NEMMAP Database: A platform for exploring the Ethnobotanical, Pharmacological, and Phytochemical profile of North-Eastern Morocco Medicinal plants

Ilyass Alami Merrouni[1*], Mostafa Elachouri[1]

[1]*Laboratory of Bioresources, Biotechnology, Ethnopharmacology and Health. Faculty of Sciences, Mohammed First University, Oujda, Morocco*

Corresponding author, Email address: alami.ilyass.90@gmail.com

Abstract: North-eastern Morocco is a wealthy region in terms of biodiversity, notably medicinal plants. These herbs are considered the primary source of medicines and drug discovery due to their secondary metabolites and bioactive compounds that are pharmacologically applicable against several diseases. Due to the lack of herbal databases in Morocco, this work aims to provide a piece of multidisciplinary scientific information regarding 283 medicinal and aromatic plants recorded in North-eastern Morocco previously through an ethnobotanical survey conducted by our team, gathered in a digital database called North-Eastern Morocco Medicinal and Aromatic Plants database (NEMMAP) database. Data were collected manually using different scientific resources such as published scientific articles, books, and databases. Afterward, data were organized and converted into a digital database using the following software and programming languages: MySQL, HTML, CSS, JAVA, and JavaScript.
NEMMAP database provides extensive information, including traditional knowledge, scientific names, synonyms, botanical description, ecology, pharmacological activities, and phytochemical constituents of the local medicinal plants. This new database provides a primary resource for further ethnopharmacological and phytochemical research. Moreover, scientific data provided within the present work were presented in a simple, uncomplicated, and improved way. Consequently, we believe that this database will highly support the conservation and advanced biological and medical research regarding the local medicinal flora.

1. Introduction

Since the ancient times, people are using plants from mother nature to manage several health problems (Alami Merrouni & Elachouri, 2023; Fakchich et al., 2022). Nowadays, Morocco is well known for its biodiversity wheatless. This bio-richness, particularly in terms of medicinal plants, up to 905 plant species (Fakchich & Elachouri, 2021), offers enormous opportunities in multiple fields of advanced biological domains such as medicine and drug discovery. The region of North-Eastern Morocco includes more than 280 medicinal and aromatic plants regrouped on 80 botanical families (Alami Merrouni *et al.* 2021). This group of herbs is primarily used traditionally by a large part of the population living in this region to manage various diseases. Therefore, they are playing a crucial role in the health management systems in North-Eastern Morocco (Ajjoun et al., 2021; Bencheikh et al., 2021). Moreover, these plant species have been reported to have a wide specter of pharmacological

properties (Antidiabetic, digestif problems, kidney diseases, renal dysfunction, respiratory ailments, skin problems…(Ajjoun et al., 2022; Alami et al., 2015; Bencheikh *et al.*, 2022; Fakchich & Elachouri, 2014), because of their Plant-derived natural products that belong to numerous secondary metabolite classes, principally alkaloids, terpenoids, phenolics, coumarins, and saponins. Consequently, North-Eastern Morocco medicinal plants could be considered a great source of bioactive compounds and natural drugs pharmacologically applicable for several diseases (Fakchich & Elachouri, 2021).

Nowadays, documenting scientific evidence related to the local biodiversity, especially medicinal plants, is necessary. Not only for conserving this ethnobotanical heritage, but also for denoting the side effects of the plants used by the population, since several species could be toxic at some level, and represents a real danger that endangers public health, particularly in developing countries like Morocco, where the medicinal herbs sector is not structured by the national health system (Alami Merrouni & Elachouri 2021). Thus, documenting information on traditional medical knowledge through digital databases remains the suitable approach to preserve these materials and ancestral cultural heritage for future researchers (Heinrich *et al.* 2006, Leonti *et al.* 2010, Ningthoujam *et al.* 2012). e.g., Uttarakhand Medicinal Plants Database (UMPDB) in India (Kumar *et al.* 2018), Phytochemica Database (Pathania *et al.* 2015), Medicinal Plants Database for Drug Designing (MPD3) (Mumtaz *et al.* 2017), Traditional Medicine Collection Tracking System (Harris *et al.* 2011), and Traditional Chinese medicine information database (Chen *et al.* 2006). Furthermore, Computerized databases promote data management and analysis, making understandable information available to academic researchers, students, and other users. Also, Ethnobotanical databases facilitate the transmission and exchange of traditional knowledge between different civilizations and countries (Ningthoujam *et al.* 2012). Benali *et al.* 2017 presented an inventory one hundred plant species used in traditional medicine in the Province of Guercif. The frequency of use of medicinal plants is closely related to the interviewe profile (age and sex). The medicinal plants most commonly used in the studied area are Rosmarinus officinalis, Origanum compactum and Artemisia herba-alba. In traditional medicine, the leaves mostly represent the plant parts used in Guercif province. Furthermore, medicinal plants are widely used to treat mainly metabolic diseases and digestive infections.

The survey reported 55 plant species belonging to 28 families used in traditional medicine by the population of the provincial region of Taza, Morocco. Informants' results showed that the most frequently used plants were Origanum compactum, Mentha pulegium, Rosmarinus officinalis L., Aloysia citrodora, Calamintha officinalis Moench, and Artemisia herba-alba Asso., with a relative frequency of citation of 76%, 72%, 60%, 42%, 40%, and 30%, respectively (Kachmar *et al.* 2021). in other work, Jeddi *et al.* summarized that 118 plants species used in traditional herbal medicine, in in northern Morocco (Taounate), are divided into 55 families, with the dominance of Lamiaceae (FIV = 19.49%), Apiaceae (FIV = 3.07%), Asteraceae (FIV = 10.34%), Rosaceae (FIV = 2.881%), Fabaceae (FIV = 9.066%) and Liliaceae (FIV = 9.752%). The most reported species are Origanum compactum Benth. (68.78%), Rosmarinus officinalis L. (56.09%), Mentha pulegium L. (52.19%), Chenopodium ambrosioides L. (33.41 %), Allium sativum L. (26.58), Aloysia citrodora Palau (25.12%), Pistacia lentiscus L. and Dittrichia viscosa (L.) Greuter (24.87%). Moreover, leaves are the most commonly used plant's parts (59%), and most therapies are prepared by decoction (40%) and administered orally (77%), in the form of herbal tea (58%). Affections of the digestive tract show the highest rate of treated diseases (40%). The cure rate is 45% with 54% relief (Jeddi *et al.* 2021).

In this respect, the present work attends to assemble most of the scientific information related to the traditional use of medicinal plants recorded by our team in North-Eastern Morocco (Part I) (Alami Merrouni *et al.* 2021) into a digital database named "North-Eastern Medicinal and Aromatic Plants

database (NEMMAP)." This informatic tool is the first and the only one of its kind in the region, which regroups Ethnobotanical, Botanical, Ecological, Pharmacological, and Phytochemical data of plants used traditionally as medicine in our region. We believe that the (NEMMAP) database will support the conservation, identification, and curation of different scientific information about the plants recorded in North-Eastern Morocco in a suitable, uncomplicated, and improved way.

2. Material and Methods

2.1. Ethnobotanical Data collection

In order to build a comprehensive repository for North-Eastern Moroccan medicinal plants, the data based on traditional information (Figure 1), including botanical family, scientific name, synonyms, vernacular names, English names, ecological status, therapeutic uses, used parts, and modes of preparation were retrieved from our previous ethnobotanical study (Part I) (Alami Merrouni *et al.* 2021). Besides, the botanical description of each plant species was retrieved from the most specialist botanical reference available in Morocco: The practical flora of Morocco, three vols (Fennane *et al.* 1999, 2007, 2014).

2.2. Pharmacological and Phytochemical Data curation

Pharmacological properties as well as the major phytochemical constituents were compiled manually from published literature using several research engines and web sources (Figure 1), such as ScienceDirect, Scopus, Web of Science, PubMed, Google Scholar, and DJOA.

2.3. Database creation

Data collected previously were gathered and organized manually into a table using Microsoft Excel. Afterward, all scientific information were converted into a digital platform using the following Software and programming languages: MySQL, HTML, CSS, JAVA, and JavaScript (Figure 1).
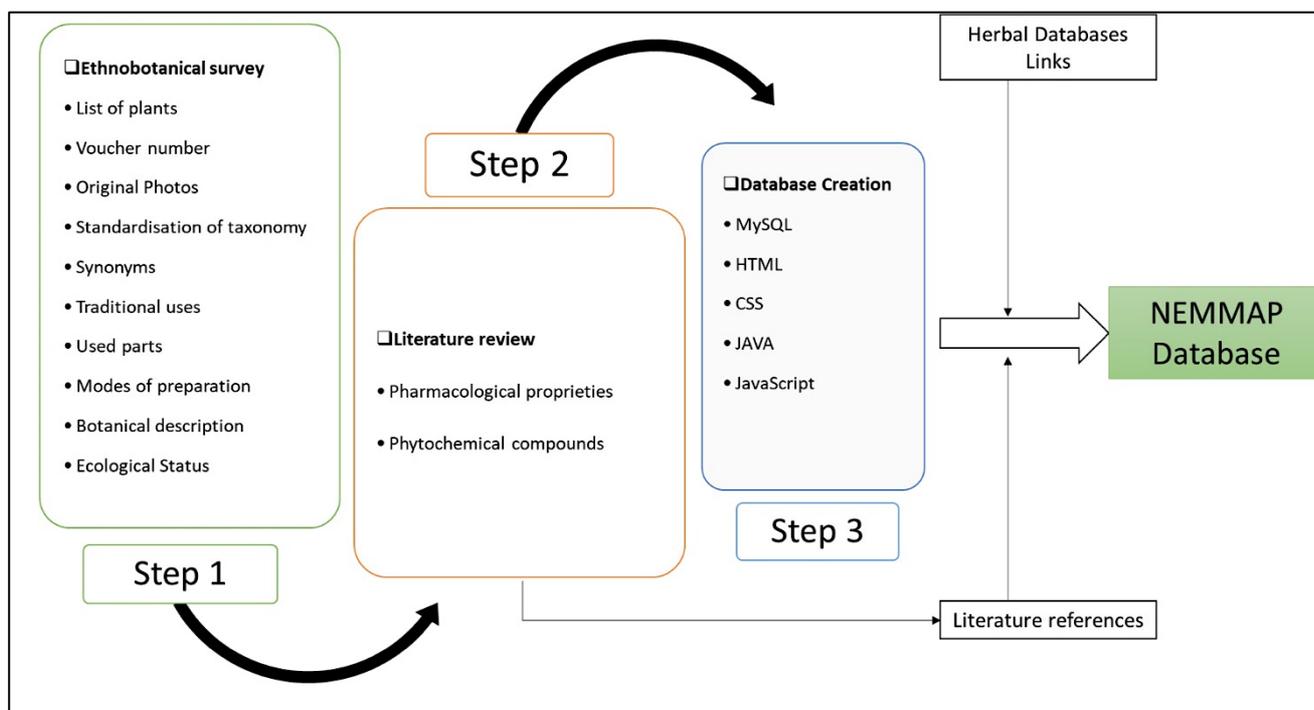

Figure 1: Methodology steps of NEMMAP database creation

- **MySQL**: An open-source Relational Database Management System (RDBMS). SQL (Structured Query Language) is the most popular language for adding, accessing and managing content in a database. It is most noted for its quick processing, proven reliability, ease and flexibility of use.
- **HTML**: The HyperText Markup Language. A standard markup language for documents designed to be displayed in a web browser.
- **CSS**: Cascading Style Sheets is a style sheet language used to style an HTML document and describes how HTML elements should be displayed.
- **JAVA**: Java is a High Level, class-based, object-oriented programming language that is designed to have as few implementation dependencies as possible.
- **JavaScript**: Programming language that conforms to the ECMAScript specification. JavaScript is high-level, often just-in-time compiled, and multi-paradigm. It has curly-bracket syntax, dynamic typing, prototype-based object-orientation, and first-class functions.

It is worth noticing that all the programs and software used to create the NEMMAP database are open source and freely available (Harris *et al.* 2011).

3. Results and Discussion

NEMMAP database provides comprehensive and straightforward data of about 283 medicinal plants belonging to 80 botanical families recorded through an ethnobotanical study carried out between 2015 and 2017 conglomerates the different provinces of the North-Eastern region of Morocco (Alami Merrouni *et al.* 2021). This group of medicinal plants is subdivided into three categories: Spontaneous (59%), Cultivated (34%), and Imported (7%). Among them 89 species were qualified as toxic (Kharchoufa *et al.*, 2021, 2018).

The information for plant species available in the database could be accessed through the keyword search tab by assigning the scientific name or the voucher number of a specific medicinal plant. Otherwise, by exploring the botanical families regrouped in the menu list (Figure 2).
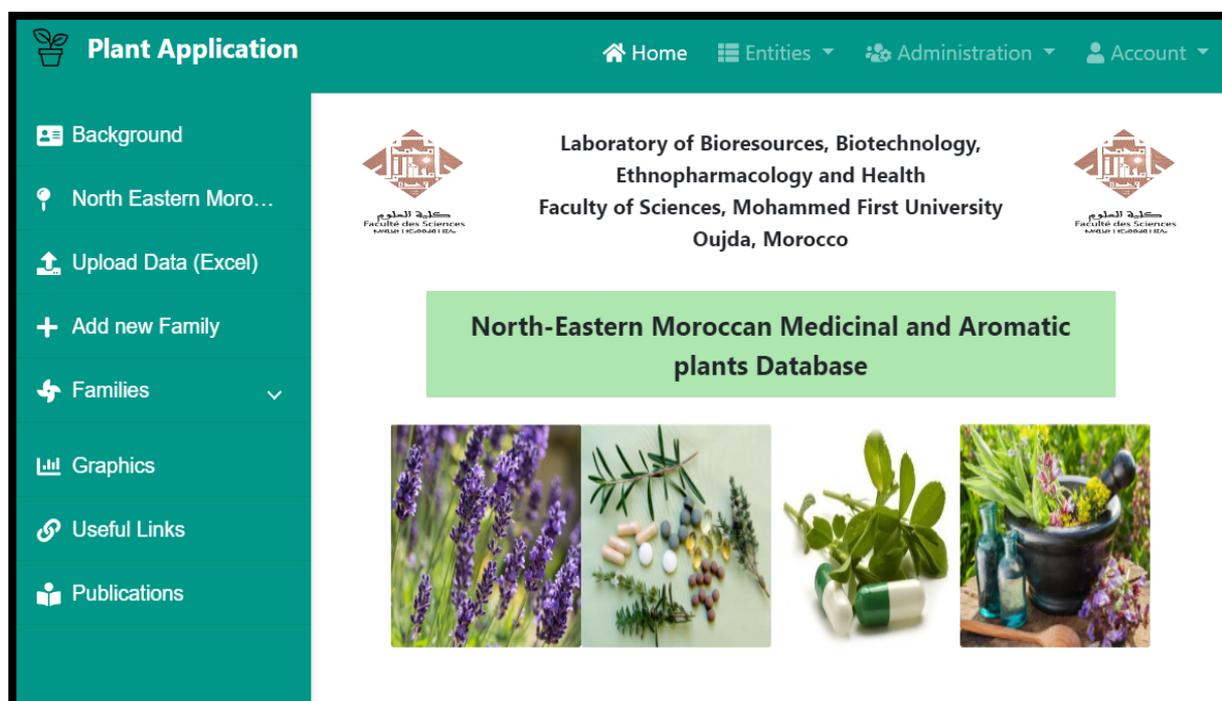

Figure 2: Principal interface of NEMMAP Database

After clicking on a family, a page will open presenting a list of medicinal plants belonging to this family classed by an alphabetic order will appear (Figure 3), with details that contain Scientific name, Voucher number, and Local name. By further clicking on 'View Details,' the web page will direct the user to complete data details of each particular medicinal plant. This scrolls down-based page provides extensive information that includes a summary of the plant, including botanical family, scientific name, synonyms, illustrate photo, local name, English name, ecological status, therapeutic uses, used parts, modes of preparation, Pharmacological proprieties, and major phytochemical constituents (Figure 4). Furthermore, the NEMMAP database provides a descriptive text about the North-Eastern Morocco region, graphics, and some useful links to other scientific databases or Websites such as Catalogue of Life database (http://www.catalogueoflife.org/annual-checklist/2019/), e-flora database (http://www.efloras.org/), and PubChem database (https://pubchem.ncbi.nlm.nih.gov/) to explore deeply the information related to all plants species -not presented in NEMMAP databases- such as the chemical details and structures about the plants' bioactive compounds, as well as other bibliographical resources (Figure 4).

Figure 3: List of plant species per botanical family (Exp: LAMIACEAE)

Finally, it is worth mentioning that all scientific names of medicinal plants presented in the NEMMAP database were standardized to the currently accepted names according to the Catalogue of Life: 2019 Annual Checklist database. Moreover, each traditional ailment was adapted to an alternative classification system accepted by the World Health Organization (WHO), International Classification of Primary Care (ICPC) second edition by the Wonca International Classification Committee (WICC), available online: (https://www.globalfamilydoctor.com/groups/workingparties/wicc.aspx).

Overall, the data standardization approach is very recommended for integrin biological information from different resources (Ningthoujam *et al.* 2012). Despite the increasing ethnobotanical studies in Morocco, no digital database was founded in Morocco to be compared with NEMMAP database. Consequently, we believe that this work will promote the motivation for several Moroccan ethnobotanists to create and developed more herbal and phytochemical databases.
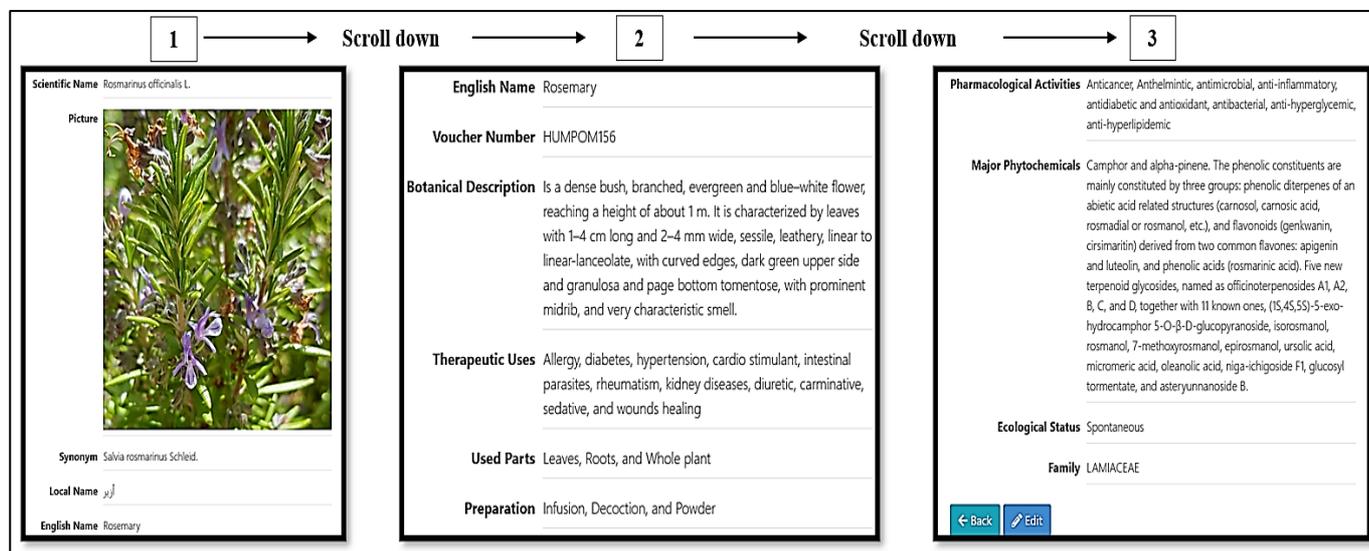
Figure 4: Scientific information for each plant species provided by NEMMAP Database (Exp: *Rosmarinus officinalis* L. 'LAMIACEAE')

4. Conclusion

The database of medicinal and aromatic plants of the North-East region of Morocco (NEMMAP) encompasses 283 species used by the population of the study region to relieve and treat multiple diseases traditionally. This group of plants was gathered through an ethnobotanical survey conducted in this region by our team (Part I). Meanwhile, an in-depth interdisciplinary bibliographic study was carried out to fulfill all the information on this group of plants to reveal a complete scientific profile for each plant recorded, including Ethnobotany, Botany, Ecology, Pharmacology, and Phytochemistry. Undoubtedly, this database needs more attention, and the information provided in it needs to be updated continuously. We believe that this work is the first and the only one of its kind within the North-Eastern region and may be in the entire country since that are no databases founded in the Moroccan published literature. However, it is worth to mention that this work needs funding to be released as a website. Overall, the NEMMAP database can be of great support and interest to academic researchers, students of Biology, Medical Sciences, Environment, and Agronomy, albeit to the general public.

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