

Floristic and ethnobotanical study of the flora used in traditional medicine: Case of the Bigoudine Watershed region (Western High Atlas)

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Abstract

A floristic and ethnobotanical study was carried out in the Bigoudine Watershed region (Western High Atlas). This study was carried out with the aim of making an inventory of plant species used in traditional medicine practised by the local population and traditional practitioners in the region studied. Ethnobotanical surveys and floristic surveys carried out in two periods, the first in 2003-2004 and the second in 2016-2018, made it possible to identify the medicinal flora used in traditional medicine in the region. The results obtained enabled the identification of 258 medicinal plants, divided into 203 genera and 77 families, of which six families are the most dominant, including *Lamiaceae*, *Asteraceae*, *Fabaceae*, *Apiaceae*, *Poaceae* and *Solanaceae*. The present study is a contribution to the elaboration of the national flora used in Moroccan traditional medicine. It also highlights the traditional phytotherapy practised in this mountainous rural area of Morocco, despite the current existence of a very advanced modern medicine in our country.

Keywords: Medicinal plants, floristic and ethnobotanical study, Bigoudine Watershed, Morocco

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1. Introduction

The natural environment, diversified by its ecosystems, constitutes a precious and inexhaustible source for the preparation of herbal virtues. The use of these in traditional care can open up horizons in scientific research to seek solutions to certain cases of unresolved diseases. The use of plants in healthcare, in rural and mountain areas, is seen as an alternative to drugs in very severe social conditions. The safeguard of biodiversity and the conservation of this ethnobotanical heritage of these rural areas are one of the major priorities for Moroccan scientific researchers. It is a question in particular of making an inventory of this national floristic heritage for traditional medicinal use, of safeguarding this knowledge, of benefiting from it and of fighting against the threats likely to weigh on this heritage and the consequences which may result from it. In this context, most botanists and ethnobotanists from Moroccan universities have focused on

studying the therapeutic aspects of the flora used in traditional medicine in Morocco. Indeed, various works on regional medicinal flora have been supported and published over the past decades. To this end, we conducted an ethnobotanical and floristic study of the flora used in traditional medicine in the Bigoudine watershed region (Moroccan High Atlas Occidental). The wealth of knowledge in traditional care and the diversity of plant species, used in traditional medicine, are considered among the major alternative sources of the rural mountain population to compensate for the lack of health infrastructure.

Also, the present study consists of making an inventory of plants used in traditional therapy and contributing to the development of the national medicinal flora. This medicinal flora will constitute an important source of information and facilitate the way to

investigations in many fields seeking new natural active substances.

2. Materials and methods

2.1. Presentation of the study area

The Bigoudine Watershed region is located in the Western High Atlas between the geographical coordinates 30 ° 42 'and 30 ° 48' North latitude and 9 ° 10 'and 9 ° 18' West longitude about 70 km North of the city of Agadir on the national road to Marrakech (Figure 1).

2.2. Demographics

The total population of this region is around 8,773 inhabitants [14], the majority of which is included in the administrative area of the Rural Municipality of Tiqqi (west of the watershed figure 1), Ida Outanane Province. Some villages located to the east of the watershed are part of the Rural Municipality of Bigoudine 5,131 inhabitants [14] and part of the rural municipality of Argana 4804 (North East of the watershed figure 1), Province of Taroudant [14] [27]. The study site is occupied by a fairly diverse ethnic population. Therefore, a phytotherapeutic tradition is strongly represented in this region. This ethnic diversity is due to the geographical position of the site at the heart of the demarcation line of the territories of two tribes the Ida Ou Tanane (to the west of the watershed figure 1) and the Ida Ou Ziki (to the east of the side figure 1). The "douar" villages located in the site, despite their different ethnic origins, enjoy a local identity and common interests that bring them together, similarly all these "douar" villages have the same traditions and frequent the same "souks" markets. The local population is made up of many "douar" villages. The "douars" is made up of a more or less large number of families called "Ikhs". Each family is subdivided into as many households as there are couples, called "takat". In general, these "Ikhs and takat" social units have a close relationship with the exploitation of natural resources and the social life of the group.

2.3. The climate

The climate of the Mediterranean-type region [2] is characterized by its aridity. The presence of certain local factors such as the orography, the exposure of the slopes and the degree of continentality, in this study region, is linked to the action of the north and northwest winds of the northern regions which brings precipitation and humidity in winter; and that of southerly and south-easterly winds "Chergui" from tropical regions which brings heat and drought in summer [15]. Also, the presence of Atlantic Ocean currents has a moderating influence on the climate and on the distribution of vegetation.

2.4. Geology

This study area belongs to the Western High Atlas which does not have the appearance of high mountains [1].

The region is made up of a mosaic of topographic forms represented by a majority of mountains, ridges and plateaus. Located at the level of the Argana corridor, which constitutes a well-marked depression between the old massif of the High Atlas and the western Atlas, this region is made up of dolomitic limestones and fine sandstones, clays of the Permian, regosols. On the lower level appear the rocks of the secondary and primary (Saharan and Devonian) sandstones, schists and clays [29]. The lithology is very varied in this region. Precambrian and primary schists and quartzites are mainly found; limestones and dolomites form plateaus which retain traces of the leveling surfaces; and finally, the Triassic clays and sandstones in which the Argan corridor was formed [31].

2.5. Methodology

Our floristic study, within the area, was preceded by ethnobotanical surveys. It was carried out in two periods, the first in 2003-2004 and the second in 2016-2018. The ethnobotanical survey enabled us to collect data from experienced people, traditional practitioners in the field of plant care, the very elderly in douars, herbalists in weekly souks, plant pickers, small traders. informal roads and small farmers in the area. Then, we identified all the plants used in the region and then we carried out floristic surveys in the field. The determination of the species, collected in the field, was carried out jointly with the Botanical laboratory - Mohammed V-Agdal University in Rabat, using available herbaria and by comparison with samples from the National Herbarium of the The Scientific Institute and those of the Veterinary and Agronomic Institute of Rabat; and by a certain number of essential works such as: the catalog of plants of Morocco [18] [19] [20] [6]; the Med-checklist [13]; the Flora of North Africa [25] and Nouvelles Floras of Algeria and the southern desert regions [28]. Other more recent works have been used for species recognition such as catalogs of vascular plants of northern Morocco, including identification keys from Valdés et al. [32], Flore du Maroc, manual for the determination of vascular plants [7] Vascular flora of Morocco: inventory and chorology [8] [10], Practical flora of Morocco [7] [9] [12]; etc. The angiosperm phylogenetic classification system [30] redefining families was used for this taxonomic level.

2.6. Sampling

In order to conduct our survey, to carry out our floristic surveys at the same time and to have a better representativeness, we adopted a stratified probability sampling (zone). We divided the study region into ten (10) survey areas (Figure 2). The number of surveys chosen for each stratum is 40 to achieve the desired objective with more than 400 people. Moreover, the people interviewed within each area were chosen randomly.

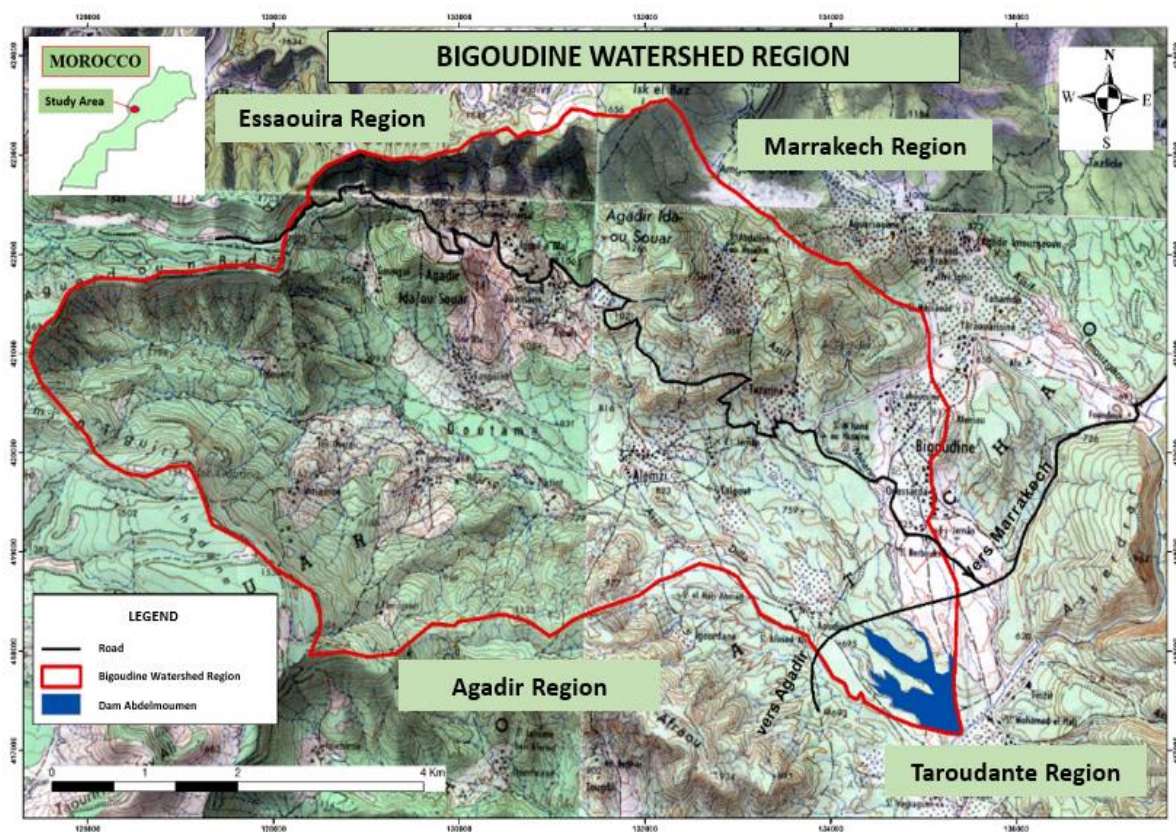


Figure 1: Situation map of the Bigoudine watershed region and the limits of the study area [26]

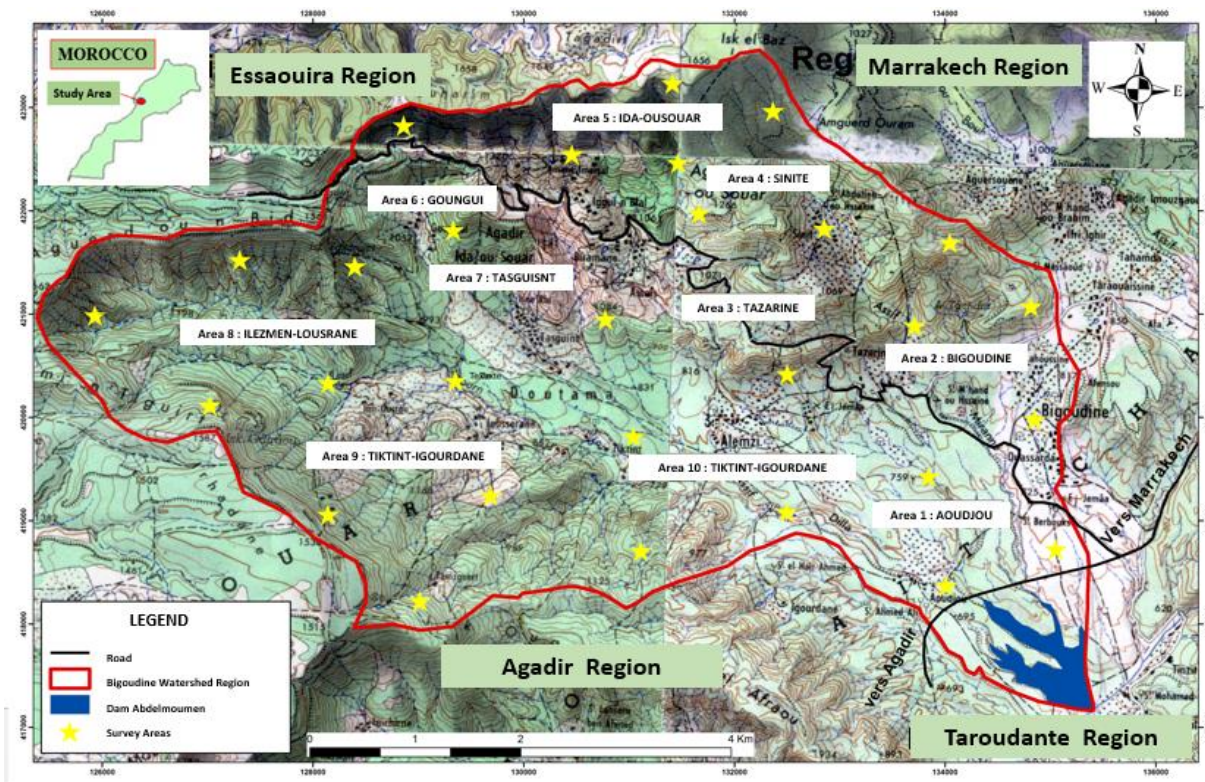


Figure 2: Distribution of the 10 survey areas within the Bigoudine Watershed region [26]

In addition, the raw data entered on the questionnaire sheets were transferred into a database and processed and analyzed using Microsoft Office software "Excel", with the aim of selecting the most used plants, parts used, methods of preparation, traditional local therapeutic care and the categories of the most common diseases.

3. Results and Discussions

3.1. Floristic wealth

The Bigoudine watershed region has an important flora used in traditional medicine. The ethnobotanical surveys carried out in the field have enabled us to develop a catalog of 258 medicinal species which are divided into 203 genera and 77 families. Among these last six families are dominant and group together 37.98% of plants used in traditional care within the Bigoudine watershed region. These families are classified in descending order, namely *Lamiaceae* (7.75%), *Asteraceae* (6.97%), *Fabaceae* (6.97%), *Apiaceae* (6.20%), *Poaceae* (5.81%) and *Solanaceae* (4.26%). The *Lamiaceae* family is the most represented with 20 species, followed by the *Asteraceae* family which ranks second with 18 species, while it ranks first in the flora of Morocco by its specific richness and in most of the regional medicinal flora inventoried (see table 1). However the *Fabaceae* family which is well represented in this specialized flora (same rank as the *Asteraceae* with 18 species). Although it is very rich in species, it keeps almost the same rank in Moroccan flora and relatively in other medicinal flora of other Moroccan regions.

3.2. Biological forms of plants used

The biological spectra of all the species of medicinal flora used in the study region (figure 1), show the dominance of the Therophytes with 31%, followed by the Phanerophytes with 25% in second place the Chaméphytes which represent 15% in third place, 12% for the Geophytes in fourth place, then come in fifth place the Hémicryptophytes with 09%, in sixth place the Nanophanerophytes with 08% and finally the lianas with 0.31%. In addition, the same classification concerning the first places at the level of the three biological spectra: Therophytes, Phanerophytes and Phanerophytes, was raised in the region of Al Haouz Rehamna [3], the region of the Central Middle Atlas [5], the region de Zaër [22] and the region of Rabat [16]. We have noticed that Phanerophytes rank second and show continuous growth with a maximum in the Semi-arid stage, this reflects the abundance of Phanerophyte use, within the study region. Still concerning the abundance and distribution of these biological forms, the same observation was noted in all regional medicinal flora: the region of Eastern Morocco [21], the region of Rabat [16], the region of Zaër [22], the region of Al Haouz Rehamna [3] and the region of the Central Middle Atlas [5]. Out of 2807 estimated endemic, rare or threatened taxa of Morocco [7] [11], the medicinal flora inventoried in the region studied has 22 endemic and rare species, ie about 14.66%. According to our statistics, the Bigoudine watershed region has 13 endemic species. Among these last

6 species are specific to Morocco with a number (E) of about 48% of the total number (*Argania spinosa* (L.) Skeels, *Cupressus atlantica* Gaussen, *Centaurea maroccana* Ball, *Lavandula maroccana* Murb., *Olea europaea* L. subsp. *maroccana* (Greuter and Burdet) P. Vargas et al. Et *Thymus broussonetii* Boiss.), then the endemics shared with Algeria (EA) occupy the 2nd place with about 24% (*Thymus pallidus* Batt., *Thymus satureioides* Cosson and *Warionia Saharæ* Benth. and Coss.), those shared with the Iberian Peninsula (EI) 7% (*Origanum compactum* Benth.) with Algeria and the Iberian Peninsula (EIA) 7% (*Salvia lavandulifolia* Vahl subsp. *blancoana* (Webb et Heldr.) Rosua and Blanca), with Algeria and the Canary Islands (EAC) 7% (*Zygophyllum gaetulum* Emb. & Maire.), And finally with the Iberian Peninsula, Algeria and the Canaries (EIAC) 7% (*Withania frutescens* (L.) Pauquy) come last.

3.3. Degree of poisonous species and flowering period

Based on the results of ethnobotanical surveys and related literature studies on the toxicity of medicinal plants, we have attempted to classify the medicinal species used in the edition, according to the degree of toxicity into five categories of plants: Non-toxic; Non-toxic at low doses; High dose toxicants; Toxic; Very toxic. The analysis of these species used in the Bigoudine watershed region shows that among the 258 species, there is a category of plants which is non-toxic at low doses and which occupies the first place with 130 species (50.38%), the second place is occupied by the non-toxic category with 65 species (25.19%), the third place is shared between the category of high dose poisonous plant with 25 species (9.68%) and the category of poisonous plants with 25 species (9.68%) and finally the category of very toxic plants with 13 species (5.03%). This analysis clearly shows that users of herbal medicines cannot be immune from the toxicity that exists within the plant in case the amount taken is random. Indeed, under very specific conditions of use, the plant gives the desirable effects, if the quantity or dose taken is respectable. For example, the species *Rosmarinus officinalis* L. in low doses does not present any health risk. However, in high doses, it causes stomach bleeding, albuminuria and steatosis of the liver [4]. This shows that poisoning of users by medicinal plants is not uncommon, but rather frequent. Among the main medicinal species most used by the population at the local level with a high degree of toxicity are presented in Table 2. The plant presents, during a phase of its development cycle, momentary toxicity; this phenomenon is also quite common for species from arid and Saharan regions [23], the example of the species *Peganum harmala* L. The majority of species inventoried in the region flower during spring with a maximum during the month of May with 19.62%, a second maximum at the end of spring and early summer during the month of June with 19.40%, followed by the April with 15.89%, then come the months July and March respectively with 12.60% and 10.96%.

Depending on the season, we deduce that the majority of inventoried species of this flora flower between March and July, i.e. in spring with 46.49% (figure 5), followed by 38.81% of species in summer, then come the rest of the species that bloom in winter with 9.86% and in autumn with 4.82% of species.

3.4. Most used plants in the Bigoudine watershed region

To highlight the most used species, we based ourselves on the frequency of use, which is the number of times a species is used in traditional medicine by the 400 respondents [16]. In this article, we present only species with a frequency greater than or equal to 100 (Figure 6). Analysis of the frequency of use of all the plants inventoried showed that the species *Thymus satureioides* Coss & Ball., *Thymus pallidus* Coss. ex Batt., *Lavandula dentata* L., *Salvia lavandulifolia* Vahl., *Argania spinosa* (L.) Skeels, *Olea europaea* L., *Ceratania siliqua* L., *Globularia alypum* L., *Cistus villosus* L., *Tetraclinis articulata* (Masters) Vahl and *Pistacia lentiscus* L., are the most widely used plants with a very high frequency exceeding 100. All of these species are spontaneous plants in the study area, learning from the *Lamiaceae*, *Sapotaceae*, *Fabaceae*, *Globulariaceae*, *Cistaceae*, *Cupressaceae* and *Anacardiaceae* families.

The high frequency of use of these species can be explained either by:

- The availability of these plants which grow in the region and the free harvest in small quantities;
- The very ridiculous sale price which is accessible to all the local population;
- Almost all of the local population know the use of these plants in traditional medicine practiced in the region.
- The experience of use and the mastery of the quantity to be handled in the preparation of traditional care recipes which makes the population very confident in these plants;
- Most of these plants are used in daily uses like *Thymus satureioides* Coss & Ball., *Thymus pallidus* Coss. ex Batt., *Argania spinosa* (L.) Skeels, *Olea europaea* L. and *Ceratania siliqua* L.

Among the 11 most used species, five are endemic to Morocco *Thymus satureioides* Coss & Ball., *Thymus pallidus* Coss. ex Batt., *Salvia lavandulifolia* Vahl., *Argania spinosa* (L.) Skeels et *Olea europaea* L. In the region studied, plants with a high frequency show excessive exploitation, which corroborates their high uses in traditional medicine; namely: *Thymus pallidus* Coss. ex

Batt.; *Thymus satureioides* Coss & Ball. ; *Lavandula dentata* L., *Salvia lavandulifolia* Vahl. ; *Globularia alypum* L. and *Cistus villosus* L. This excessive and anarchic use threatens the sustainability of the ecosystems of these species which are sometimes endemic. The continuity of this overexploitation will affect not only the local biodiversity, but also the social life of the population of this region.

3.5. Traditional phytotherapy

Analysis of survey data shows that 61% of the local population use traditional herbal medicine, 34% use traditional herbal medicine and modern medicine and 5% choose modern medicine (Figure 7). The practice of traditional herbal medicine in this rural Moroccan region is an accumulation of many practices passed down from generation to generation. In this article, we discuss the main categories of traditional practitioners who use plant material (Appendix) in traditional care in the region and its surroundings. The analysis of the data relating to the consultation of traditional healers (figure 8), showed that 47% of respondents resort to herbalists, 21% seek advice from the Attars, followed by 15% consult the F'kih, 7 % of which the majority of women request the knowledge of the Kablates, 5% make periodic visits to the Hajjam, 3% consult the Kaway as a last resort after visiting the herborites and finally 2% have recourse to Jebbar as first aid and an alternative in the absence of a local dispensary in rural and mountain areas. This diversity of the different traditional practitioners contributes through these traditional practices to the persistence of traditional Moroccan medicine in general. Moreover, the majority of patients testify to the effectiveness of these traditional practices. These advanced remarks are based on arguments, particularly in rural mountain areas, based on easy accessibility, the cost of consultation within reach or even sometimes free, confidence in traditional herbal medicine, the availability of remedies prepared from plant that grow in the area and sometimes a last resort in the absence of any other therapeutic alternative.

This region, like the other regions of Morocco, keeps and preserves the same categories of traditional practitioners practicing in the field of traditional medicine. These traditional practitioners maintain a close relationship with the potentialities of the natural environment that surrounds them: the Ahab (Bou Issafarane), The Attâr (Aattaar), the F'kih or Cheikh Taleb (Talab), the Kab'la (Jads n'tarwa), J'bar (Ouss'mile, ajjabar), Kaway (Amsat'fel, Ajjabar) and Hajjame (Ahajjame) (see appendix).

Table 1: Classification of families by number of medicinal species in the Bigoudine Watershed Region.

	Bigoudine watershed region	region of the Central Middle Atlas [5]	Al Haouz Rehamna region [3]	Zaër region [22]	Rabat region [16]	Eastern Morocco region [21]	Moroccan flora
Family	R (n)	R (n)	R (n)	R (n)	R (n)	R (n)	R (n)
<i>Lamiaceae</i>	1 (20)	1 (20)	2(42)	3 (23)	4 (21)	2 (34)	6 (202)
<i>Asteraceae</i>	2 (18)	2 (16)	1(47)	2 (24)	1 (26)	1 (53)	1 (550)
<i>Fabacea</i>	2 (18)	5 (08)	3(35)	4 (15)	3 (22)	3 (29)	2 (424)
<i>Apiaceae</i>	3 (16)	3 (12)	4(27)	1 (28)	2 (25)	4 (28)	7 (153)
<i>Poaceae</i>	4 (15)	4 (09)	6(16)	7 (10)	7 (10)	5 (17)	3 (355)
<i>Solanaceae</i>	5 (11)	7 (05)	5 (18)	6 (11)	5 (14)	9 (10)	29 (15)

R: Rank in the region and n: number of species in the region

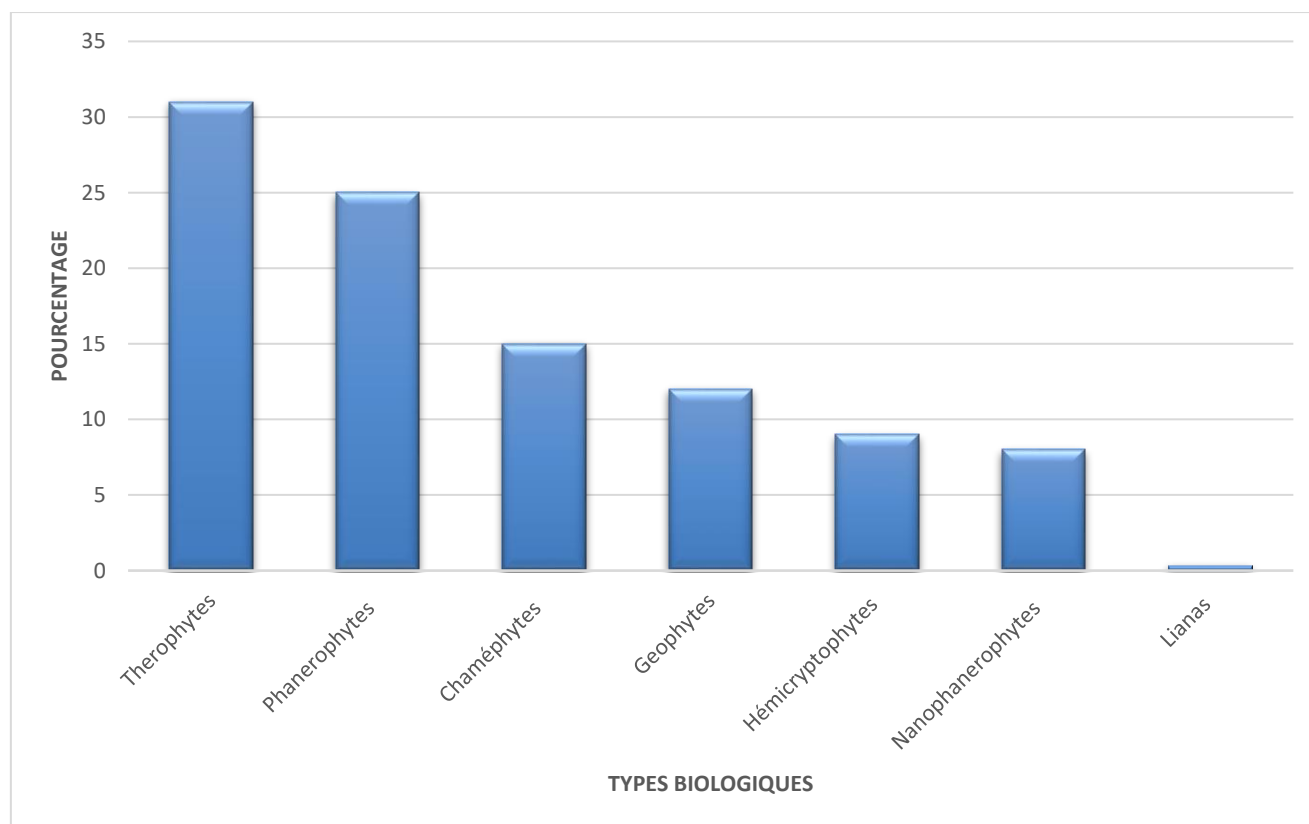


Figure 3: Distribution of biological types of flora species used in the traditional medicine of the Bigoudine watershed region

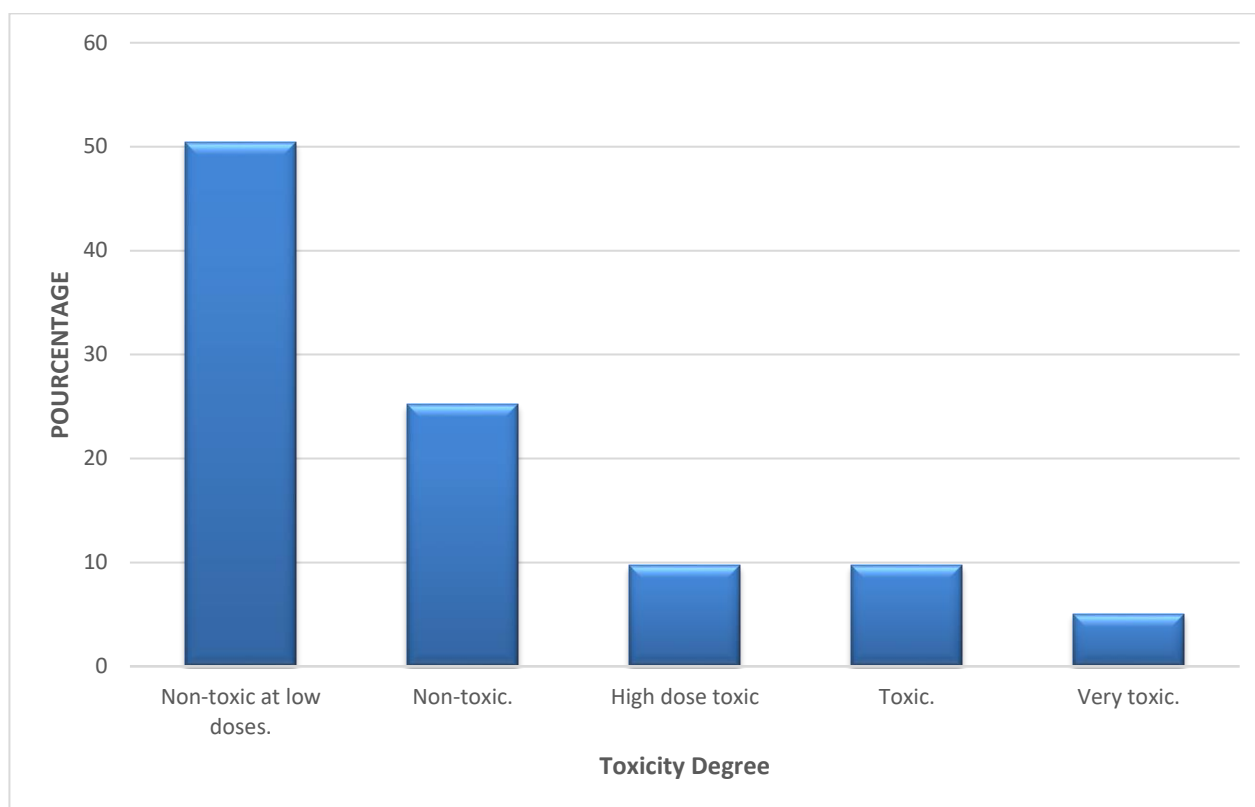


Figure 4: Distribution of RTE categories according to the degree of toxicity

Table 2: Main medicinal species with a high degree of toxicity

<i>Toxic Medicinal Species</i>	<i>Vernacular names</i>
<i>Aristolochia paucinervis</i> Pomel	Tabrass'tem't - Masmkurn - Breztame
<i>Nerium oleander</i> L.	Alili - Ilili - Dafla
<i>Euphorbia officinarum</i> L. subsp. <i>echinus</i> (Hooker fil. & Cosson) Vindt	Tikiwate - Daghmouss -Tikiwout
<i>Ricinus communis</i> L.	Kherwaê -War'ouira-Wararou- wayrourou -Tazar't n'yidane
<i>Drimia maritima</i> (L.) Stearn.	Bssal eddib-Azalime ouchen- Baçal dib - An'ssal
<i>Drimia undata</i> (Desf.) Stearn	Tass'limet -B'ssila- Ik'file- Igu'refile
<i>Atropa belladonna</i> L.	Adil ouchene - Tiddile- Zbibe laydore
<i>Datura stramonium</i> L	Tabour'ziguete -Tabour'zijente - Chdak jmel
<i>Thapsia transtagana</i> Brot	Driasse -Adiryasse-Daryousse -Toufal'te -Abou -Wabou- Rouaba -Abaghour-Bounfa.
<i>Hammada scoparia</i> (Pomel) Il'in	Tiwarmite -Ramt
<i>Asparagus albus</i> L.	Azzawi - Asakoume -Ssekoume
<i>Carlina gummifera</i> (L.) Less.	Dâd -Addad
<i>Dysphania ambrosioides</i> (L.) Mosyakin & clemants,	Tamalkoda -Talkouta -Mkhinza .
<i>Staphisagria macrosperma</i> Spach,	Habat rasse
<i>Daphne gnidium</i> L.	Lezzâz - wal'zaze - Azzaze-Al'zaze - Meth'nane

The toxicity of these species can be found on one or more parts of the plant and varies with the seasons. Indeed,

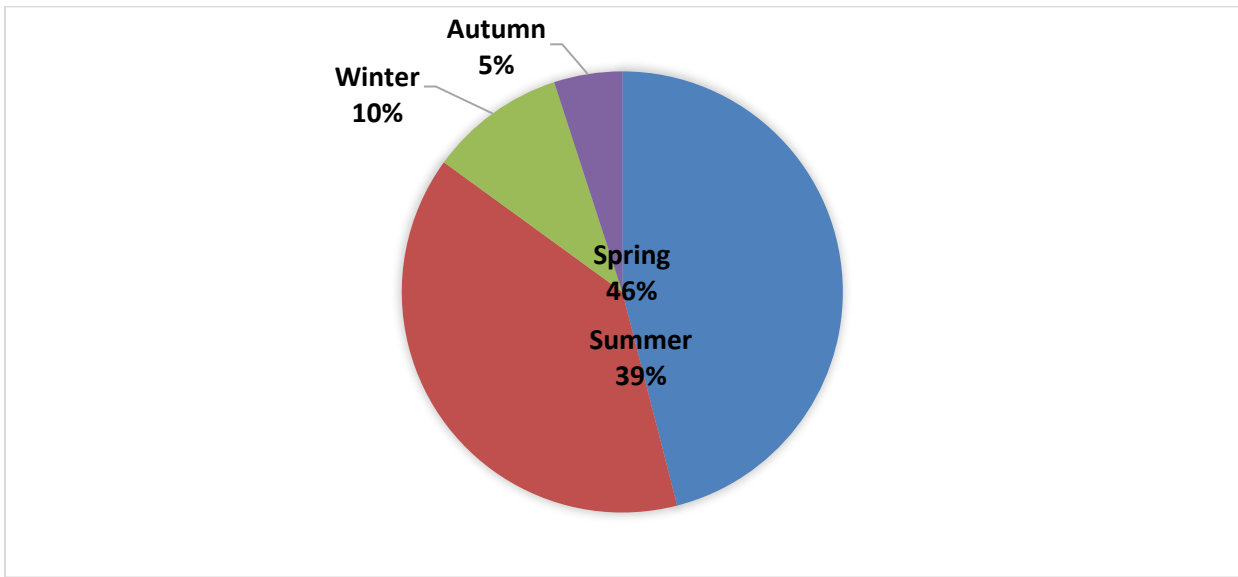


Figure 5: Distribution of medicinal plants according to flowering period

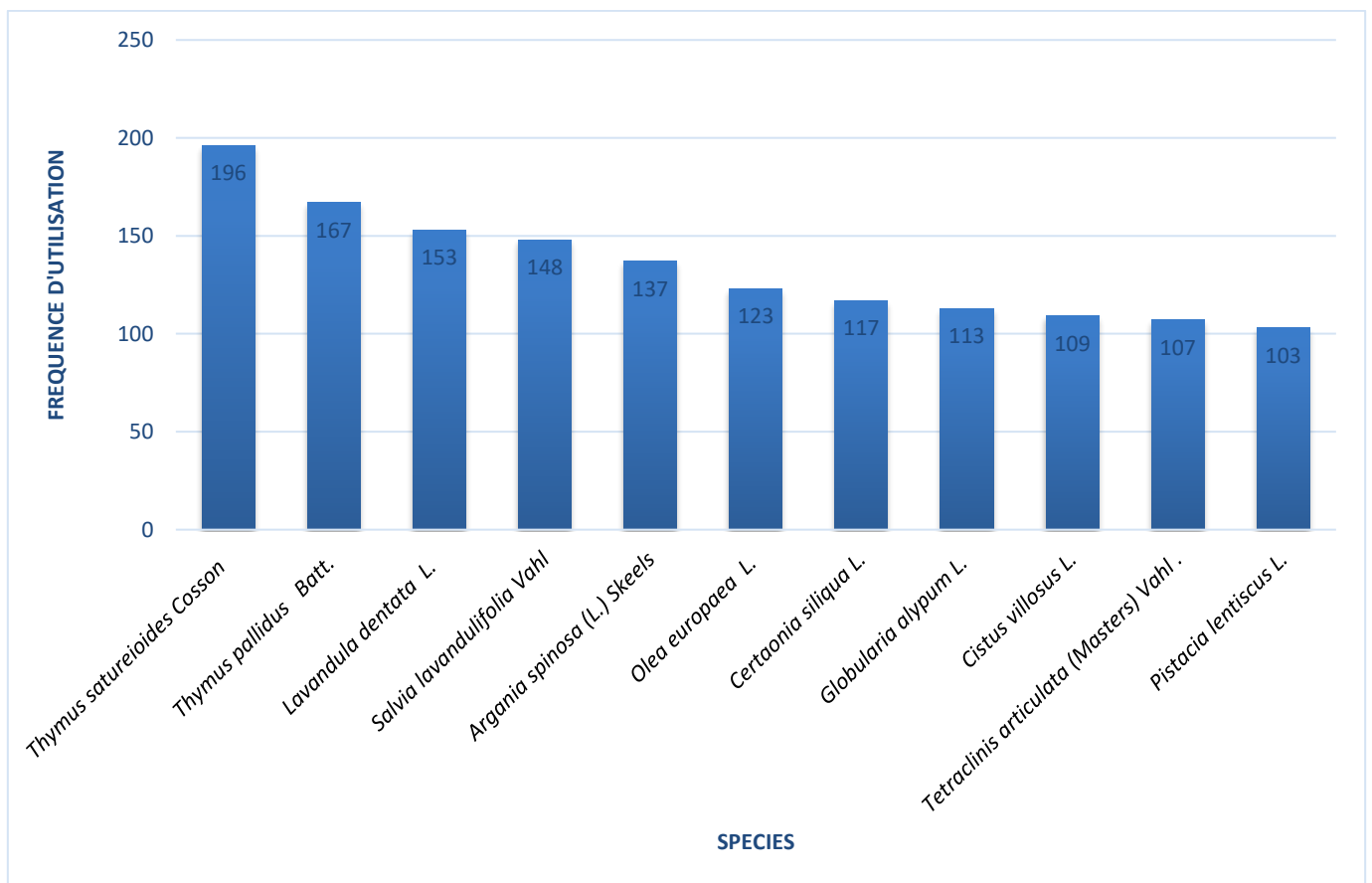


Figure 6: Plants most used in traditional herbal medicine in the study region

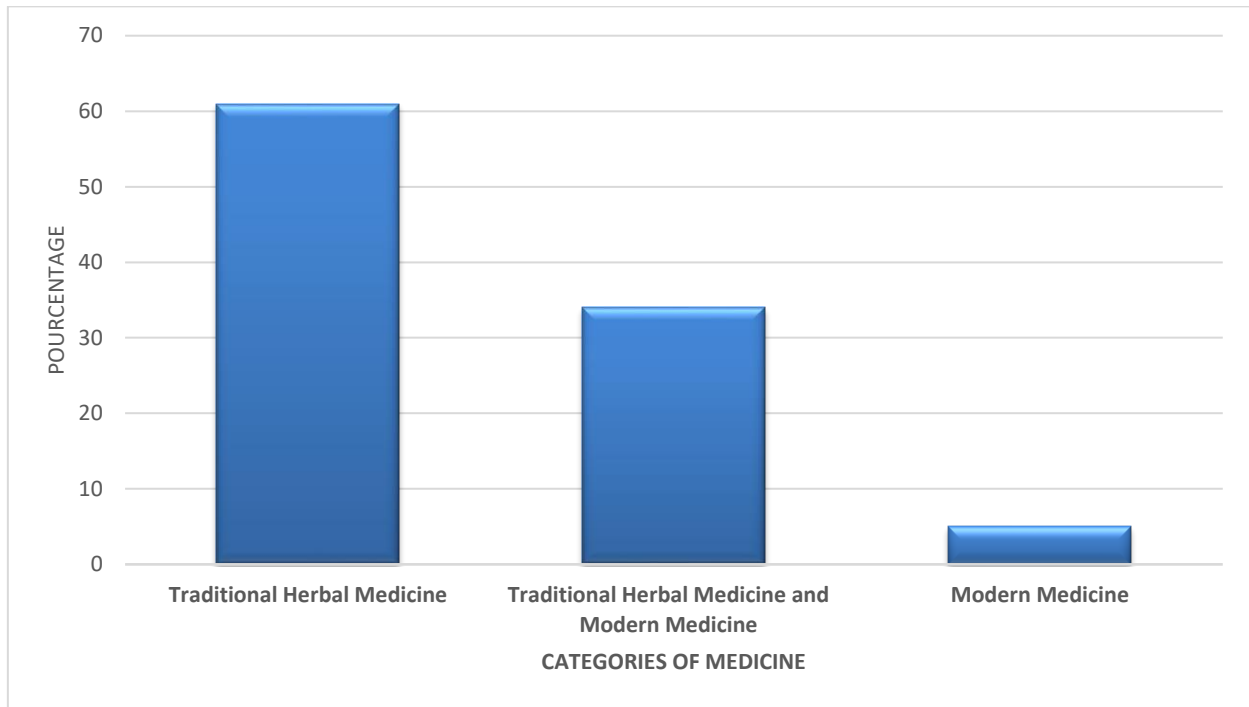


Figure 7: Distribution of categories of medicine according to the choice of the local population

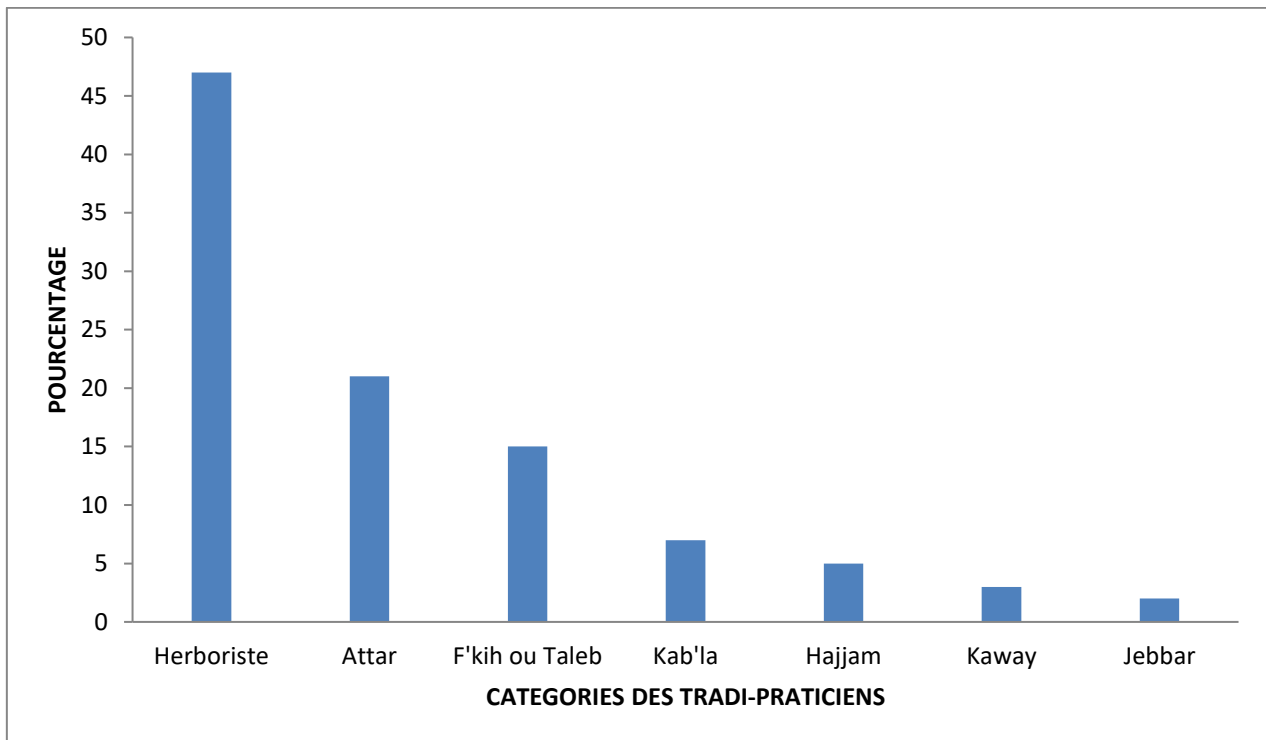


Figure 8: Main categories of traditional practitioners in the region

4. Conclusions

This ethnobotanical and floristic study highlighted the importance of traditional herbal medicine through the diversity of traditional practitioners who practice it in this region. The information acquired, from ethnobotanical surveys and floristic surveys carried out in the field, enabled us to identify 258 medicinal plants which are divided into 203 genera and 77 families. These medicinal species, which constitute an inventoried floristic wealth and used in local traditional medicine, belong to six most dominant families, in particular the *Lamiaceae*, *Asteraceae*, *Fabaceae*, *Apiaceae*, *Poaceae* and *Solanaceae*. The results obtained from the data processing showed that the biological form the most used in the region is that of the Therophytes with 31% of the medicinal flora. These results also showed the presence of 22 endemic and rare species, ie around 14.66% of the species inventoried in the region. Among these endemic and rare species 5 are among the 11 plants most used in the local medicinal flora, namely *Thymus satureioides* Coss & Ball., *Thymus pallidus* Coss. ex Batt., *Lavandula dentata* L., *Salvia lavandulifolia* Vahl subsp. *blancoana* (Webb and Heldr.) Rosua and Blanca, *Argania spinosa* (L.) Skeels, *Olea europaea* L. subsp. *maroccana* (Greuter and Burdet) P. Vargas et al., *Certaonia siliqua* L., *Globularia alypum* L., *Cistus villosus* L., *Tetraclinis articulata* (Masters) Vahl and *Pistacia lentiscus* L. We have noticed that the most used species are spontaneous plants in the study region, belonging to the families of *Lamiaceae*, *Sapotaceae*, *Fabaceae*, *Globulariaceae*, *Cistaceae*, *Cupressaceae* and *Anacardiaceae*. The high frequency of use of these species is mainly due to their availability in the wild in the region. The analysis of the degree of toxicity of the species used in this traditional medicine shows that there are 14.71% of toxic and very toxic plants.

This finding clearly demonstrates that plant users are exposed to a risk of toxicity if the quantity taken is not respected. Finally, it emerges from this ethnobotanical research carried out that traditional herbal medicine, still practiced by many traditional practitioners, still persists in this Moroccan mountainous rural area and this despite the current existence of a very advanced modern medicine in our country.

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Contribution: MSK, SH, YZ., BJ, LZ and AK conceived and designed the study; MSK and SH helped design the study, performed experiments, and helped with data extraction; MSK, YZ and AK wrote the manuscript; and all authors read and approved the final manuscript.

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