



## Ethnobotanical Study of Medicinal Plants Uses in the Treatment of Female Infertility at the High Atlas Central of Morocco

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**A**N ETHNOBOTANICAL survey was conducted among 108 interviews of the local population and herbalists of the High Atlas Central (HAC) region of Morocco in order to record and identify the medicinal plants used in the treatment of sterility. According to the survey results, 41 species from 19 families are used in the treatment of female infertility, with the most important families being Apiaceae, Asteraceae, and Lamiaceae, each with six species. The most cited plants with the very prominent relative frequency of citation (RFC) are: *Lepidium sativum* L. (RFC= 0.546), *Caralluma europaea* (Guss.) N.E.Br. (RFC= 0.546) and *Phoenix dactylifera* L. (RFC= 0.509). The root is the most commonly used plant part (24.39%), with decoction (29.26%) and infusion (24.39%) being the most popular preparation methods. The majority of receipts (65.85%) are given orally. For plants used to promote fertilization, the degree of agreement on medication (ICF) was very high (ICF= 0.982). This study is the first one in Morocco concerning female infertility. It revealed that there was real knowledge about medicinal plants used for the treatment of female infertility. Its findings could lead to the discovery of natural pharmaceutically active principles and/or drugs that are active, safe, and easily accessible to populations.

**Keywords:** Ethnobotanical survey, Female infertility, High Atlas Central of Morocco, Medicinal plants.

### Introduction

Reproduction is one of the most fundamental human desires and is critical to the survival of every community (Parsanezhad et al., 2013). Infertility is a worldwide issue that affects over 80 million people (Anokye, 2017). Infertility is defined by the World Health Organization (WHO) as the inability to conceive after at least 12 months of unprotected sex (Zegers-Hochschild et al., 2009). While, Mauduit et al. (1999) estimated that after one year of infertility, the average fertility rate is 12%: after two years it is only 7.9% and after 5 years, 4%. Furthermore, Kazemijalish et al. (2015) stated that approximately 20-40% of infertile couples have an isolated male factor, 30-55% have a female factor, 5-35% have a combination of female and male factors, and 5-15% have no evidence leading to a well-defined diagnosis.

Infertility affects 800,000 Moroccan couples, or 15% of all Moroccan couples, with 30% of women, 30% of men, and 40% of couples affected (Hajjami, 2017). Indeed, as in most low-income countries, medically assisted human reproduction services were only available in the private sector in Morocco, resulting in only a small number of low-income people receiving adequate reproduction care. Sterility is a significant public health concern due to its inherent complexity in management and widespread prevalence, and it has a direct impact on the couple's psycho-affective balance as well as society's.

According to a study conducted in 2020 by Morocco's Public Center for Assisted Human Reproduction, the average length of infertility was five years, with 26.1% of couples experiencing infertility. When compared to developed countries, this percentage is high. The prolonged

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duration of infertility may explain the lack of precise knowledge about infertility and the high cost of assisted human reproduction techniques in Morocco (Benbella, 2020).

In this context, most women, particularly in rural areas, rely on traditional medicine for solutions since it is inexpensive and widely available. Several studies have shown that many secondary metabolites derived from medicinal plants play a role in the regulation of reproductive functions (Mazaro-Costa et al., 2010; Diallo, 2020). In Morocco, despite ethnobotanical and ethnopharmacological surveys on medicinal plants (Mazaro-Costa et al., 2010), no studies on the specific treatment of infertility by plants have been conducted. As a result, there is a need to document this ethnobotanical use of medicinal plants, as well as emphasize the importance of

mandatory phytochemical studies of these plants to identify active principals, toxicological studies to ensure their safety, and pharmacological studies to investigate possible therapeutic applications and justify doses, routes, and duration of use.

## Material and Methods

### Study area

Due to its geographical position and climate, the HAC of Morocco offers a tremendous ecological and floristic diversity. Also, traditional phytotherapeutic knowledge is well represented in this region.

This study was conducted in the center of the Atlas chain of Azilal North, Ouarzazate, and Tinghir South, in the High Central (Fig. 1).

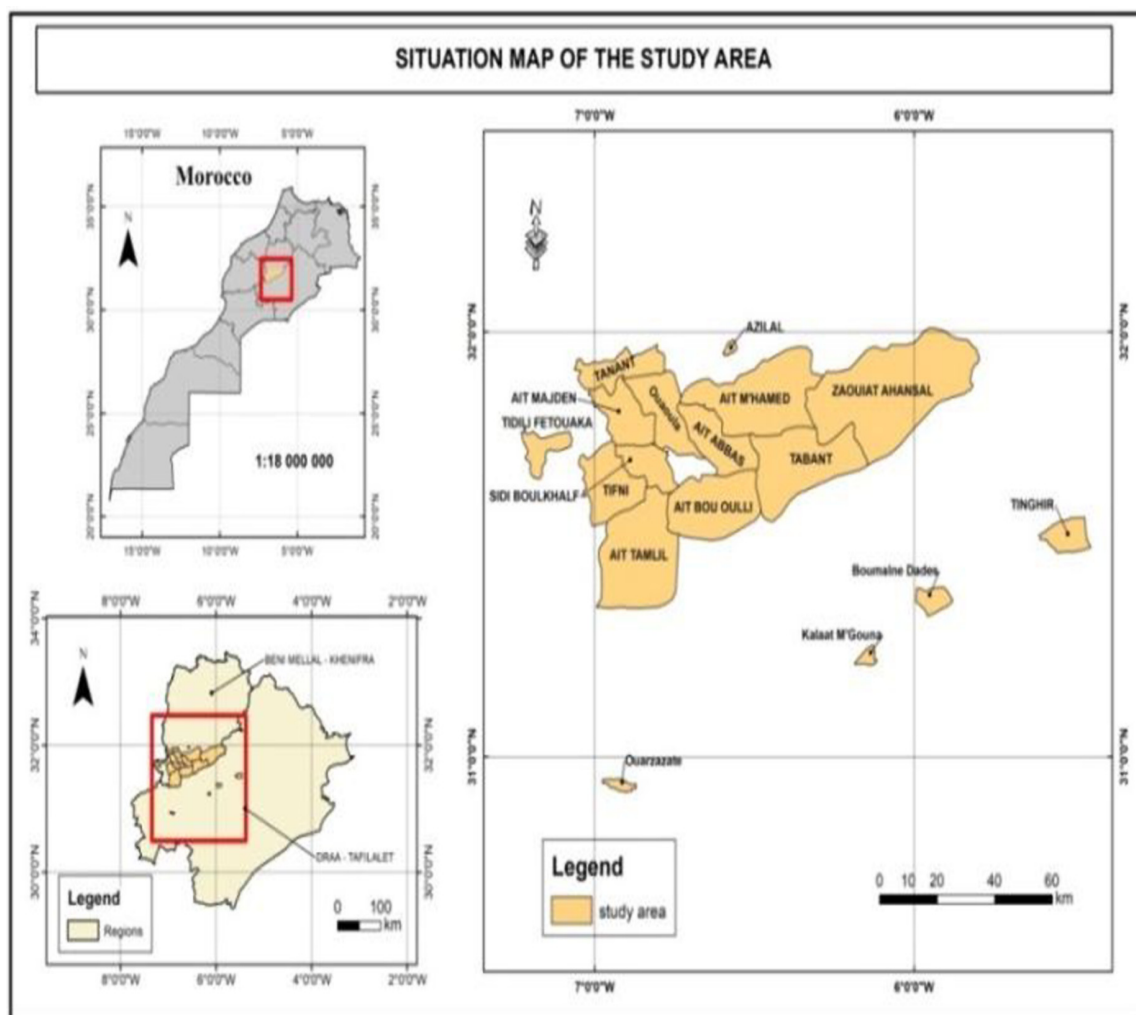


Fig. 1. Map situation of the study area: High Central Atlas (Realized by Belhaj according to the administrative division of 2015, Arcgis)

*The north side of the HAC (Fig. 1)*

The municipalities of At Abbas, At Bou Oulli, Tabant, Zaouiat Ahansal, At Majden, Tifni, Sidi-boulkhalef, Ouaoula, At M'hamed, Ait Tamlil, Tidli-Fetouaka, Tannant, and Ouzoud belong to the city of Azilal, which is geographically located in the center of the Kingdom and belongs to the Beni Mellal-Khen (Official Bulletin, 2015). It covers an area of approximately 1 million hectares, with the exception of a small portion of the Tadla plain.

Administratively, the Beni Mellal-Khenifra region comprises five provinces: Azilal, Beni Mellal, Fquih Ben Salah, Khenifra, and Khouribga, 135 communes including 16 municipalities and 119 rural Communes (HCP, 2018a). About 80% of the surface area of the province is situated at an altitude, of more than 1000 m and 60% above 1500m (Tabuti et al., 2003).

The climate is generally the Mediterranean, characterizes by heavy rainfall during winter and spring and a severe drought in summer (Sauvage & Vindt, 1952). Geologically, the area of the province extends over nearly one million hectares and covers a large part of the high limestone Atlas of the secondary age (Pique, 1994). Its population is 2 520 776 inhabitants, of which 1 282 037 are rural according to the national census of the population 2014 (HCP, 2018a). The main plant formations in the area are as follows: The Holm oaks, Junipers, and Maritime Pine beside a few secondary species.

*The south side of the HAC (Fig. 1)*

This work was done also on the southern slope in the provinces of Tinghir, Ouarzazate, and the Dra'a-Tafilalet region.

Tinghir Province has a total population of 22,966,666, with 168,084 (or 73.19%) living in rural areas. Todgha and Dades-Mgoun sub-basin soils are mostly alluvial, undeveloped, deep, silty-sandy, and sandy. Special crops in the province, particularly perfume roses, occupy small areas but provide a significant income to producers (HCP, 2018b).

*Data collection tools and procedures*

The ethnobotanical survey was based on a direct questionnaire on the applications of plants mentioned in the local traditional pharmacopeia for treating female infertility. The study was carried out between May 2015 and August 2017 with 108 people using a pre-determined

questionnaire (Appendix). The respondents' approach was focused on the discussion in local languages and Arabic. Following the interviews, respondents supplied information about the plants described, including the local name, the part utilized, the technique of preparation, the mode of administration, and the length of use, as well as personal information (age, sex, academic level, professional situation).

Furthermore, we organized a number of field trips to the research areas, the vast majority of which were successful. We were accompanied by guides (elderly people) to take digital photos and decide on the vernacular names given to these medicinal plants in order to create herbarium sheets. Plant species were determined on a systematic level at the Laboratory of Plants, Animal Productions, and Agro-industry using floristic and taxonomic references (Hmamouchi, 2001; Fennane & Ibn Tattou, 2005). The database "The Plant List 2020" (<http://www.theplantlist.org>) was used to validate taxonomy and species names.

*Data analysis*

The collected data were analyzed with the SPSS 20.0 software. The phytotherapeutic importance of each species was assessed by calculating indices of quantitative value such as, the frequency of citation (FC), the relative frequency of citation (RFC), the family importance value (FIV), and the informant consensus factor (ICF).

*The relative frequency of citation (RFC)*

It is used to assess the local importance of each species. This frequency is calculated according to the following formula followed by Tardío & Pardo-De-Santayana (2008):  $RFC = FC / N$ . Where FC refers to the number of respondents who mentioned the use of the species and N is the total number of respondents.

*The FIV* recognizes the importance of plant families. It demonstrates the significance of plant families. It was calculated using the Molares & Ladio (2009) formula:

$FIV = RFC / N_s$ , where  $N_s$  is the total number of species in each family.

*The informant consensus factor (ICF)*

Calculated for each category to determine the homogeneity of knowledge in the use of medicinal plant species. It is obtained according

to the method used by Heinrich et al. (1998):

$$ICF = \frac{Nur - Nt}{(Nur - 1)}$$

where, Nur= number of use citations for a disease category and Nt= number of species used by informants in a given use category.

ICF value varies from 0 to 1. It is close to 1 when the plant is used by a large number of respondents for a specific disease and/or when information on the use of the species for a specific disease is exchanged between informants, and close to 0 (low) when the plant is randomly selected or there is no exchange of information about use among informants.

## Results

### *Demography data of informants*

A total of 108 individuals were interviewed on traditional knowledge and uses of herbal medicines for female infertility (Table 1). The analysis of the questionnaires showed a clear female predominance (86.11%). The age of the

respondents varied between 20 and 80 years, the majority of them are in the [20-40] age group (37.96%). In terms of education, 47.22% of the study population did not attend school. In our study, 60.18% of patients were unemployed, and the majority of respondents (91.66%) did not have health insurance. The majority of respondents (61.66%) reported having inherited their herbal knowledge.

### *Diversity of medicinal plants*

The study has revealed the identification of 41 species from 19 families and 40 genera. Table 2 lists these plants alphabetically. For each medicinal plant identified, the scientific and local names, the component used, the method of preparation and administration, the local medicinal usage, and the FC, RFC, FIV, and ICF values were determined. It is worth noting that the most commonly used families are Apiaceae, Asteraceae, and Lamiaceae, each of which contains six species (Fig. 2). Based on FIV values, the majority of common botanical families were Apocynaceae (FIV= 0.527), Arecaceae (FIV= 0.509), and Braccaceae (FIV= 0.481) (Table 2).

**TABLE 1. Demographics profile of informants interviewed in the High Atlas Central of Morocco**

Variables	Category	Total	Percentages (%)
Gender	Female	93	86.11
	Male	15	13.88
Age groups	20-40 years	41	37.96
	40-60 years	33	30.55
	60-88 years	34	31.48
Family situation	Married	72	66.66
	Single	17	15.74
	Divorced	14	12.96
	Widow	5	4.63
The level of education	Illiterate	51	47.22
	Primary	37	34.26
	Secondary	11	10.18
	University	9	8.33
The living environment	Rural	76	70.37
	Urban	32	29.63
Socio-economic level	Employees	7	6.48
	Students	9	8.33
	Farmers	11	10.19
	Daily workers	16	14.81
	Unemployed	65	60.18
Medical coverage	Yes	9	8.33
	No	99	91.66

TABLE 2. List of medicinal plants ethnobotanical used to treat female infertility in the High Atlas Central of Morocco

Families	Scientific name (voucher number)	Local name	Part used	Preparation	Administration	Medicinal use	FC	RFC	FIV
Amaryllidaceae	<i>Allium sativum</i> L. (LBNR6)	Touma	Bulb	Supposit-ory	Anal	Purification of the female reproductive system.	23	0.21	0.21
Apocynaceae	<i>Caralluma europaea</i> (Guss.) N.E.Br. (LBNR28)	Darmouss	Aerial part	Juice	Oral	Caring for ovary kists. Regulates ovulation disorders.	57	0.52	0.52
Apiaceae	<i>Coriandrum sativum</i> L. (LBNR18)	Kezbour	Root	Poultice	Vaginal	Promote fertilization.	33	0.30	0.29
	<i>Daucus crinitus</i> Desf.,	Bouzzfour	Root	Powder	Vaginal	Purification of the female reproductive system.	22	0.20	
	<i>Elaeoslimum meoides</i> (Desf.) W.D.J.Koch ex DC.	Toufssa	Root	Poultice	Body bath	Promote fertilization.	13	0.12	
	<i>Ferula communis</i> L. (LBNR22)	Boubal	Fruit	Cooked	Oral	Warming of uterus.	43	0.39	
	<i>Smyrniium Olusatrum</i> L. (LBNR26)	Lhayar	Seed	Powder	Oral	Regulates ovulation disorders.	29	0.26	
Araliaceae	<i>Thapsia garganica</i> L. (LBNR27)	Addryas	Root	Poultice	Vaginal	Promote fertilization.	49	0.45	0.12
	<i>Panax ginseng</i> C.A.Mey. (LBNR258)	Arq al hayat	Root	Infusion	Oral	Regulates ovulation disorders.	14	0.12	
Araceae	<i>Phoenix dactylifera</i> L. (LBNR32)	Dekar nkhal	Male inflo.	Infusion	Oral	Regulates ovulation disorders. Promote fertilization.	55	0.50	0.50

TABLE 2. Cont

Families	Scientific name (voucher number)	Local name	Part used	Preparation	Administration	Medicinal use	FC	RFC	FIV
Asteraceae	<i>Achillea millefolium</i> L. (LBNR37)	Khalaki	Aerial part	Infusion	Oral	Promote fertilization.	12	0.11	0.25
	<i>Anacyclus pyrethrum</i> (L.) Lag. (LBNR40)	Tigentest	Root	Infusion	Oral	Promote fertilization.	18	0.16	
	<i>Artemisia absinthium</i> L. (LBNR43)	Chiba	Aerial part	Poultice	Vaginal	Warming of uterus.	26	0.24	
	<i>Artemisia herba-alba</i> Asso (LBNR46)	Chih /izri	Aerial part	Poultice	Vaginal	Warming of uterus.	41	0.37	
	<i>Atractylis gummifera</i> Salzm. ex L. (LBNR47)	Addad	Flower	Infusion	Oral	Regulates ovulation disorders.	33	0.30	
	<i>Dittrichia viscosa</i> (L.) Greuter (LBNR57)	Terhla	Stem	Infusion	Oral	Caring for kists.	37	0.34	
Brassicaceae	<i>Anastatica hierochuntica</i> L. (LBNR253)	Chajrat kaff mryem	Aerial part	Infusion	Oral	Promote fertilization.	53	0.49	0.48
	<i>Eruca sativa</i> Mill. (LBNR74)	Al girjir	Seed	Powder	Oral	Promote fertilization. Regulates ovulation disorders.	44	0.40	
	<i>Lepidium sativum</i> L. (LBNR75)	Hab rchad	Seed	Powder	Oral	Promote fertilization.	59	0.54	
Euphorbiaceae	<i>Ricinus communis</i> L. (LBNR259)	Wriwra	Leaf	Supposit-ory	Anal	Warming of uterus.	9	0.08	0.08

TABLE 2. Cont

Families	Scientific name (voucher number)	Local name	Part used	Preparation	Administrat-ion	Medicinal use	FC	RFC	FIV
Fabaceae	<i>Acacia gummifera</i> Willd. (LBNR108)	Telh	Root	Supposit-ory	Vaginal	Caring for kists.	11	0.10	0.19
	<i>Lupinus luteus</i> L. (LBNR116)	Semkala	Seed	Decoction	Oral	Regulates ovulation disorders.	18	0.16	
	<i>Trigonella foenum-graecum</i> L. (LBNR12)	Halba	Seed	Powder	Oral	Regulates ovulation disorders.	33	0.30	
Lamiaceae	<i>Ajuga reptans</i> (L.) Schreb. (LBNR130)	Chandgoura; timarna	Aerial part	Decoction	Oral	Promote fertilization.	25	0.23	
	<i>Lavandula maroccana</i> Murb. (LBNR136)	Iguiz	Inflo.	Supposit-ory	Vaginal	Warming of uterus.	51	0.47	
	<i>Ocimum Basilicum</i> L. (LBNR143)	Lhbaq	Leave	Decoction	Vaginal	Purification of the female reproductive system.	12	0.11	
	<i>Sabia officinalis</i> L. (LBNR147)	Salmiya	Leave	Decoction	Oral	Regulates ovulation disorders.	57	0.52	
	<i>Thymus broussonetii</i> Boiss. (LBNR150)	Azoukenni	Leave	Supposit-ory	Anal	Warming of uterus.	38	0.35	
	<i>Vitex agnus Stokes</i> (LBNR154)	Anguirf	Flower	Infusion	Oral	Regulates ovulation disorders.	15	0.13	
Malvaceae	<i>Hibiscus sabdariffa</i> L. (LBNR162)	Karkadil	Fruit	Decoction	Oral	Promote fertilization.	11	0.10	0.10



TABLE 2. Cont

Families	Scientific name (voucher number)	Local name	Part used	Preparation	Administration	Medicinal use	FC	RFC	FIV
Moraceae	<i>Ficus carica</i> L. (LBNR164)	Karmouss	Bark	Decoction	Oral	Care of uterine myomas.	41	0.37	0.37
Myrtaceae	<i>Eucalyptus globulus</i> Labill. (LBNR165)	Eucalyptus	Leave	Decoction	Vaginal	Warming of uterus.	32	0.29	0.29
Poaceae	<i>Cynodon dactylon</i> (L.) Pers. (LBNR186)	Njem	Root	Decoction	Oral	Promote fertilization.	19	0.17	0.21
	<i>Zea mays</i> L. (LBNR194)	Draa	Stigma of corn	Infusion	Oral	Regulates ovulation disorders.	27	0.25	0.16
Ranunculaceae	<i>Clematis flammula</i> L. (LBNR201)	Nar el-barda	Flower	Poultice	Vaginal	Warming of uterus.	19	0.17	0.26
	<i>Ranunculus bullatus</i> L. (LBNR204)	Mrmis	Root	Decoction	Oral	Regulates ovulation disorders.	17	0.15	0.13
Rosaceae	<i>Rubus ulmifolius</i> Schott. (LBNR217)	Laallik, tabgha	Leave	Infusion	Oral	Regulates ovulation disorders.	29	0.26	0.09
Rutaceae	<i>Citrus aurantium</i> L. (LBNR220)	Larange	Fruit	Decoction	Oral	Care of uterine myomas	15	0.13	0.09
Solanaceae	<i>Capsicum annum</i> L. (LBNR227)	Felfla	Fruit	Decoction	Oral	Promote fertilization	9	0.08	0.33
	<i>Solanum nigrum</i> L. (LBNR233)	Aneb dib	Flower	Decoction	Oral	Caring for ovary kists	11	0.10	0.33
Zingiberaceae	<i>Zingiber officinale</i> Roscoe (LBNR247)	Skinjibir	Root	Powder	Oral	Promote fertilization	36	0.33	

FC, frequency of citation; FIV, family importance value; RFC, relative frequency of citation. Inflo.= Inflorescence



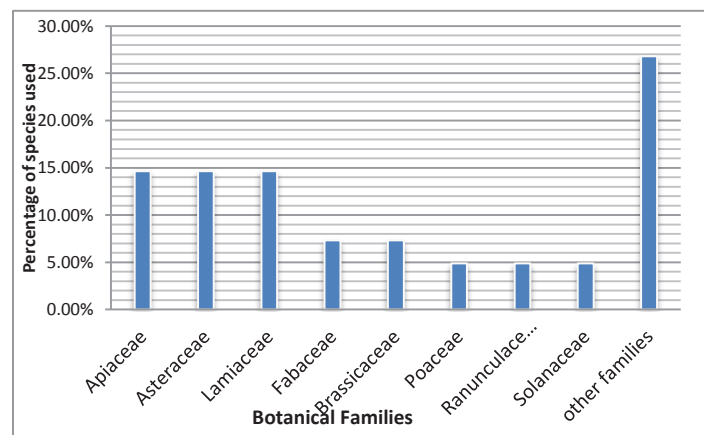


Fig. 2. Percentage of species used

The findings of this study revealed that 14 plants were used to aid fertilization, with *Lepidium sativum* L. (FC= 59) and *Phoenix dactylifera* L. (FC= 55) being the most commonly cited species, and 13 plants were used to regulate ovulation disorders, with *Salvia officinalis* L. (FC= 57) and *Phoenix dactylifera* L. (FC= 55) being the most commonly cited, and 9 plants were recorded for uterus. Respondents also mentioned four plants for ovarian cyst removal, three species for female reproductive system purification, and two species for uterine myoma (Table 2). Regarding the degree of homogeneity in the use of medicinal plant species in the treatment of female infertility, there is a high level of agreement (ICF= 0.982) among local populations in the use of medicinal plant species to stimulate fertilization and to treat uterine myoma (ICF= 0.981). Similarly, local populations have a fairly high affinity for a class of medicinal plants used to warm the uterus (ICF= 0.970), treat ovarian cysts (ICF= 0.969), regulate ovulation abnormalities (ICF= 0.964), and purify the female reproductive system (ICF= 0.957) (Table 3).

Several plant organs, such as leaves, seeds, and barks, were used in various ways to facilitate the preparation of the recipes used in treating female sterility. The data obtained revealed that the roots were the most commonly used parts (24.39%), followed by leaves and aerial parts (14.63%) (Fig. 3). Thus, to facilitate the preparation of drugs, seven techniques were noted: powder, decoction, infusion, poultice, cooked, juice and suppository. Among them, decoction was the most used drug form (Fig. 4). The different routes of administration used in the case of female

infertility in our study area were the oral route (65.85%), the vaginal route (36.93%), and the anal route (7.32%).

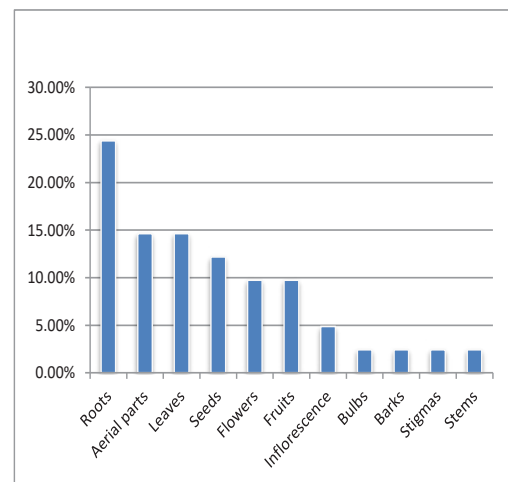


Fig. 3. Distribution of the different parts used

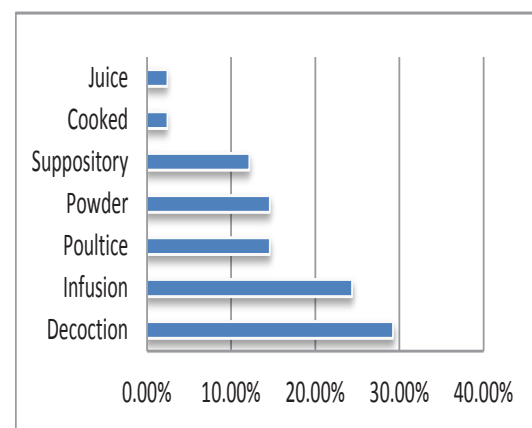


Fig. 4. Methods of preparation

TABLE 3. Informant consensus factor values (ICF) by category for ethnobotanical treating female infertility

Category	Plant Species Used and Number of Citations	Total number of		ICF
		Species	Use citations	
Promote fertilization.	<i>Coriandrum sativum</i> L. (33), <i>Elaeoselinum meoides</i> (Desf.) W.D.J.Koch ex DC.(13), <i>Thapsia garganica</i> L. (49), <i>Phoenix dactylifera</i> L. (14), <i>Achillea millefolium</i> L. (12), <i>Anacyclus pyrethrum</i> (L.) Lag. (18), <i>Anastatica hierochuntica</i> L. (53), <i>Eruca sativa</i> Mill. (23), <i>Lepidium sativum</i> L. (59), <i>Ajuga iva</i> (L.) Schreb. (25), <i>Hibiscus sabdariffa</i> L. (11), <i>Cynodon dactylon</i> (L.) Pers. (19), <i>Capsicum annum</i> L. (9), <i>Zingiber officinale</i> Roscoe (36).	14	374	0.982
Regulates ovulation disorders.	<i>Caralluma europaea</i> (Guss.) N.E.Br. (16), <i>Smyrniolum olusatrum</i> L. (29), <i>Panax ginseng</i> C.A.Mey. (14), <i>Phoenix dactylifera</i> L. (41), <i>Atractylis gummifera</i> Salzm. ex L. (33), <i>Eruca sativa</i> Mill. (21), <i>Lupinus luteus</i> L. (18), <i>Trigonella foenum-graecum</i> L. (33), <i>Salvia officinalis</i> L. (44), <i>Vitex agnus Stokes</i> (15), <i>Zea mays</i> L. (27), <i>Ranunculus bullatus</i> L. (17), <i>Rubus ulmifolius</i> Schott. (29).	13	337	0.964
Warming of uterus.	<i>Ferula communis</i> L. (43), <i>Artemisia absinthium</i> L. (26), <i>Artemisia herba-alba</i> Asso (41), <i>Ricinus communis</i> L. (9), <i>Lavandula maroccana</i> Murb. (51), <i>Salvia officinalis</i> L. (13), <i>Thymus broussonetii</i> Boiss(38), <i>Eucalyptus globulus</i> Labill. (32), <i>Clematis flammula</i> L. (19).	9	272	0.970
Caring for kists.	<i>Caralluma europaea</i> (Guss.) N.E.Br. (41), <i>Dittrichia viscosa</i> (L.) Greuter (37), <i>Acacia gummifera</i> Willd. (11), <i>Solanum nigrum</i> L. (11).	4	100	0.969
Purification of the female reproductive system.	<i>Allium sativum</i> L. (14), <i>Daucus crinitus</i> Desf. (22), <i>Ocimum Basilicum</i> L. (12).	3	48	0.957
Care of uterine myomas.	<i>Ficus carica</i> L. (41), <i>Citrus aurantium</i> L. (15).	2	56	0.981

In the current study, knowledge of the properties and uses of medicinal plants was generally acquired through the ascendants' experience, which represented a percentage of 56, 48% in our case. Herbalists provided 20.37% of the information, while reading and media provided only 12.96% and 10.18%, respectively (Fig. 5).

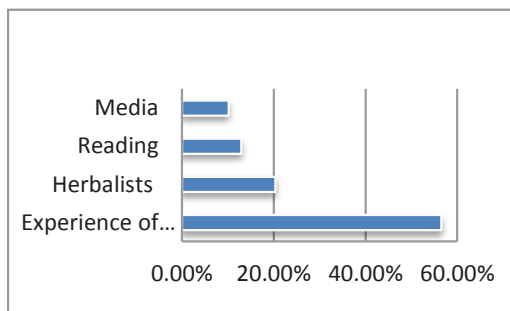


Fig. 5. Methods of acquisition of traditional knowledge

### Discussion

The goal of this study was to find and collect information on plants used in the treatment of female infertility in (HAC) Morocco. Through ethnobotanical surveys, we discovered that herbalists and older people have endogenous knowledge of the management of female infertility. Females (86.11%), married people (66.66%), and people living in rural areas (70.37%) were all familiar with the use of plants in the treatment of female infertility, according to the data collected. This observation is supported by Jouad et al. (2001), Mehdioui & Kahouadji (2007), and Jamila & Mostafa (2014).

According to the results gathered from the respondents, people aged 20 to 40 years had more information than those of other ages. This could be explained by the fact that traditional medicine knowledge was mostly passed down from ancestors (wise people) to descendants (young people). As a result, the two types of people had nearly identical levels of knowledge. This is all the more understandable given that the majority of those surveyed (56.48%) stated that their knowledge was inherited from their families. This finding is consistent with Skalli et al. (2019) and Zougagh et al (2019).

For the educational level, 47.22% of the patients were illiterate. This result confirmed the

data of other ethnobotanical studies conducted in several African countries such as Morocco (El Amri et al., 2015; Alaoui & Laaribya, 2017), Algeria (Zatout et al., 2021), and Mali (Bah et al., 2011). On the other hand, the majority of the study population had a low socioeconomic level (60.18%) were unemployed, and only 8.33% had medical health insurance. This distribution could be explained by the high ancestral potential of our study area, particularly in rural areas, for the use of medicinal plants in therapy. It also justified the high cost and difficulty of access to modern health care, particularly in rural areas where transportation is limited and poverty is increasing. Similar results had been found in studies conducted in the Rif (Chaachouay et al., 2019) and the Middle Moulouya of Morocco (Douiri et al., 2007).

Asteraceae, Apiceae, and Lamiaceae were the botanical families with the greatest species. These three families were therapeutically important, as has been stated numerous times. They were the most common plant families on the central Moroccan plateau (El Hilah et al., 2015), northern Morocco (Orch et al., 2015), and western Morocco (Lahsissene et al., 2009).

The calculation of the relative frequency of citation (RFC) revealed that *Lepidium sativum* (RFC= 0.546), *Caralluma europaea* (RFC= 0.527), and *Phoenix dactylifera* (RFC= 0.509) have the greatest local importance. These were the most popular plants in Morocco's Central High Atlas. As a result, pharmacological, phytochemical, and biological investigations should be conducted on these high RFC plant species to validate and establish their genuineness (Mukherjee et al., 2012).

The highest Informant Consensus Factor values (ICF= 0.982) and (ICF= 0.981) were noted for stimulating fertilization and for treating uterine myoma, this demonstrates the high reliability of informants on the use of these therapeutic plants (Lin et al., 2002). This also demonstrates that local people communicate knowledge about the use of species for ethnobotanical treatment of female infertility in our study (ethnobotanical treatment of female infertility in our study area).

The roots were the most commonly used plant part, accounting for 24.39% of all plant parts. This merited special consideration. Indeed, it has

been identified as one of the factors threatening the long-term viability of populations and plant species. These plants are in danger of extinction as a result of being sought after for their roots.

These findings contradicted many other ethnobotanical studies, which found that medicinal plant leaves were the most commonly used in the treatment of various diseases and ailments in various parts of the world, Such as in Morocco (Abouri et al., 2012; Daoudi et al., 2016), Cameroon (Didier et al., 2011), Senegal (Gueye et al., 2012), Niger (Manzo et al., 2017), Pakistan (Malik et al., 2018), and Spain (González et al., 2010).

Infusion and decoction were the most common mode of preparation. Similar results were also observed in the method of preparation among populations from several regions in Morocco (Abouri et al., 2012; Tahri et al., 2012; El Amri et al., 2015). The ethnobotanical administration of drugs recommended to patients was the internal route especially oral (65.85%). This predominance could be explained by the convenience and simplicity of this mode, which facilitated the absorption of active ingredients of medicinal plants, and consequently their transport easily in the body. This predominance of oral administration had also been reported by several ethnobotanical studies conducted in Africa: in Morocco (Skalli et al., 2019; Chaachouay et al., 2020; Idm'hand et al., 2020); Cameroon (Mpondo et al., 2017); Togo (Françoise et al., 2018); Benin (Sangare et al., 2012); Nigeria (Okafor & Ham, 1999) which all confirmed the effectiveness and importance of this mode of administration.

### **Conclusion**

The investigations carried out in the framework of this study made it possible to highlight the potential of medicinal plants and the ethnobotanical endogenous knowledge related to the use of these plants in the (HAC) of Morocco. It was the first study of its kind carried out in this study area with regard to female infertility.

The study revealed a diversity of 41 plant species used in the ethnobotanical treatment of female infertility; some of them, such as *Caralluma Europaea*, *Lepidium sativum*, and *Phoenix dactylifera*, had a very significant relative frequency of citation. Nonetheless, none

of these plants had been scientifically studied in the laboratory to justify their pharmacological, biological, and phytochemical potentialities, as well as to confirm their negative and positive effects on female fertility. As a result, it became a promising research field for discovering new active principles that could be used therapeutically and, as a result, developing natural drugs from medicinal plants found in the studied area.

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*Competing interests:* The authors report no conflicts of interest regarding this work.

*Authors' contributions:* All the co-authors wrote and reviewed the manuscript equally and approved the final version of the manuscript.

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## الدراسة الاثنوبولوجية للنباتات الطبية المستخدمة في علاج العقم عند النساء في الأطلس الكبير المتوسط بالمغرب

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تم إجراء هذه الدراسة الإثنوبولوجية في الأطلس الكبير المتوسط بالمغرب من خلال القيام ب 108 مقابلة مع السكان المحليين والمعالجين بالأعشاب بهذه المنطقة، بهدف جرد وتحديد النباتات الطبية المستخدمة في علاج العقم.

من خلال تحليل نتائج هذه الدراسة، فقد تم جرد 41 نوعا نباتيا ينتمي إلى 19 عائلة نباتية يستعمل في العلاج المحلي للعقم لدى النساء. أهم هذه العائلات استعمالا بستة أنواع لكل منها Asteraceae و Apiaceae و Lamiaceae. بينما تعتبر النباتات التالية هي الأكثر استعمالا من طرف السكان المحليين مع تكرار الاقتباس النسبي المرتفع حيث أنه لكل واحد من هذين النوعين *Caralluma europaea*(Guss.) N.E.Br و *Lepidium sativum* L. (RFC= 0.546). وكذا *Phoenix dactylifera* L. (RFC= 0.509).

من جهة أخرى يعتبر الجذر الجزء الأكثر استخدامًا من النبات % 24,39 ، بينما الديكوتيون % 29,26 والتسريب % 24.39 هما أكثر الطرق استخداما لتحضير هذه النباتات كما أن أغلبية الوصفات % 65.85 تعطى عن طريق الفم. بالنسبة للنباتات المستخدمة لتعزيز الإخصاب، كانت درجة الاتفاق على الوصفات النباتية المستعملة لعلاج العقم لدى النساء عالية جدًا (ICF = 0.982).

تعتبر هذه الدراسة هي الأولى في المغرب فيما يتعلق باستعمال النباتات الطبية لعلاج العقم عند النساء. وقد كشفت عن وجود معرفة حقيقية باستعمال هاته النباتات بهذه المنطقة. كما يمكن أن تؤدي نتائج هذا البحث لاكتشاف مكونات صيدلانية طبيعية ونشطة و / أو عقاقير فعالة وآمنة يسهل الوصول إليها خاصة من قبل السكان المحليين.