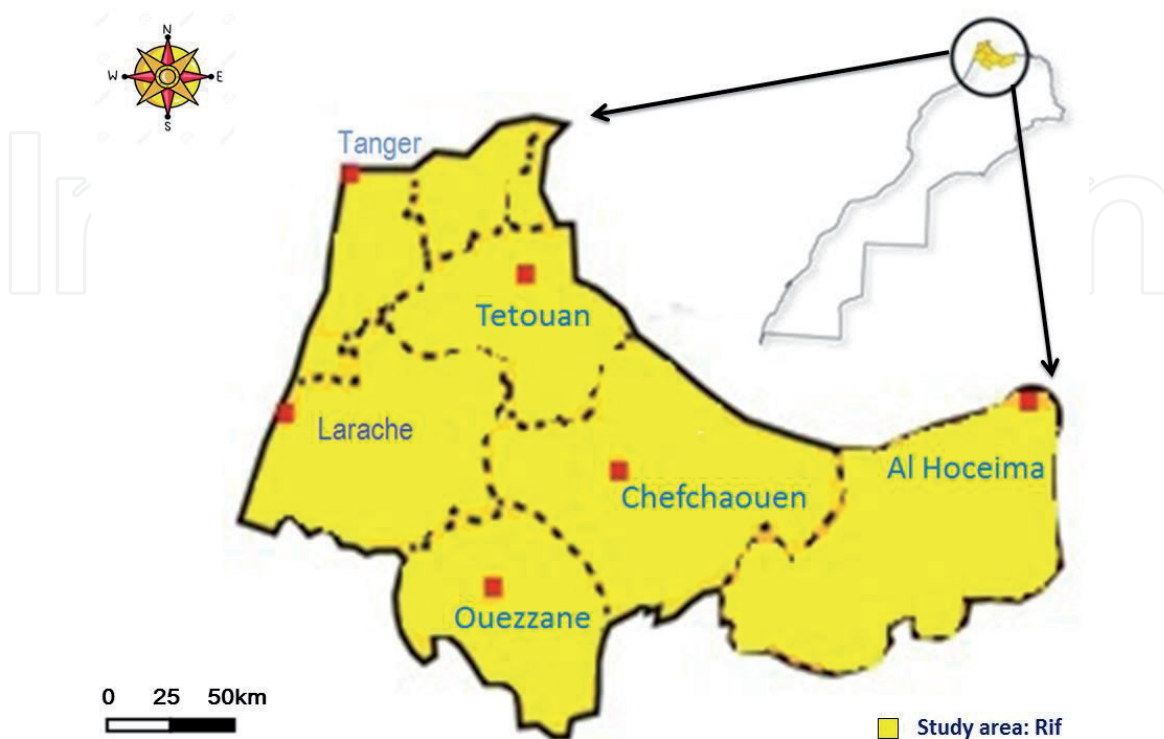


Figure 1.
Map of the study area in Morocco.

Mast., *Cupressus atlantica* Gaussen, *Pinus halepensis* Mill., *Cedrus atlantica* (Endl.) *Quercus suber* L., *Quercus ilex* L., and *Quercus canariensis* Willd. Principally inhabitants of Rif are very much dependent on subsistence agriculture, livestock, and to a minor degree, from forest reserves for their livelihood. Popular medicine is the first choice for the population for health problems, and traditional healers in this area are reputed to have good knowledge of plants and disease treatment [11, 12].

2.2 Methodology

2.2.1 Ethnobotanical survey

Ethnobotanical investigations were carried out from June 30th, 2016 to June 1st, 2018 to collect knowledge on plant species used to treat neurological disorders in the Rif. The techniques employed for data collection were semi-structured interviews [13], free listing, open-ended, group discussion, and noted and recorded with a digital voice recorder. The free survey was designed to collect data on: Socio-demographic information of the informants (gender, age, academic level, and origin of oral health information) and plants used in the treatment of neurological disorders (local names, popular uses, parts used, the form of preparation, method of administration, and posology). Five hundred twenty interviewees aged 17 to 80 were randomly chosen for discussions (cautery installer, farmers, elder people, bonesetters, herbalists, and therapists) in the study area (houses, pharmacies, weekly markets, hospitals, and mosques). By conducting a stratified random sampling, samples were then formed in each of the 28 strata (**Figure 2**), including seven urban communes, and they are put together to make up the overall sample of all informants. The inhabitants in the study area speak Amazigh, Arabic dialects, and therefore, informants were conducted in Arabic dialects or Amazigh. All the documented data was later translated into English.

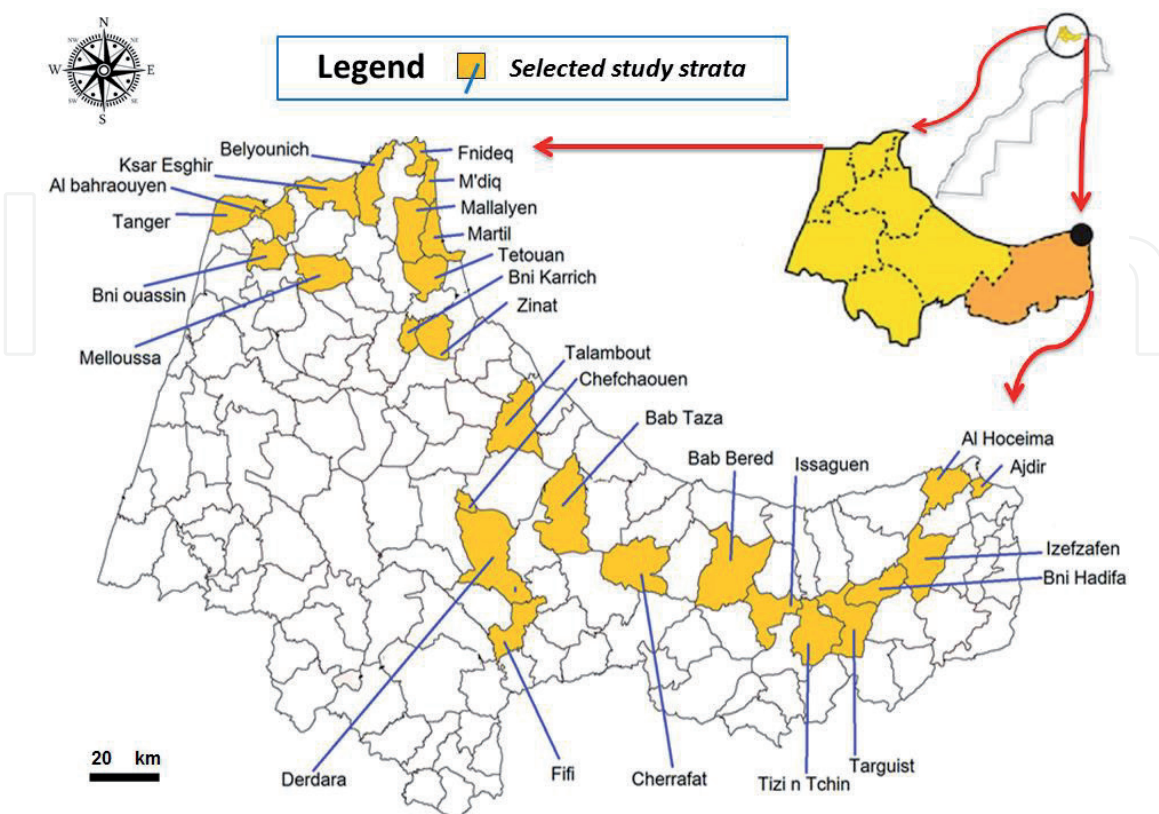


Figure 2.
Distribution of survey points at the study area level.

2.2.2 Plant species collection and identification

Medicinal species being mentioned by the informants were registered with local names and photographed. For each reported plant species, the plant species were accumulated, classified, and voucher specimens were archived. 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* by one of the authors using some floristic works of literature as well as: The medicinal plants of Morocco [14], Practical flora of Morocco, tomes I, II and III [14–16] and Catalogs of vascular plants of northern Morocco, including identification keys, tomes I, II [17, 18]. Taxonomy and denominations of species were validated using “The Plant List 2020” database (<http://www.theplantlist.org>). Voucher specimens have been kept at our University, for future reference.

2.2.3 Data analysis

Data were classified and interpreted by Statistical Package for Social Science (SPSS) version 21 and Microsoft Excel 2010. A representative and quantitative statistical method was adopted to examine the socio-demographic information of the interviewees. All statistical analyses were carried out with Statistical Package for Social Science (SPSS) version 21 and Microsoft Excel 2010.

3. Results

3.1 Demographics of participants

A total of 520 study informants, including 178 herbal sellers, 213 herbalists, 45 pharmacists, 30 midwives, and 54 other traditional healers (bonesetters, fouqaha, cautery installer, farmers, elder people, and nobles), were interrogated using semi-structured surveys and group interviews. In the study area, both sexes are interested in herbal medicine. However, the numbers of females participants were more important (267 informants) than those of male (253 informants). In this study, results showed that the utilization of medicinal species is widespread in all age groups with various percentages. The bulk of informants surveyed were between 40 and 60 years old (232), and over 50 years old (170), while 3 of the informants were the age less than thirty years old. Concerning the educational level, our results revealed that the majority of the informants (77.1%) were uneducated, (19.8%) have primary education, 2.3% have secondary education, and only 0.8% of the informants had high education (**Table 1**).

3.2 Diversity of botanical families

In this study, 42 plant species belonging to 37 genera and 23 families were recorded to be used by indigenous people from the Rif to treat neurological disorders. The scientific names of reported species, their families, vernacular names, plant parts used; method of preparation of each plant species was illustrated in **Table 2**. The family Lamiaceae was designed by the largest number of plant species (6 species), followed by Solanaceae with 4 species, Asteraceae, Brassicaceae, and Fabaceae (3 species each), whereas, the rest of botanical families were represented by one or two species in each.

3.3 Species diversity

The collected information analysis indicates that among the 42 plant species found in the Rif region, 5 medicinal plants are the most used. The specie *Marrubium*

Variables	Categories	Number of informants	Percentages (%)	P-values
Gender	Female	267	51.3	0.857
	Male	253	49.7	
Age groups	< 20 years	6	1.2	0.000
	20–40	112	21.5	
	40–60	232	44.6	
	> 60 years	170	32.7	
Family situation	Married	450	86.5	0.000
	Divorced	32	6.2	
	Widower	23	4.4	
	Single	15	2.9	
Educational level	Illiterate	400	77.1	0.000
	Primary	103	19.8	
	Secondary	12	2.3	
	University	5	0.8	
Income/month (Dirham)	Unemployed	209	42.2	0.000
	250–1500 MAD	192	36.9	
	1500–5000 MAD	80	13.4	
	> 5000 MAD	39	7.5	

Table 1.
 Socio-demographic profile of the informants.

vulgare L. was used by 153 informants, followed by *Allium cepa* L. (120), *Matricaria chamomilla* L. (110), *Linum usitatissimum* L. (107), and *Rosmarinus officinalis* L. (103). While the other plants are less used by the local population (**Table 2**).

3.4 Neurological disease categories

Local people of Rif used 42 medicinal plants to treat various neurological disease categories (**Table 3**). The 2 691 use reports were classified into 4 health diseases categories following the International Classification of Primary Care classification system (ICPC) [19]. Most use records were in the category epilepsy (1 142 use reports) and the highest number of plant species used to treat it (21 plant species) followed by headache (950 use reports; 20 plant species) and sciatica (389 use reports; 9 plant species). The last category was associated with meningitis (210 use reports; 6 plant species).

3.5 Plant parts used to treat neurological disorders

In phytotherapy, various plant parts reported particularly leaves, flowers, seeds, roots, fruits, or even whole plant are exploited by the indigenous communities. In this study, the leaf was reported as the dominant plant part used for remedial preparation in their study area (44.3%), followed by bark (11.5%), aerial parts (10.3%), seed (10.2%), bulb (8.8%), fruit (6.6%), root (3.7%), and flower (1%) respectively.

3.6 Methods of preparation

The preparation of herbal remedies needs liquids. The major solvent with the plant was water, but milk, butter, tea and honey, cereal oils were also widely used

Family and Scientific name	Vernacular name	Part used	Preparation mode	Medicinal uses	UR
Amaranthaceae					
<i>Spinacia oleracea</i> L.	Sabanikh	Leaf	Infusion	SC	20
Amaryllidaceae					
<i>Allium cepa</i> L.	Bassla	Bulb	Cataplasm	EL, HC	120
<i>Allium sativum</i> L.	Thoma	Bulb	Cataplasm	EL, HC	70
Asteraceae					
<i>Artemisia herba-alba</i> Asso	Chih	Leaf	Infusion	HC, EL	53
<i>Chrysanthemum coronarium</i> L.	Lgahouan	Leaf	Infusion	HC	28
<i>Matricaria chamomilla</i> L.	Lbabonj	Leaf	Infusion	HC	110
Brassicaceae					
<i>Brassica nigra</i> (L.) K.Koch	Lkhardel	Aerial parts	Cataplasm	SC	23
<i>Brassica oleracea</i> L.	Lmelfof	Aerial parts	Infusion	EL	17
<i>Brassica oleracea</i> var. <i>botrytis</i> L.	Lkrneb	Aerial parts	Infusion	EL, HC	14
Cupressaceae					
<i>Cupressus macrocarpa</i> Hartw.	Sarw	Leaf	Infusion	EL, MG	58
Fabaceae					
<i>Acacia longifolia</i> (Andrews) Willd.	Telh	Root	Decoction	SC	10
<i>Lens culinaris</i> Medik.	Laades	Aerial parts	Infusion	EL, SC, MG	11
<i>Pisum sativum</i> L.	Jelbana	Flower	Infusion	EL, HC	08
Fagaceae					
<i>Quercus canariensis</i> Willd.	Qerrich	Leaf	Cataplasm	HC	60
<i>Quercus suber</i> L.	Bellout	Leaf	Cataplasm	MG	33
Juglandaceae					
<i>Juglans regia</i> L.	Ljawz	Seed	Infusion	EL, SC	56
Lamiaceae					
<i>Lavandula dentata</i> L.	Lkhzama	Leaf	Infusion	EL	98
<i>Marrubium vulgare</i> L.	Mrouiate	Leaf	Cataplasm	EL, HC	153
<i>Mentha pulegium</i> L.	Naa Naa	Aerial parts	Infusion	HC	22
<i>Rosmarinus officinalis</i> L.	Azir	Leaf	Infusion	SC	103
<i>Salvia officinalis</i> L.	Salmia	Aerial parts	Infusion	HC, MG	16
<i>Thymus saturejoides</i> Coss.	Zaatar	Aerial parts	Cataplasm	EL, HC	27
Lauraceae					
<i>Cinnamomum zeylanicum</i> Blume	Lquerfa	Bark	Infusion	SC	89

Family and Scientific name	Vernacular name	Part used	Preparation mode	Medicinal uses	UR
<i>Laurus nobilis</i> L.	Rend	Laef	Infusion	HC	75
Linaceae					
<i>Linum usitatissimum</i> L.	Zriat elKtan	Seed	Decoction	EL	107
Myrtaceae					
<i>Myrtus communis</i> L.	Rayhan	Leaf	Decoction	HC	24
<i>Syzygium aromaticum</i> (L.) Merr. & L.M.Perry	Lqronfel	Flower	Decoction	HC, SC	13
Piperaceae					
<i>Piper nigrum</i> L.	Ibzar	Seed	Decoction	HC, SC	12
Poaceae					
<i>Avena sativa</i> L.	Choufan	Seed	Decoction	HC	20
Portulacaceae					
<i>Portulaca oleracea</i> L.	Rejla	Root	Infusion	EL	69
Rosaceae					
<i>Prunus dulcis</i> (Mill.) D.A.Webb	Louz	Fruit	Infusion	EL, MG	16
Rubiaceae					
<i>Coffea arabica</i> L.	Qahwa	Seed	Decoction	EL	26
Rutaceae					
<i>Citrus limon</i> (L.) Osbeck	Limon	Leaf	Infusion	HC	18
Salicaceae					
<i>Salix alba</i> L.	Sefsaf	Leaf	Cataplasm	EL	36
Santalaceae					
<i>Viscum album</i> L.	Dbeq	Bark	Decoction	EL	24
Solanaceae					
<i>Capsicum frutescens</i> L.	Lharra	Fruit	Decoction	HC	30
<i>Datura stramonium</i> L.	Chdeq jmel	Leaf	Decoction	HC	77
<i>Solanum lycopersicum</i> L.	Maticha	Fruit	Infusion	EL	95
<i>Solanum tuberosum</i> L.	Bettata	Aerial parts	Infusion	EL	90
Verbenaceae					
<i>Aloysia citriodora</i> Palau	Louiza	Leaf	Infusion	MG	76
Zingiberaceae					
<i>Curcuma longa</i> L.	Lkharqom	Bark	Decoction	EL	70
<i>Zingiber officinale</i> Roscoe	Skinjbir	Bark	Decoction	SC	63

EL: Epilepsy, HC: Headache, SC: Sciatica, MG: Meningitis.

Table 2.
 List of medicinal plants used to treat neurological disorders in the Rif, Morocco.

ingredients. No traditional healers reported toxicity associated with their therapies, but in most cases, patients were told to water, milk, butter, tea, and honey, cereal oils were also widely used ingredients. The informants in the present survey were

Categories	Number of taxa	Number of citations
Epilepsy (EL)	21	1 142
Headache (HC)	20	950
Sciatica (SC)	9	389
Meningitis (MG)	6	210

Table 3.
Medicinal plants are used to treat different disease categories.

practicing 3 different types of preparation methods. The results showed that the majority of remedies (53.4%) were prepared from infusion (42.12%), followed by cataplasm (24.4%), and decoction (22.2%).

3.7 Source of medicinal plants

Most of the medicinal plant species recorded in this study grow wild in that region. These species are generally collected at high-mountainous elevation in the highlands surrounding the Rif. Thirteen species (31%) were collected in the wild, 10 plants were cultivated (23.8%), 5 taxa were introduced (11.9%) and 14 (33.3%) were collected as both wild and cultivated.

4. Discussion

Popular medicine practice in the Rif region is diversified and rich. The floristic analysis showed that a total of 42 medicinal species belonging to 37 genera and 23 botanical families were commonly utilized by local people in the therapy of cystitis. The botanical family Lamiaceae was described by the most important number of medicinal plants (6 species). The dominance of Lamiaceae might reflect a rich bioactive ingredient and a wide variety of phytochemical compounds in the species taxa belonging to this family. Scientific studies on these plant families could provide insights into their rich phytoconstituents and understandings of the pharmacological actions of their active compounds. These results are in general agreement with ethnomedicinal inventories which indicated that the most prominent family was Lamiaceae [11, 20–24].

The most commonly used plant species were *Marrubium vulgare* L. the most common significant (29.4%) followed by *Allium cepa* L. (23.1%), *Matricaria chamomilla* L. (21.2%), *Linum usitatissimum* L. (20.5%), and *Rosmarinus officinalis* L. (19.8%). According to many authors, all these plants have phytochemical components with effects on the nervous system [25]. They contain flavonoids, alkaloids, tannins, saponins terpenoids, steroids, and cardiac glycosides. These chemical constituents were considered as the main bioactive compounds of medicinal plants [26]. These chemical contents could be responsible for the traditional use of this plant. Indeed, alkaloids are the most known molecules possessing psychoactive properties [27]. Likewise, some flavonoids, terpenoids, and steroids were quoted to have a psychoactive effect [28, 29]. These chemical constituents intervene to disturb neurotransmitter activities. Moreover, our investigations showed that medicinal plant species that were used by a single or few informants tend to have lower use values than the more prevalent species as shown in **Table 2**. This can imply that some medicinal plant knowledge was maintained and used by a specific traditional healer of Rif's people. However, Tardio et al. [30] stated that a plant with a low use value could be a very important plant for a few people. Therefore, the study of

culturally important medicinal plants could provide a deeper understanding of the study area of traditional medicinal practice [31].

The medicinal plants that are widely used by the people of Rif have higher use values than those that are less popular. The highest value of use indicates that plant species are mostly preferred for the study population to treat a given disease. There are 28 plant species highly cited for neurological disorders that should be taken into further consideration through phytochemical, pharmaceutical, and biological studies to evaluate more data regarding their efficacy and authenticity. The present study showed a high degree of agreement among interviewees especially in the categories of epilepsy problems and headache problems.

The reported ailments were grouped into 4 categories based on the information gathered from the interviews. The highest use value was obtained for epilepsy (1 142 use reports, 21 species). These data correspond to those of other ethnopharmacological studies [12, 24, 32–36], which revealed that these pathologies are well-known and treated in the traditional medicine of many countries. The informant consensus values also indicated that the people share the knowledge of the most important medicinal plant species to treat the most frequently encountered neurological diseases in the study area. The agreement information reflects the homogeneity of information provided by different indigenous people regarding medicinal species used to treat a category of ailments. High agreement information is correlated to species that could be efficient in treating a particular ailment [37].

The analyses of results revealed that leaf is the most frequently used part of the plants (44.3%), followed by bark (11.5%), aerial parts (10.3%). The selection of leaves was due to its natural availability, easy gathering, and simplicity in herbal remedy preparation. Besides, the leaves are the seat of the photosynthesis and sometimes the storage of the secondary metabolites responsible for the biological properties of the plant. Similar findings indicated leaf as a major dominant plant part in Morocco [22, 38–41] or Africa [36, 42–44] for herbal medicine preparation.

In the Rif, infusion remains the most dominant method of preparation (41.6%), (53.4%), followed by cataplasm (24.4%), and decoction (22.2%). Infusion is the most common preparation method that is used by traditional healers in other ethnobotanical studies at national and international scales [22–24, 45–48]. These results show that the local population believes in infusion mode and found it suitable for heating the body and disinfecting the plants [49]. On the other hand, the decoction allows collection the most for the active ingredient and attenuates or cancels the toxic effect of certain recipes.

In our study, 68% of the population acquired knowledge about the medicinal use of plants as a remedy for neurological diseases through others' experiences. This reflects the relative transmission of traditional practices from a generation to the next one; the environment and others' experience remain therefore the most effective means to transmit knowledge about medicinal purposes of plants.

The strength of this study is to discover and assess the knowledge and use of medicinal plants in the treatment of neurological diseases in the Rif region of northern Morocco.

5. Conclusion

The present study revealed a very rich indigenous knowledge in terms of traditional herbal medicine used by indigenous people in the study area. The identified natural products used in Rif's communities are a potential source of a novel class of drugs for the treatment of neurological disorders. Based on results, plants scoring high use values should be further tested for their phytochemical

and pharmacological investigation. It is important to promote clarity of the general indigenous public, particularly the practitioners of traditional medicine, on the causes, symptoms, and possibilities of treatments for neurological diseases. Therefore, protection measures should be adopted for the conservation of multi-purpose and other medicinal plant species. The young generation should be mobilized toward learning ethnomedicinal practices before its extinction.

Acknowledgements

We want to send our sincere gratitude to all the guides and inhabitants of the Rif region for their help. To all sellers of medicinal plants. We also extend our greetings to all those who participated in the success of this work.

Author statement

NC: Carried out field research in the Rif, compiled the literature sources, data analysis, Realization manuscript and evaluation, interpretation and wrote the manuscript, helped in data and made a substantial contribution to data analysis. **LZ:** Performed data analysis and drafted the manuscript; designed the research and identification of plant species. All contributors understand and accepted the final document.

Funding

This study did not take any special grant from funding businesses in the public, commercial, or not-for-profit sectors.

Consent for publication

Consent for publication was obtained from participants.

Declaration of Competing Interests

We guarantee that there is no conflict of interest with any commercial institution concerning the paper.

Ethical Approval and Consent to participate

Consent for this research was given by the Committee for ethical research of the Department of Biology, Ibn Tofail University. Before starting data collection, we received oral informed approval in each case on a site level and then individually before each interview. Informants were also informed that the aims of the investigation were not for financial objectives or other benefits but for academic reasons. Informants provided verbal informed approval to participate in this study; they were free to remove their data at any point in time. Lastly, interviewees have accepted voluntarily the idea and they have agreed to have their names and personal data to be published.

Availability of supporting data

All data collected and analyzed in this paper are included in the article and attached in the form of 'Appendices' as additional files. Plant species are stored in Ibn Tofail University, Kenitra, Morocco.

Appendix A

Questionnaire sheets: Medicinal plants and herbal medicine

Date.....
 Region.....
 Commune.....
 Survey number.....

Informant:

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}

Therapeutic practices:

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

Vegetal material:

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 the 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:.....

Use:

Diagnosis By: Himself Doctor Herbalist Other
 Results: Healing Improvement Ineffective
 Side effect: Toxicity: Caution of use:

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Author details

Noureddine Chaachouay^{1*} and Lahcen Zidane²

1 Higher education and training school, University Hassan, Settat, Morocco

2 Plant, Animal Productions and Agro-Industry Laboratory, Department of Biology, Faculty of Sciences, Ibn Tofail University, Kenitra, Morocco

*Address all correspondence to: nour.chay@gmail.com

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