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Water and nutrient fluxes from three coastal Mediterranean Rivers (N-E Algeria)

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Abstract

The objectives of the present study were to estimate water delivery and dissolved nutrients loads (nitrogen N, phosphorus P and silicates Si) from three minors coastal rivers (about 14% of Algerian coastal watersheds). Freshwater flow dissolved inorganic nitrogen DIN (NH_4, NO_3 and NO_2), dissolved organic nitrogen DON, dissolved inorganic phosphorus DIP, phosphate (PO_4), dissolved organic phosphorus DOP and silicates SiO_4 were measured monthly at River outlet in the year 2011. The rivers were characterized by high values of ammonia (NH_4) and phosphate (PO_4) which reveal the dominance of organic and domestic pollutions. In contrast, values of SiO_4 were very low and will be in relation to the retention in dams. Dissolved nitrogen loads varied considerably from 43 to 227 kg/km²/y where DON formed 20 to 40%. Loads of total dissolved phosphorus (TDP) fluctuated in the range of 20- 80 kg/km²/y in which the organic fraction forms largely dominated (51 to 74%). At River outlets, the loading ratio of nutrients (Si: N: P) were altered by agricultural and household wastes. Here, Si:N and N:P mass ratios ranged from 3-6 and 10-20 respectively, indicating large N and P inputs. These biogeochemical conditions would induce deep impacts on the ecology and the productivity of the adjacent coastal waters.

Keywords: Nutrients, discharges, ratio, River, Mediterranean, Algeria.

1. Introduction

The marine ecosystem functioning is considerably influenced by the freshwater received to the seas, through their control on the general water circulation in the Mediterranean Sea (Skliris et al., 2007). In last decades, humans activities have widely transformed the hydrology of coastal rivers by perturbing their overflow in artificial reservoirs. Also, the immoderate employ of fertilizers from agricultural and domestic wastes have altered the chemistry of freshwater delivery into the sea that affected the nearby coastal ecosystems (Howarth et al., 1996; Meybeck, 2003; Turner et al., 2003; Nixon et al., 2003; Liu et al., 2008). Furthermore according to Margat and Treyer (2004), water and related constituents discharged by rivers of to the Mediterranean Sea undertook important changes during latest decades; principally water resources in the Mediterranean are limited and anthropogenic pressures on rivers are very significant. The hydrological stability, dissolved nutrients (nitrogen or N, phosphorus or P, silica or Si), carbon, sediment and biodiversity of water surfaces are mainly controlled by the transfer of river materials to the sea (Meybeck, 2003). Inaddition to their hydrological role, the rivers are recognized to play a particular role in supporting the production of the Mediterranean Sea where the productive regions are restricted to the bordering coast (Bosc et *al.*, 2004). The adjustments in river discharge and

nutrient entrance are established to be central in controlling the productivity and the functioning of the marine environment. Geochemical modifications of nutrient loading to coastal waters influence negatively human health and environment, for example damage of habitat and biodiversity, eutrophication and expand in blooms of some species of harmful algae, fish kills and hypoxia (Cloern et *al*., 2001; Ragueneau et *al*., 2006; Billen and Garnier, 2007; Howarth et *al*., 1996; Rabalais, 2002). Moreover, Rabalais and Turner (2001) and Turner *et al*. (2003) elucidated surprising impacts resulting from modifications occurring at the global scale and are now far upstream. Further data on coastal catchments of Algeria regarding water discharges and fluxes of N, P and Si is missing, excepting some works of Khélifi-Touhami M et *al.* (2006) and Ounissi M and Bouchareb N (2013). In addition, the assessments of nutrient inputs from both atmospheric and riverine sources into Mediterranean waters are still rare especially in southwestern Mediterranean regions (Ounissi et all 2018).
In view of the severe lack of geochemical data for coastal river basins, the aim of the present work is to evaluate water and nutrient loadings of N, P and Si in three representative coastal catchments of Algeria.

2. Materials and methods

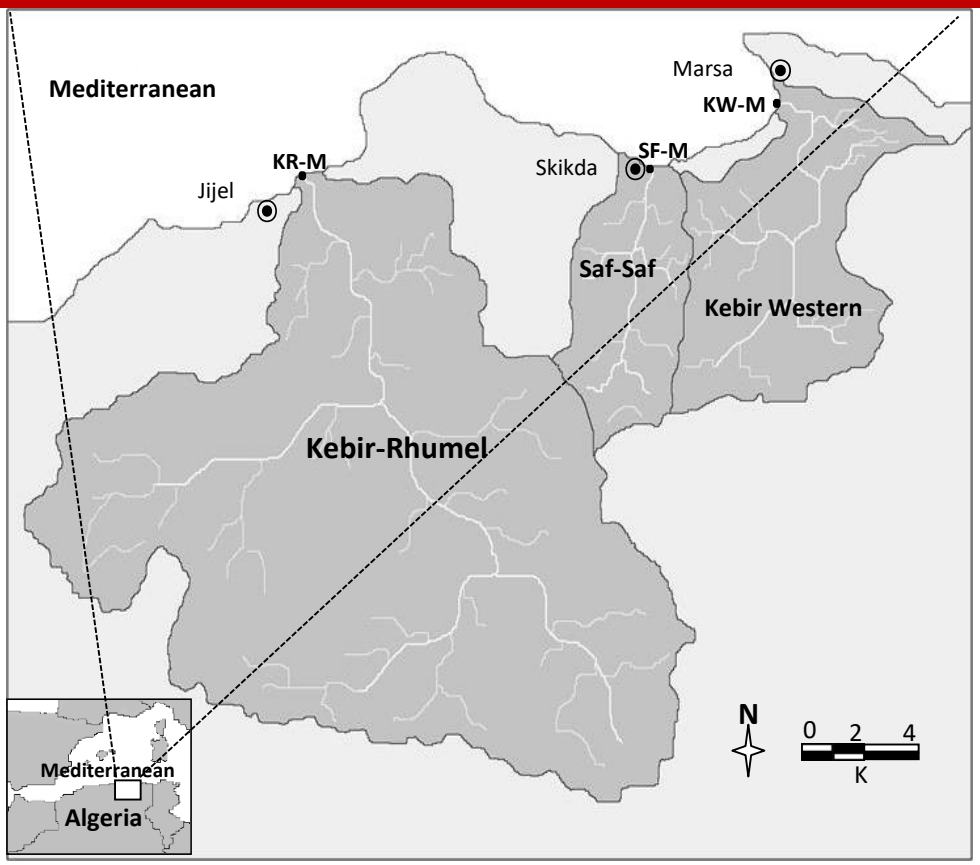
2.1. Study area

The three watersheds of the studied rivers have a total surface of 1, 1160 km² with a population of about two Millions and are mainly submitted to domestic and agricultural wastes (Fig. 1). They are heavily managed by numerous dams that retain more than the half ofthe precipitation wealth. In the Kebir-Rhumel (KR) catchment is arranged by the Beni- Haroun dams (one Billion m³ water), however that is populated by approximately 1 Million inhabitants. On the other hand the catchment of Kebir Western (KW) is arranged by the Zit- Amba dam of a capacity of (50 million m³) and gathers only 30.000 inhabitants. Also the Safsaf (SF) catchment is controlled by the Zardaza dam of a capacity of (120 million m³) and gathers approximately of 70.000 inhabitants. The catchments receive an annual precipitation yield of about 400-800 mm inducing large fluctuation in river flow. In summer period all rivers fall almost dry at the entering of dams while at the exit the dams continue to deliver lowflows. Being irrigated from dams and near-river mouths, the northern areas sustain large intensive agricultural activities and the land use becomes mainly dominated by intensive agricultural practices and forests occupied always less than 20%.

2.2. Methods

Flow velocities of the estuarine water, at the moment of sampling from the same water mass, were assessed with the current meter CM-2 (Toho Dentan Co.Ltd, Tokyo). The flow rate ($m^3\ s^{-1}$) was calculated by multiplying the water velocity ($m\ s^{-1}$) by the total surface area (m^2) of the estuary's transecting at the mouth station. Water salinity and temperature measurements were taken with the multiparameter probe WTW 197i. Two liters of water from the middle of the flow were collected for nutrient analysis. Water samples for nutrient analyses were frozen in polyethylene bottles and processed within two days from collection. In the laboratory, after filtration of the sample through Whatman GF/C glass filters (0.5µm porosity), dissolved inorganic nitrogen DIN (NH_4, NO_3, NO_2), dissolved organic nitrogen DON and silicates (SiO_4) were determined by means of standard colorimetric methods described in Parsons and al. (1989). Total dissolved phosphorus TDP, polyphosphate P_2O_5, and dissolved organic phosphorus DOP were determined following the standard method of Rodier (1998).

Figure 1.



Sampling stations in the coastal Rivers of Kebir-Rhumel (KR), Kebir West (KW) and Safsaf (SF): KR-M: mouth of KR River; KW-M: mouth of KW River; SF-M: mouth of SF River.

All hydrological parameters and nutrients were measured monthly from March 2011 toFebruary 2012 in one stations for each Rivers KR, KW and SF respectively (Fig. 1). The instantaneous flux of nutrients was calculated by multiplying their concentrations by the estuary flow. The annual loads for nutrients were estimated using the method of average instantaneous loads (Preston et al., 1989):

$$F = K \sum_{i=1}^{n} \frac{CiQi}{n}$$

where F is the annual load (tons/years), Ci is the concentration of nutrients (µM converted to kg m^{-3}), Qi is the concomitant instantaneous flow (m^3 s^{-1} converted to m^3 day^{-1}), n is the number of days with concentration and flow data and K is the conversion factor to consider the period (365 days) and unit of estimation.

3. Results and discussion

3.1. Physical parameters deliveries at the rivers' outlets

The quantity of fresh water discharged to the sea varies according to the river between 258.10^6 and 536.10^6 m^3/y (Tab. 1). On the other hand water flowing to the sea accompanied by significant quantity of suspended materials where vary according to the river between 13519 t/y and 149401 t/y (Tab. 1). Concerning dissolved solids (TSS) and electrical conductivity (EC) they range in order between 365 mg/l and 467 mg/l for TSS and 902 (µs/cm) and 1014 (µs/cm) (Tab. 1) , All the Rivers studied represent an important variation of water discharges and precipitation (between 400-600mm) this variability of water mass

depends on the climate and water retention in the dams of a share and in addition it is influenced directly by the loadings of the nutrients.

Table 1. Mean and standard error (±) of electrical conductivity (EC), total dissolved solids (TDS) and flows at river outlets and water flow.

	EC (µs/cm)	TDS (mg/l)	Flow (m^3/s)	TSS delivery (t/y)	Water delivery (10^6 m^3)
Outlet KR	1014±311	467±165	17±15	149401	536
Outlet KW	916±158	365±58	13.5±8	13519	409
Outlet SF	902±293	364±110	8.2±4.7	19685	258

3.3. Nutrients loadings at river outlets

Nutrient fluxes and specific loadings from the studied Rivers are shown in the Table 2. Mediterranean rivers are characterized by large variations in River flow. River export of the forms of TDN, TDP and of SiO_4 increased in the KR mouth during the period compared with KW and SF, the high level of nutrients could be explained by the human activity in the KR basin compared with KW and SF (Ounissi M and Bouchareb N 2013). The input by all Rivers represents about 78-91% of the inorganic forms (DIN) and 26-49% of the (DIP) (Tab. 2). For dissolved organic forms (DON and DOP), the major fluxes can be observed in the KR River with a fraction of 52-60% respectively of total contribution of all the basins. In term of specific loadings, the small watersheds of KW and SF deliver to the sea considerable masses of PO_4 and NH_4 (19 to 22kg P-PO_4/km^2/y and 57 to 78kg N-NH_4/km^2/y) in comparison to the large watershed of KR characterizing the biggest dam of Algeria (Tab. 2). According to Ludwig et al. (2009), these quantities can represent one of the high ratios in Mediterranean rivers. An important quantity of Si was introduced to coastal water (338 to 520kg SiO_4/ km^2/y), and weakest flow specific is in the SF River is remarked compared has them in addition to basin studied with a value of (125kg SiO_4 km^2/y). The specific loadings of DIN were however low in KR watershed (27kg N/km^2/y) than 70% of the major Mediterranean rivers as reported by (Ludwig et al., 2009) compared to strong value in the SF and KW (130to 185kg N/km^2/y). The large amount of the DON brought to coastal water ranged between (53 to 131 t/y) suggests that organic nitrogen inputs may contribute markedly to marine eutrophication than was previously assumed, as already established by Seitzinger and Sanders, (1997). In the same way, the fluxes introduced to the coastal zone showed that DIN: PO_4 and Si: PO_4 ratios were frequently superior to the Redfield ratios values, suggesting thatP may be the limiting factor for phytoplankton growth. The N: P ratios increased greatly since the rise of agricultural practices and the latest reduction of phosphates in washing powders. Thus, the production of phytoplankton in coastal marine would be essentially controlled by P, which is the limiting nutrient at the river mouths. The alteration of Si: N ratios becomes a worldwide problematic as indicated in the data (Bernard et al., 2010; Ragueneau et al., 2006; Hamburg et al., 2008).

Table 2. Annual fluxes of nutrients at rivers outlets. Specific loadings (kg/km^2/y) are given between parentheses.

	NH_4 (t/y)	NO_2 (t/y)	NO_3 (t/y)	DIN (t/y)	DON (t/y)	TDN (t/y)	PO_4 (t/y)	P_2O_5 (t/y)	DIP (t/y)	DOP (t/y)	TDP (t/y)	SiO_4 (t/y)	N :P (g/g)	Si :N (g/g)	Si :P (g/g)
KR	82	23	108	213	131	344	32	15.5	47	136	183	1011	20	6	87
	(11)	(3)	(13)	(27)	(16)	(43)	(4)	(2)	(6)	(17)	(23)	(125)			
KW	109	32	107	248	68	316	36	23	59	95	154	988	21	5	72
	(57)	(17)	(56)	(130)	(36)	(166)	(19)	(12)	(31)	(50)	(81)	(520)			
SF	97	20	114	231	53	284	28	6	34	35	69	485	10	3	24
	(78)	(16)	(91)	(185)	(42)	(227)	(22)	(5)	(27)	(28)	(55)	(388)			

4. Conclusion

In conclusion, it can be stated that the major characteristics of the river that formed the subject of this study are marked by conditions of strong enrichments in particular in NH_4 and PO_4 contrary to the SiO_4. Overall, the water and nutrient transfer in the coastal rivers can be summarized as follows:

- The high level of nutrients could be explained by the human activity in the KR basin compared with KW and SF.
- Water mass flow varies depends on the climate and water retention in the dams of a share and in addition it is influenced directly by the loadings of the nutrients.
- The rivers were characterized by high values of ammonia (NH_4) and phosphate (PO_4) which reveal the dominance of organic and domestic pollutions.
- The loading ratio of nutrients (Si: N: P) were altered by agricultural and household wastes.

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We are very grateful and thankful to everyone who helped us accomplish this work.

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Antibiotic resistance profile of *Escherichia Coli* isolated from patients with urinary tract infections

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Abstract

Urinary tract infections (UTIs) are among the most common bacterial infections whether they are community or hospital acquired. Several risk factors are associated with UTIs, such as, amongothers, sex, previous UTIs, vaginal infections, and genetic susceptibility. In the present study, weanalyzed the resistance profile of *Escherichia coli* which is the bacterium frequently associated with urinary tract infections. *E. coli* strains were isolated by culture from urine from 150 episodes of urinary tract infections. Our results showed that among the 150 episodes tested, 102 were from females (69%) and 45 were from males (31%). The antibiogram results showed that *E. coli* strains exhibited high resistance against ampicillin and amoxicillin because these two antibiotics are the most widely used in the medical field. Imipenem and aminoglycosides, on the other hand, remain the most active molecules. Nevertheless, it is prudent to use these antibiotics, in order to reduce the risk of developing resistance against them.

Key words: urinary tract infections, UTIs, antibiotic resistance, *E. coli*,

1. Introduction

Urinary tract infections (UTIs) are among the most common bacterial infections in both community and hospital facilities. Urinary tract infections vary in severity and can affect all patients regardless of age (Bergogne-Bérézin, 2006). They come in the second rang of reasons for consultation and prescription of antibiotics after respiratory infections (Akpabie & Prieur, 2001). More 150 million cases of urinary tract infections are diagnosed each year in the world (Lavigne et *al.*, 2005). Overall, we estimated that almost half of women and 12% of men will suffer from at least one urinary tract infection during their lifetime, and that a quarter of these people will have the recurrent form of the disease (Brumbaugh et *al.*, 2013). These infections constitute a real public health problem due to the additional cost linked to the care they cause (Elfane et *al.*, 2016). Several risk factors are associated to UTI, including gender, previous UI, sexual activity, vaginal infection, diabetes obesity, and genetic susceptibility (Foxman, 2014; Hannan, 2012). Uncomplicated urinary tract infection is commonly seen in patients with a healthy urinary system and without using medical devices, which is often the case for outpatient (community acquired infections) (Hooton, 2012; Lichtenberger & Hooton, 2008; Mann et *al.*, 2017). The diagnosis of urinary tract infection is based on the presence of suggestive clinical signs and the existence of significant bacteriuria and leukocyturia. Cytobacteriological examination of urine (CBEU) is the gold standard that allowsconfirmation of infection by identifying and isolating the causative agent mostly followed bydetermination of the sensitivity of isolated bacteria to antibiotics. Most UTIs are particularlycaused by bacteria, the most common of which belonged to the *Enterobacteriaceae* family(*Escherichia coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Citrobacter* and *Enterobacter*) with a predominance of *E. coli*. Other bacteria such as *Streptococcus* and *Enterococcusfaecalis* may also be detected (Asadi-Karam et *al.*, 2019). Antibiotics were considered to bepowerful weapons that could eradicate infectious diseases of bacterial origin (Monnet D L,

2000). Routine treatment of UTIs relies on the use of antibiotics such as β-lactams, trimethoprim, nitrofurantoin and quinolones in many countries (Asadi-Karam et *al.*, 2019). Unfortunately, the widespread and misuse of these antibiotics has led to an increase in the rate of resistance to these antibiotics and such resistance remains to date a major public health problem. The increasing rate of antibiotic resistance among uropathogens, particularly among *Escherichia coli* and *Klebsiella pneumoniae* as the most common etiological agents of urinary tract infections, causes difficulty in choosing an adequate empirical therapy and treatment success (Arana et *al.*, 2017). Moreover, the widespread use of antibiotics imposes strong selection pressure for the development of antibiotic resistance (Yoneyama & Katsumata, 2006). Herein, we analyzed the resistance profile of *E. coli* which is the bacterium frequently associated with urinary tract infections. *E. coli* strains were isolated by CBEU test from urine retrieved from episodes of urinary tract infections.

2. Materials and methods

2.1. Patients and specimens

In total, our study included episodes of community urinary tract infections collected from 150 patients for whom *E. coli* strains were isolated from theirs urines by CBEU. All urines specimens were received and different analyses were carried out at Mirouh medical laboratory which is localized in Ferdjioua, Mila, in the northeastern of Algeria.

2.2. Cytobacteriological testing

The microbiological diagnosis was based on the cytobacriological urinary examination of the urine. The urine is collected from the first urination in the morning in order to obtain urine that has stayed for a long time (at least 3 to 4 hours) in the bladder. After evacuation of the first 20ml of the urine, the following 20ml are collected in a sterile tube (Gonthier, 2000). The urine is seeded on an agar medium. For these patients, CHROMagar^{tm} Orientation culture medium was used. The cultures were then incubated at 37°C for 18 to 24 hours. Phonotypical identification was carried out by using VITEK 2 system.

2.3. Antibiotic resistance testing

The antibiotic susceptibility testing is a test that allows determination of the sensitivity of a microbial strain to a given antibiotic or to a panel of antibiotics. Depending on the results of the testing, the doctor can direct his choice of treatment in order to better adapt it to the pathology (Dupeyron, 2014). Herein, antibiotic susceptibility was performed using the fully VITEK 2 compact 15 automated susceptibility testing system as recommended by the supplier.

2.4. Biochemical, Serological and hematological testing

Biochemical parameters were performed using Abbott Architect C 4000 automaton. Serological and hematological parameters were performed using VIDAS biomérieux (ELFA) automaton, Abbott Architect i1000 sr automaton or Architect C4000 automaton as needed. Cell blood count was performed by flow cytometry on a sysmex XN-350 automaton. All parameters were performed and analyzed according to the recommendations of the manufacturers of the apparatus.

2.5. Statistical analysis

Statistical analysis was performed using Graph-Pad program. Student t-test, chi2 test or Fischer exact test were used as needed. *P* values less than or equal to 0.05 were considered significant.

3. Results and discussion

3.1. Patients sex and clinical data outcomes

Our study included 150 episodes of community-acquired urinary tract infections from which *E. coli* was isolated by culture. Of these episodes, 102 were from women (69%) and 45 were from men (31%) (Figure 1). For all of our patients the average age was 43.07 ± 25.76 years, with domination of young women whose age is below 38 years old (38%).

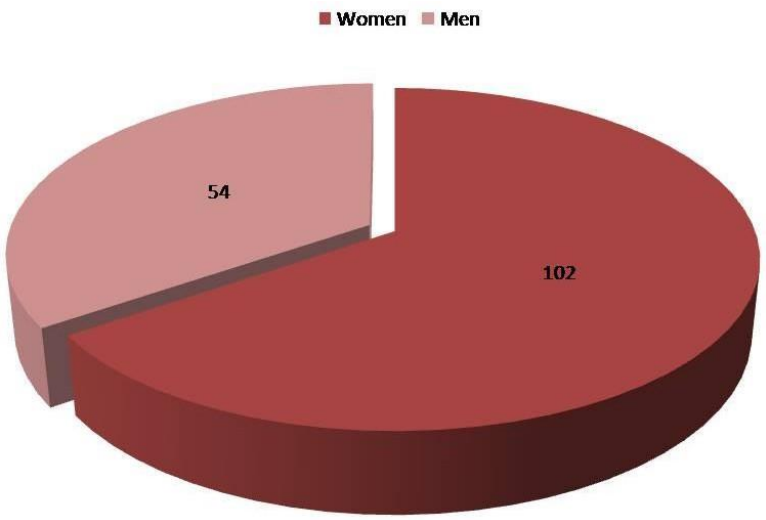

Figure 1. frequency of urinary tract infections depending on sex.

These results suggested that women are more susceptible to UTIs than men, as previously reported (Jeandel & Blain, 2004), which may be due to several risk factors such as the difference of the anatomy of the urinary tract apparatus between men and women. In fact, the urethra is shorter in women and it is located near the vagina and anus (Jeandel & Blain, 2004). Men are relatively protected due to their anatomical structure of the urinary system where the distance from the anus to the urethra can further reduce fecal contamination. Concerning clinical data, our results showed that pregnancy was observed among 6 women while 3 patients were diabetics (Table 1).

Table 1. clinical data of patients

Parameters	Frequency
Age (Years)	43,07 ± 25 ,76
Women	102 (69%)
Men	48 (31%)
Pregnancy	6 (5.88%)

Diabetes	3 (2%)
Rubella IgG	5
Rubella IgM	Negative
Toxoplasmosis IgG	3
Toxoplasmosis IgM	Negative
Hepatitis B virus	Negative
Hepatitis B virus	Negative
HIV	Negative

3.2. Comparative analysis of clinical parameters depending on sex

To identify probable variation in clinical parameters related to UIs between men and women, we performed statistical comparison of available clinical parameters between the two groups (Table 2). The obtained results showed a statistically significant difference particularly in age, as well as in titers of creatininemia that were detected in high averages among men compared to women. Also, while the difference was not statistically significant, urinary leucocytes where detected at high rates among males than females. In contrast, titers of calcemia were in highly detected among women compared to men. Our results showed that for the majority of affected patients whose age ranged between 18 and 38 years were females, which inspires a female predisposition to UTIs in this age group. In women, it has been reported that the frequency increases with age, with 2 peaks, one at the start of sexual activity and the other in the postmenopausal period. In contrast, our results showed that the predisposition to UTIs after 65 years is almost masculine (Table 2). This result agrees with the results of Dia et al., published in 2015, which showed that a high frequency of UTIs was found among people over60 years who were particularly men (Dia et *al.*, 2015). Among men, frequency of UTIs increases after 50 years and it is particularly in relation to prostate pathology.

Table 2: clinical data of patients depending on sex

Parameters	**Women**	**Men**	**P Value**
Patients number	102	48	/
Age (years)	34.13 ±21.40	61.02±25.09	**0.0001**
Blood urea (g/L)	1.24±2.11	0.23±0.08	0.7305
Creatininemia (mg/L)	0.23±0.08	8.84±2.11	**0 .0270**
Calcemia (mg/L)	88±4.24	0	**0.0306**
White blood cells (013/µL)	8.86±2.7	8.83±2.62	0.9490
Platelets (103/µL)	249.64±106.03	259.2±106.03	0.6072

C reactive protein (mg/L)	98.62±91.93	81.96±81.43	0.9032
TSH 3 (µUI/ml)	1.57±1.05	0	/
Urinary leukocytes (/mm3)	1327,20±2483,60	4076.83±15996,50	0.0914
Rubella IgG	5	Negative	/
Rubella IgM	Negative	Negative	/
Toxoplasmosis IgG	3	Negative	/
Toxoplasmosis IgM	Negative	Negative	/
Hepatitis B virus	Negative	Negative	/
Hepatitis B virus	Negative	Negative	/
HIV	Negative	Negative	/

3.3. Resistance profile of *E. coli* to different antibiotics

The study of susceptibility of the 150 stains of *E. coli* against different types of antibiotics showed high levels of resistance to ampicillin (84%) because it is the antibiotic mostly used in the medical institutions. Resistance against Trimethoprim coupled to sulfamethoxazole and amoxicillin coupled to clavulanic acid, but at moderate levels, was also showed (42.67% against Trimethoprim coupled to sulfamethoxazole, and 34.67% amoxicillinc oupled to clavulanic acid) (Figure 2). The high resistance of *E.coli* to ampicillin is concordant with what has been previously reported in other regions in Algeria. Indeed, a study conducted by Benyagoub et *al.* in2013 at Bechar, Algeria, reported that the rate of resistance of *E. coli* against amoxicillin and clavulinic acid, cotrimoxazole and ampicillin was significant (Benyagoub et *al.* in 2013). Moreover, according to a study by Bouzenoune et *al.* in 2007, the resistance to antibiotics of bacteria isolated from UTI at the hospital of Ain M'lila, Algeria, showed that ampicillin has become the least active antibiotic on *E. coli* (Bouzenoune et *al.* 2009). This result has also been confirmed by other studies conducted round the world (Messai et *al.*, 2006; Larabi et *al.*, 2003). Nevertheless, except these antibiotics previously mentioned, our study showed that strains of *E. coli* studied are marked by a high sensitivity to many different antibiotics (Fig. 2). In fact, all of the *E.coli* trains that where tested showed total sensitivity to amikane (100%) and Imipenem (100%). High levels of sensitivity were also observed against Fosfomycin (98.67%), Gentamycin (92%), Ciprofloxacin (86.67%), Cefotaxime (82%), Ceftazidime (82%) and Cefazolin (71.33%) which may be due to the rare use of these antibiotics as previously demonstrated by researchers Kalantar E et *al.* in 2008 (Kalantar et *al.* in 2008). In fact, Imipenem and aminoglycosides remain highly active on *enterobacteriaceae* as well as in others countries such as Tunisia and Turkey, and their use must therefore be favored (Larabi et al., 2003. Yüksel et al., 2006). In contrast, according to the study by Thabet et al. in 2010 carried outat the Aziza Othmana Hospital in Tunis showed high resistance of *E. coli* to antibiotics (Thabetet *al.*, 2010). This high resistance could be explained by the fact that the majority of these patients were hospitalized, and that the large use of antibiotics in the hospital environment, which means that a reasoned antibiotic therapy in hospitals remains highly recommended in order to ovoid development of multi-resistant strains.

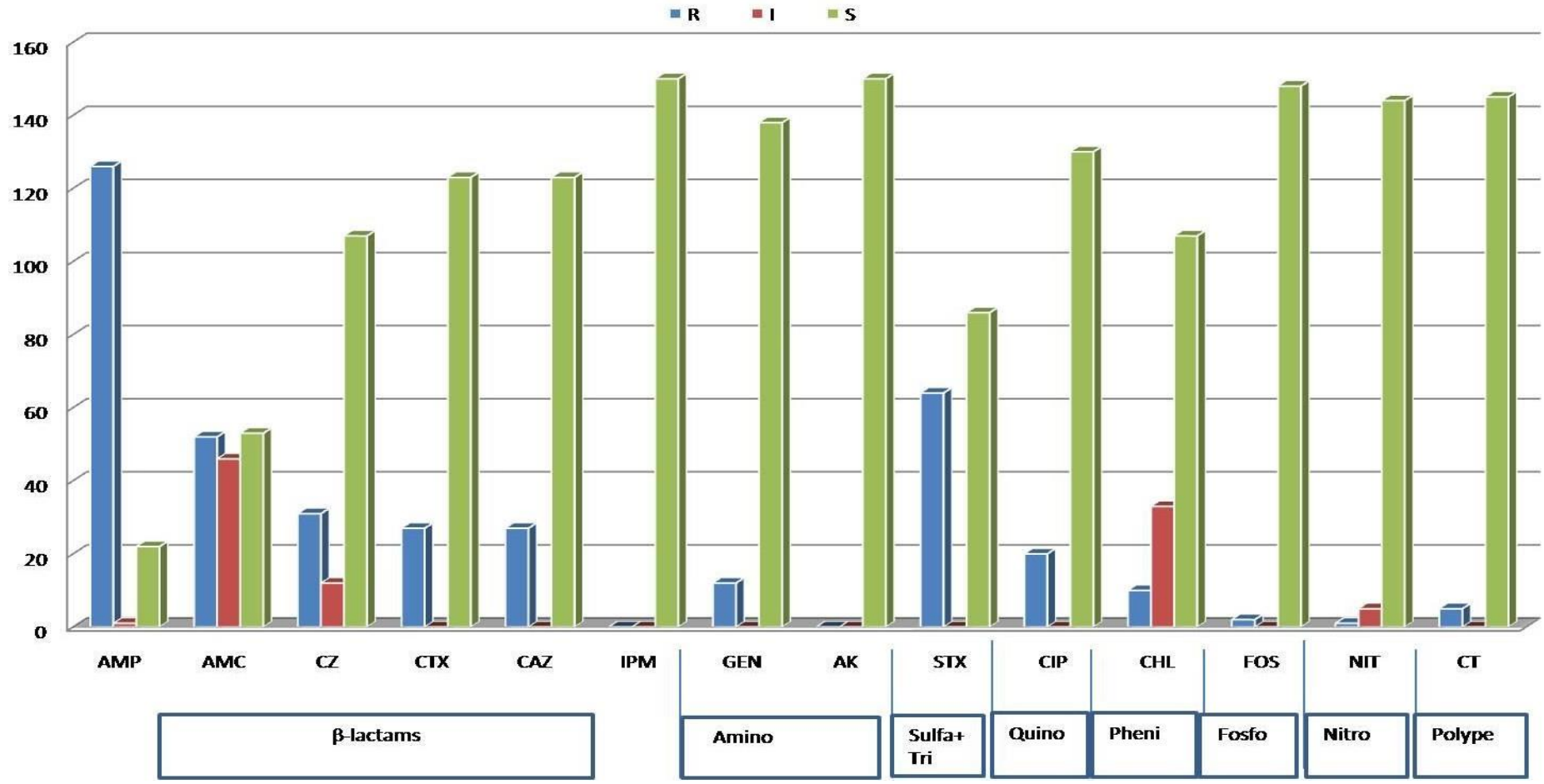

Figure 2: resistance profile of 150 strains of *E. coli* to different antibiotics. AMP= Ampicillin. AMC= Amoxiclav. CZ= Cefazolin. CTX= Cefotaxime. CAZ= Ceftazidime. IPM= Imipenem. GEN= Gentamycin. AK= Amikacin. SXT=Trimethoprim+Sulfamethoxazole. CIP= Ciprofloxacin. CHL= Chloramphenicol. FOS= Fosfomycin. NIT= Nitrofurantoide. CT= Colistin. R, Resistant; I, Intermediate, S, sensitive.

4. Conclusion

E. coli is the most widely recognized extra-intestinal Gram-negative pathogen isolated from urine culture in patients with complicated or uncomplicated UTIs. The bacterium is implicated in 70 to 80% of community-acquired infections as well as in 40-60% of healthcare-associated infections. Furthermore, such a situation has not changed much in recent years and *E. coli* is continuing to rank first among the isolated uropathogens. Moreover, knowledges about the antibiotic resistance profile of this bacterium is a valuable tool for the choice of first-line antibiotic therapy, which needs to be adapted to eradicate the pathogen. Bacteriological diagnosis of urinary tract infections that must be supplemented by aantibiotic sensibility testing for resistance analysis is the most effective mean allowing better therapeutic care and management of patients, and the inadequate use of antibiotics is responsible for a large part of developing resistance against these antibiotics. Additionally, resistance to antibiotics is becoming higher in recent years, reaching worrying levels for some of them. Our study shows that *E. coli* associated to UTIs developed resistance particularly oriented against ampicillin and amoxicillin due to their wide use. However, imipenem and aminoglycosides, especially amikacin, remain, on the other hand, the most active molecules. Nevertheless, it is recommended to avoid excessive use of these molecules, in order to reduce the risk of development resistance against them.

Conflict of interest: none

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National food safety depends on the modernization and mechanization of agriculture

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Abstract:
Since independence, Algeria's economy has relied on the hydrocarbons sector, which represents 98% of the population. This has caused all economic indicators and national policies, whether development or related to the state budget, to be anchored directly to the figures for the export of gas and oil. Algeria has been unable, for more than half a century, to establish a diversified and affluent economy, in light of the dominance of the container economy, which is not immune from external crises and the requirements of the international market. Algeria is distinguished from the countries of the Mediterranean basin by its vast area, the diversity of its climate and environmental systems, and its unique geographical structure. This has made its space characterized by four climatic systems, from the Mediterranean in the north to the coastal climate in the far south. Climate diversity is logically related to the diversity of resources, ecosystems and agricultural products throughout the year. These natural advantages also allowed some products to be impersonated twice a year.
All scientific experiments and economic approaches have reached the inevitable conclusion that we must modernize the agricultural sector through modernizing its structures, modernizing its production factors, and, in particular, introducing modern technology into all stages of the agricultural production process in its various divisions and specializations, and in various climatic regions.

Keywords: Food security. Economic indicators. agrarian economy. Livestock. Agricultural Growth. Mechanization.

1. Introduction

Digital economic indicators show that Algeria was unable, for more than half a century, to establish a diversified and wealth-generating economy under the dominance of the container economy, which is not immune from external crises and the requirements of the international market. and fierce competition for the rich countries' products.

Algeria is distinguished from the countries of the Mediterranean basin by its vast area, the diversity of its climate and environmental systems, and its unique geographical structure. This has made its space characterized by four climatic systems, from the Mediterranean in the north to the coastal climate in the far south. Climate diversity is logically related to the diversity of resources, ecosystems and agricultural products throughout the year. These natural advantages also allowed some products to be impersonated twice a year.

2. Algeria is an open agricultural space with unique resources

The estimated total agricultural areas are 42.5 million hectares, which represent only 18%, and this is a very low percentage compared to the total area, as the south and the plains are

almost unexploited or have taken on another non-agricultural character, although the prevailing theory of the south that is not suitable for agriculture is incorrect, as the south has become a farmer and contributes a large part to national production in various peoples. "The cultivated area is estimated at 8.5 million hectares, about 28 percent of the total agricultural area."

Farming in Algeria continued to rely primarily on rainfall before it developed through the introduction of protected agricultural technologies and the construction of irrigated areas, which constituted a major revolution in national agricultural production and contributed to a large number of quarterly products throughout the year on the one hand, and on the other, allowed for a production surplus which reached some exports and a drop in market prices for consumers, while causing some financial damage to the product in the absence of a rational policy to balance the complex economic process to protect all actors, including consumers, merchants and producers.

3. Mechanization and modern technology are essential to meet current economic challenges

The agricultural sector employs about 22% of the national labor force. There has been a great reluctance of labor during the last ten years for various reasons, the most important of which is the mass rural displacement witnessed in the Algerian countryside during the black decade, which made the rural space affected by a radical change in its basic components, which are driven by the individual or man. There is also a lack of appreciation for the hard manual farming work, which remains below the threshold in comparison to manual work and other professions. This is in addition to the problem of insurance and full-time work, which constituted a major obstacle for the agricultural sector as a whole, in light of the great deficit of modern mechanization and the introduction of technology in all agricultural operations and all the people on which the national agricultural sector is based.

Despite the resources mobilized, whether in the form of financial support in the form of various agricultural loans or human resources, through a rational policy of training, research and guidance, the Algerian farmer is still far from the objective of modernization and mechanization, which is considered a fundamental factor for the advancement of the productive agricultural sector and a true guarantor of national food security.

Modernization of the sector in Algeria has become more than necessary, not only in order to raise the levels of production and productivity per hectare, but also to face the challenges of the new millennium, to reduce the costs of production and to confront the competition of the neighboring countries, especially the Mediterranean countries, which have begun to produce agricultural products and export them, and sell them at a price lower than the national product. This is necessarily due to the reduction in the cost of production in these countries, due to the modernization that has been followed in all agricultural and production processes and in all people.

It is noteworthy that the current status of the sector is modest compared to neighboring countries and the Mediterranean countries, which enjoy the same climate composition and the same diversity of resources, especially the Maghrebi countries that have taken giant steps in the field of mechanization, the introduction of accurate and intelligent technology, and the modernization of agriculture in general.

Among the mechanisms of mechanizing and modernizing agriculture, we can give examples in all agricultural operations, such as plowing, planting and harvesting of crops and the

maintenance of various plants during their biological cycle, as well as in the use of pesticides and fertilizers, which remain in a traditional form that does not reflect the aspirations of the sector and does not guarantee our farmers guaranteed continuity and high productivity in light of the fierce competition experienced by the world of agriculture, which is directly linked to microtechnology.

Among the examples that could be the scene of modernity are the Algerian agricultural machines, which have not undergone significant changes since the seventies. Despite their good quality and strength, they remain weak in terms of equipment and modernization, relying on mechanical strength rather than smart technological power, which has become an unavoidable necessity. This is also the case with the auxiliary machines, which are limited to mechanical machines that do not meet the requirements of modern agriculture. The agricultural industry has been restricted to installing tractors and their appendices, or traditional harvesting machines. The rest is imported in hard currency, despite the experience and competence of the Algerian factory in the field. Agricultural machinery has become an area through which hard currency is depleted due to heavy imports. The agricultural equipment bill is estimated at more than $500 million, and the food bill, according to Ministry of Finance statistics, is more than $1 billion a year.

Even the workshops that were approved were restricted to installation and marketing, as was the case with cars, which constituted a real obstacle to the development of agricultural mechanics in Algeria.

In addition to importing seeds, fertilizers, and pesticides of all kinds, the import bill has burdened the national economy in light of the inability of the traditional local mechanical industry to keep up with the smart technological revolution and thus the inability to meet the requirements of Algerian agriculture, which has undergone a great transformation during the last two decades.

4. The need to rely on mechanization and artificial intelligence to keep up with the challenges of the stage

The modernization of our agricultural sector is not limited to the introduction of agricultural machinery to cover agricultural operations. It is related to plant and animal production, to techniques for the management of water resources, and to the land receptacle, the cleansing of which remains an urgent desire of producers and investors alike. It is also related to the introduction of artificial intelligence in the management of available resources, such as irrigated land, forest cover, and agricultural and environmental production systems, the preservation of which is closely linked to agriculture.

The challenge of the new millennium in agriculture is based primarily on the management of water resources, which have become scarce, both surface and underground, especially non-renewable. This calls for the adoption of high technologies in the field of artificial intelligence and the introduction of models appropriate to each climate system and to the Division of Practice and the nature of the soil... The requirements and specificities of each field transplant.

The introduction of large agricultural machinery (half-manufactured) has become necessary, especially in medium and large investors, in order to effectively control production costs and quickly prepare the transformation steps that must be synchronized with agricultural systems in order to optimize the agricultural activities and their products. Reducing production costs through the introduction of modern and smart technology will allow our farmers to be

competitive in the economic transformations of the economic and social sphere. In addition, the introduction of technology allows for the rational and efficient use of available natural resources, such as water and soil, and the maintenance of necessary fertility levels, thereby contributing to a reduction in the excessive return of organic fertilizers and chemical pesticides.

5. Passage from a productive to an export-priced farm as a source of hard currency and the creation of wealth by the development of manufacturing and food industries has become an imposed imperative

One of the most effective and effective policies that allow for keeping pace with all the agricultural people, is the strategy of developing the manufacturing and food industries on the national level, which allows for the direct evaluation of the national product, the creation of wealth and jobs, and raising the consumption levels of the Algerian individual, and consequently the recovery of the national economy. In light of the weakness or absence of manufacturing industries, the national product will continue to face major challenges and risks from the economic and marketing aspects. This will have a negative impact on farmers and the people, since not all products can be absorbed by consumers. This will lead to a major recession, especially with regard to the limited private sector and its storage capabilities, and the lack of investment in this field, especially in the inland regions and in the south.

It is currently observed that most of our agricultural products are consumed directly in their raw form and at low prices, in the absence of manufacturing industries, which, if available, would play a valuable role for the product by creating wealth and a very effective marketing and economic budget to protect farmers and encourage them to produce strongly. One kilogram of potatoes, for example, is sold for 30 dinars in its raw form. It can also be sold for 3,000 dinars, which is converted into other by-products and derivatives. Through this chain, it will create jobs and help to absorb a large part of the surplus in the market.

6. Modern mechanization and technology are essential in desert production systems to reduce high production costs

In light of the unprecedented prosperity and development of desert agriculture and the remarkable success of some people, such as vegetables and some grains, legumes and fruit trees, agriculture in desert areas depends mainly on groundwater and non-renewable artesian wells, in addition to consuming electric power and fertilizers due to soil poverty and infertility.

Artificial intelligence technologies can take their place in large-scale investments in irrigation, in a water economy in planted areas, and in large-scale exploitation of solar energy for electricity production. So we can imagine farmers investing in energy-self-financing deserts, and using smart agricultural machines that help turn products on the spot to solve logistics and to the distance from consumption centers like big cities and export ports.

This integrated strategy can be contributed by all sectors to make agriculture in the South successful and more competitive nationally and internationally.

7. Conclusion

Finally, the diversification of the national economy, which is currently dependent on fuel, can only be achieved through the concerted efforts of all sectors, in accordance with integrated and coordinated frameworks, especially in the field of scientific research and innovation. The recent serious steps taken by the Ministry of Agriculture to establish new research units are

evidence of the new trend that the next two decades will witness, as well as the strengthening of coordination with the higher education sector, which must play a pivotal role in the field of training, scientific research and guidance. This represents a new and renewed strategy to exploit the results of research and apply them in the field to benefit the agricultural sector and the national economy as a whole.

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Antioxidant activities of *Hypochaeris laevigata* var. *hipponensis*: Endemic species from Algeria

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Abstract

Hypochaeris laevigata var. *hipponensis* (Asteraceae) is an endemic plant from Algeria. In the current study, we analyzed for the first time the antioxidant activities by five methods (*β*-Carotene bleaching test, DPPH test, ABTS radical cation reduction test, CUPRAC test, Ferrous ions chelating test) of three fractions of aerial part of plant: dichloromethane (DCM), ethyl acetate (EA) and n-butanol (BuOH). We also determined the total phenolic and flavonoid contents. The fraction EA showed the highest values, followed by BuOH and DCM fractions. Furthermore, the antioxidant action was dictated by five methods and the tested plant fractions demonstrated a noteworthy antioxidant action.

Key words: *Hypochaeris laevigata* var. *hipponensis*, Asteraceae, phenolic compounds, antioxidants activities.

1. Introduction

A large number of medicinal and aromatic plants grow there spontaneously in the Edough Peninsula such as plants of family Asteraceae which are rich in phenolic compounds, volatile oils and other bioactive compounds. It is fundamental to extend the knowledge of the chemical composition of some plants of this family **(Hamel., 2013).** According to **Stebbins (1971),** *Hypochaeris* is a small genus of Asteraceae family, that contains about 50 species. On the other, the genus of *Hypochoaeris* contains 100 species, the majority of which are native to South America. The species of *Hypochaeris laevigata* var. *hipponensis* is a perennial plant with a bitter root, endemic to Algeria, very common everywhere and on the coast, usually develops on wet rocks **(Quezel and Santa, 1962).**

Until today, any phytochemical study is mentioned for the *Hypochaeris laevigata* var. *hipponensis*, except that some studies on the species *H. radicata* by **Jamuna *et al.* (2014)** on the presence of alkaloids, flavonoids, glycosides, cardiac glycosides, phenols, resins, saponins, steroids, tannins, terpenoids and triterpenoids. *Hypochaeris radicata* is medically important and has anti-inflammatory, anticancer, antioxidant **(Jamuna *et al.*, 2012),** antibacterial **(Jamuna *et al.*, 2013a),** antifungal **(Jamuna *et al.*, 2013b)** properties and antidiuretics. It is used for the treatment of jaundice, rheumatism, dyspepsia, constipation, hypoglycemia and kidney problems in the traditional medicinal practice of Tamil Nadu, India **(Pullaiah, 2006).** However, no scientific validation has been made for this species for medicinal purposes.

To the best of our knowledge, the aim of the present work was to study the chemical composition of *Hypochaeris laevigata* var. *hipponensis,* which is an endemic species of Algeria, has not been reported before and to evaluate its antioxidant activities.

Figure.1. *Hypochaeris laevigata* var. *hipponensis*

2. Materials and Methods

2.1. Plant material and extraction method

Samples of the plant (*Hypochaeris laevigata* var. *hipponensis*) are collected in full bloom in Sérraïdi (Annaba), in northeastern Algeria during the month of May 2015. The plant was identified by Dr. Tarek Hamel, Lecturer at the Department of Plant Biology and Environment, Badji Mokhtar University (Annaba, Algeria). A reference specimen was deposited in the herbarium of the laboratory under the reference code: ChifaDZUMCAPBC000038. The samples were dried in the shade at room temperature in a ventilated place, and cut into small pieces.

The aerial parts powder (800 g) were macerated in a mixture of methanol/water (70/30, v/v) at a ratio of 1:10 (w/v) for 24 h with a constant stirring speed of 200 rpm, at room temperature. The suspension was then filtered on whatman paper. The extraction is repeated three times till exhaustion, then the solvent was evaporated at 40 °C using Rota Vapor (Büchi R-200, Germany) to afford 29.86 g extract. The crude extract was dissolved in 90% aqueous methanol for fractionation with different solvents such as dichloromethane (DCM), ethyl acetate (EA) and n-butanol (BuOH). Briefly, first fractionation was carried out with 100 ml DCM three times (3x). DCM fraction was collected and evaporated under reduced pressure to give a semisolid paste. Then the residual aqueous phase of dichloromethane was further fractionated with EA and BuOH solvents. The resulting fractions were evaporated to dryness. The yields of DCM, EA and BuOH fractions were found to be 8.73, 6.30 and 13.04 g, respectively. Dried fractions were dissolved in methanol and kept at a temperature of 4 °C for further analysis

2.2. Quantification of total phenols

The total phenolic content was evaluated according to the method described by **Li *et al*. (2007).** a 1.5 ml of the Folin-Ciocalteu reagent previously diluted ten times with distilled water was added to300 µl of the extract. After 4 minutes a 1.2 ml of 7.5% sodium carbonate (Na_2CO_3) was poured onto the solution. The samples were placed in the dark. After 2 hours, the results were read on a spectrophotometer at 750 nm, the concentration of total phenols is deduced from a calibration curve established with gallic acid and the results were expressed in mg of gallic acid equivalent per g dried extract (mg GAE/ g extract).

2.3. Quantification of flavonoids

The content of total flavonoids was determined according to the method described by **Djeridane *et al*., (2006).** 500 µl of the extract was mixed with 500 µl of 2% aluminum chloride. The absorbance of the mixture is measured at 430 nm, after 10 minutes of incubation. The flavonoid concentrations were expressed in mg equivalent quercetin per g dried extract (mg QE/g extract) with reference to a calibration curve.

2.4. Antioxidant activities

2.4.1. Evaluation of Antioxidant Activity by *β*-Carotene bleaching test

The antioxidant activity of the extracts was evaluated using the *β*-carotene-linoleic acid system described by **Miller (1971)** with a slight modification. Dissolve 0.5 mg of *β*-carotene in 1 ml of chloroform. The solution obtained was introduced into a flask containing a mixture of 25 µl of linoleic acid and 200 mg of Tween 40. After evaporation of the chloroform under vacuum, 100 ml of distilled water saturated with oxygen were added by vigorous stirring. From this new solution 4 ml was transferred to different test tubes containing different concentrations of the sample in ethanol. As soon as the emulsion was added to each tube, the absorbance of the zero time was measured at 470 nm, using a spectrophotometer. The emulsion system was incubated for 2 hours at 50 °C. A negative control, free of *β*-carotene, was prepared for background subtraction. The bleaching rate (R) of *β*-carotene was calculated according to the following equation: $R = \ln_{a/b} / t$.

Where ln is the natural log, a is the absorbance at zero time, b is the absorbance at time t (120 min). Antioxidant activity (AA) was calculated in terms of percent inhibition versus control, using the following equation: ***% inhibition = [R control - R sample / R control] x 100.***

Quercetin, BHT and *α*-tocopherol have been used as antioxidant standards for the comparison.

2.4.2. DPPH free radical scavenging test

The anti-radical activity against DPPH of the studied extracts was measured by the DPPH test described by **Blois (1958)** with a slight modification. Briefly a 0.1 mM solution of DPPH in methanol was prepared and 4 ml of this prepared solution were added to 1 ml of sample solutions in methanol at different concentrations. After 30 minutes of incubation in the dark at room temperature, the absorbance is measured at 517 nm. Lower absorbance of the reaction mixture indicated greater free radical scavenging activity. The antioxidant activity was expressed as a percentage of DPPH radical inhibition, and calculated from the following equation: ***% inhibition = [A control - A sample / A control] × 100.***

The IC_{50} value (the inhibitory concentration of the extract necessary to decrease the initial concentration of the DPPH radical at 50%) was calculated from the percentage plot of the trapping effect of the different

concentrations of each extract (Scherer & Godoy, 2009). We deduced the anti-radical activity of the extracts by calculating the inverse of the IC_{50} values found (Maisuthisakul *et al*., 2007), by the following formula: $ARA = 1/IC_{50}$. Quercetin, BHT and α-tocopherol have been used as antioxidant standards for the comparison of activity.

2.4.3. ABTS radical cation reduction test

The anti-radical activity against the radical $ABTS^{\cdot+}$ of the studied extracts was determined according to the method of **Re *et al*. (1999)** with slight modification. In this test, the radical cation $ABTS^{+}$ is generated by mixing 7 mM ABTS in H_2O and 2.45 mM Potassium Persulfate. The mixture is then stored in the dark at room temperature for 12 hours. The oxidation of $ABTS^{\cdot+}$ started immediately, but the absorbance was not maximal and stable until more than 6 hours had elapsed. The radical cation was stable in this form for more than 2 days with storage in the dark at room temperature. Before use, the $ABTS^{+}$ solution was diluted with ethanol to obtain an absorbance of 0.700 ± 0.02 at 734 nm. Then 2 ml of $ABTS^{+}$ solution was added to 1 ml of sample solution in ethanol at different concentrations (5-50 mg/ml). After 30 min, the percent inhibition at 734 nm was calculated for each concentration based on a blank absorbance (methanol). The $ABTS^{+}$ scanning capability was calculated using the following equation:

% inhibition = [Abs control - Abs sample / Abs control] × 100

Where the Abs controls are ABTS solution absorbance plus methanol, and the Abs sample is ABTS absorbance plus extract or standard. The IC_{50} value is calculated for each sample and compared with quercetin, BHT and α-tocopherol, which were used as antioxidant standards for activity comparison.

2.4.4. Cupric reducing antioxidant capacity (CUPRAC) Test

The cupric reductive antioxidant capacity was determined according to the method of **Apak *et al*. (2004)**, with a slight modification. In each well, in a 96-well plate, 50 µl of 10 mM Cu (II) solution, 50 µl of 7.5 mM neocuprone and 60 µl of NH_4Ac buffer (1 M, pH 7.0) were added. 40 µl extracts at different concentrations were added to the initial mixture to obtain the final volume of 200 µl. After 1 h, the absorbance at 450 nm was recorded against a reagent blank using a 96-well microplate reader. The results were given as $A_{0.50}$ (µg/ml) which corresponds to the concentration providing 0.500 absorbance. The concentration of the sample providing 0.50 absorbance ($A_{0.50}$) was calculated from the graph of the absorbance of cupric reductive antioxidant capacity. BHT and α-tocopherol were used as antioxidant standards for comparison of activity.

2.4.5. Ferrous ions chelating test

The chelating activity of the Fe^{2+} extracts was measured using Ferrin **(Decker and Welch, 1990)** with slight modifications. The extract solution (80 µl dissolved in ethanol at different concentrations) was added to 40 µl of 0.2 mM $FeCl_2$. The reaction was initiated by the addition of 80 µl of 0.5% ferene. The mixture was stirred vigorously and left at room temperature for 10 minutes. After the mixture reached equilibrium, the absorbance was measured at 593 nm. The chelating activity was calculated using the following equation: ***% of metal chelation activity = [A control - A sample / A control] × 100***

Where A control is the absorbance of the sample-free control and A sample is the absorbance of the sample in the presence of the chelator. The concentration of extract providing 50% of metal chelation activity (IC_{50}) was calculated from the graph of the percentage of Fe^{2+} chelation effects relative to the

concentration of extract. EDTA and quercetin were used as antioxidant standards for comparison of activity.

2.5. Statistical analysis

All data of antioxidant activities tests were the average of three analyses. The data were recorded as mean ± standard deviation. Significant differences between means were determined by student's-t test and p values < 0.05 were considered as significant results.

3. Results and Discussion

3.1. Total phenolic and flavonoid contents

The results of the total phenolic contents (Table 2) of the three extracts of *H. laevigata* var. *hipponensis* showed that the ethyl acetate (EA) and n-butanol (BuOH) extracts have the highest value of 202.86 ± 14.64 and 200 ± 10.93 mg GAE/g extract, respectively compared to dichloromethane (DCM) extract with 184.07 ± 0.17 mg GAE/g extract. Also, the total flavonoid content (Table 2) of the BuOH extract (46.76 ± 0.36 EQ/g of extract) was greater than that of EA and DCM extracts (17.92 ± 0.12 EQ /g extract and 16.28 ± 0.16 EQ /g extract, respectively).

Table 1. Total phenolic and flavonoid contents of the extracts of *H. laevigata* var. *hipponensis*

Extracts	Total Phenols[a]	Flavonoids[b]
DCM	184.07 ± 0.17	16.28 ± 0.16
EA	202.86 ± 14.64	17.92 ± 0.12
BuOH	200 ± 10.93	46.76 ± 0.36

[a] : mg gallic acid equivalent/g extract ; [b] : mg quercitin equivalent/g extract

3.2. Antioxidant activities

In the present work, the antioxidant activity was determined by five methods (Table 3). For β-carotene test, a good activity was found in the three extracts (IC_{50} value of 5.02 ± 0.95, 5.66 ± 2.03 and 7.60 ± 4.37 for dichloromethane, *n*-butanol and ethyl acetate, respectively), it were better than that of catechin (8.79 ± 0.89 µg/ml) and a higher of α-tocopherol, BHT and quercetin (2.10 ± 0.08, 1.34 ± 0.04 and 1.81 ± 0.11 µg/ml).

In DPPH test, maximum scavenging activity was found in *n*-butanol extract (IC_{50} value : 8.12 ± 1.47 µg/ml) and ethyl acetate extract (IC_{50} value : 8.70 ± 1.87 µg/ml) in comparaison to catechin, quercetin and α-tocopherol (4.32 ± 0.15, 2.07 ± 0.10 and 7.31 ± 0.17 µg/ml). While, dichloromethane extract (47.24 ± 0.11 µg/ml) showed a bit important activity with previous standards. Studies reported that anti-radical activity is correlated with the level of polyphenols and flavonoids in medicinal plant extracts **(Mariod *et al.*, 2009).**

For the ABTS+ method, the ethyl acetate extract (EA) exhibited the highest activity with an IC_{50} value of 4.32 ± 0.09 µg/ml in comparaison to α-tocopherol and BHT (4.31 ± 0.10 and 4.10 ± 0.06 µg/ml). While, dichloromethane extract (DCM) and *n*-butanol extract (BuOH) showed a bit important activity (IC_{50} value of 13.10 ± 0.97 and 15.02 ± 0.73 µg/ml, respectively). The results proved that the extracts have the ability to trap the various free radicals in the different systems, indicating that they can be useful therapeutic agents for the treatment of radical-related pathological lesions **(Wang *et al.*, 1998).**

The results of CUPRAC test, shows that the EA and BuOH extract exhibited the highest activity ($A_{0.50}$ value : 1.48 ± 0.33 and 3.00 ± 0.98 µg/ml), and it were better than the BHT and α-tocopherol (3.80 ± 0.00 and 10.20 ± 0.01 µg/ml). **Prior *et al*., (2005)** classify the CUPRAC antioxidant method as one of the electron transfer methods, and summarize the superiority of the CUPRAC method over other antioxidant tests. **Gorinstein *et al*. (2006)**, also note that the highest capacities of polyphenolic compounds are measured with CUPRAC. For the ferrous ions chelation test, all extract were not active.

Table 3: Antoxidant activities of the three extracts of *H. laevigata* var. *hipponensis*

Extract	β-carotene IC50 (µg/ml)	DPPH IC50 (µg/ml)	ABTS+ IC50 (µg/ml)	CUPRAC A0.50 (µg/ml)	Fe^{+2} Chelation IC_{50} (µg/ml)
Dichloromethane	5.02 ± 0.95	47.24 ± 0.11	13.10 ± 0.97	16.86 ± 3.02	> 800
Ethyl acetate	7.60 ± 4.37	8.70 ± 1.87	4.32 ± 0.09	1.48 ± 0.33	> 800
***n*-Butanol**	5.66 ± 2.03	8.12 ± 1.47	15.02 ± 0.73	3.00 ± 0.98	> 800
(+)-Catechin [a]	8.79 ± 0.89	4.32 ± 0.15	1.16 ± 0.02	NT	NT
Quercetin [a]	1.81 ± 0.11	2.07 ± 0.10	1.18 ± 0.03	NT	NT
α-Tocopherol [a]	2.10 ± 0.08	7.31 ± 0.17	4.31 ± 0.10	10.20 ± 0.01	NT
BHT [a]	1.34 ± 0.04	45.4 ± 0.47	4.10 ± 0.06	3.80 ± 0.00	NT
EDTA [a]	NT	NT	NT	NT	6.50 ± 0.07
Ascorbic acid [a]	NT	NT	NT	NT	NT

[a] Standard compounds, NT : Not Tested.

4. Conclusion

This study was performed to investigate the chemical composition of phenolic compounds in dichloromethane, ethyl acetate and *n*-butanol extracts of *H. laevigata* var. *hipponensis*. The total phenolic contents indicated that EA fraction and BuOH presented the highest value. The flavonoid contents showed that BuOH exhibited the highest value. Furthermore, the antioxidant activity was determined by five methods, such as: *β*-carotene bleaching method, DPPH radical scavenging activity, ABTS cation radical scavenging activity, metal chelating activity and cupric reducing antioxidant capacity CUPRAC. The tested extracts showed significant antioxidant activity with all assays except ferrous iron chelation assay which showed a negative result. In fact, the ethul acetate extract was more potent as antioxidant than the n-butanol and dichloromethane extracts. A continuation of this work in the future is desirable to study the components present in the extracts and to evaluate more biological activities for this promising plant.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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Anticoagulant Activities of *Centaurea macrocephala* L.

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Abstract

Our study is based on the biological activities of the plant *Centaurea macrocephala* L., from the Mechtat Seraghna in the wilaya of Mila (Algeria).This work consists to study the anticoagulant activity of the extracts of the seeds and leaves of *Centaurea macrocephala* L., obtained by maceration in the solvent of ethanol. The extraction yield showed values between31% for the leaves and 25% for the seeds. The anticoagulant activity was evaluated by the testof prothrombin levels (TP) and the blood of a normal man, the results obtained indicate avery important anticoagulant activity of the two extracts on the exogenous pathway of coagulation (TQ of 47,26 s in the leaves and 29,23s for the seeds).

Keywords: *Centaurea macrocephala*, polyphenols, anticoagulant activity.

1. Introduction

Centaurea macrocephala L. is from to the Caucasus, is a perennial plant, with robust, leafy stems, which reaches a height of 1 m and bears yellow flowers, of the *Centaurea* genus, the Asteraceae family, includes about 700 species in the world. In Algeria, this genus is represented by 45 species **(Quezel and Santa, 1963; Mabberley, 1987).**

The genus *Centaurea* has been the subject of many phytochemical studies, these works allowed the isolation of various secondary metabolites, citing; phenolic compounds, flavonoids, lignans, tannins, saponins, alkaloids, terpenes and sesquiterpene lactones **(Sarker et *al.*, 1997)**, the latter generally considered as constituents of the genus *Centaurea* and in particular act as primary antioxidants and stabilized radicals **(Formisano et *al.*,2012)**. Many species of the genus *Centaurea* have been used in traditional medicine. In this context this study was inscribed aiming to evaluate *in vitro* the anticoagulant activity of the polyphenolic extracts of the leaves and fruits of *Centaurea*.

2. Materials and Methods

2.1.Plant material

The plant material used in our study is constituted of the leaves and seeds of *Centaurea macrocephala* L. They were collected from Mechtat Seraghnain the wilaya of Mila (Algeria).

2.2.Methods

We took forty leaves and seeds in a random manner for each organ, and then each material for extract (leaves and seeds) is placed in the oven at 40°C for 5 days to dry. The dehydrated samples were triturated to obtain homogeneous samples.

2.3. Extraction of polyphenols

Having the objective to make an extraction of phenolic compounds, 5g powder obtain from homogeneous samples were added to a mixture of methanol and water (100ml, 70:30(vv)). The mixture was allowed to stand for 5 days at room temperature in the dark. Then, it was filtered using a 0.45µm filter **(Abaza et *al*., 2007)**. After filtration, the filtrate was evaporated using a rotavapor at a temperature of 60°C for a total elimination of methanol.

2.4. Anticoagulant activity

The anticoagulant activity of the polyphenolic extracts of the leaves and seeds of *Centaurea macrocephala* L. was evaluated *in vitro* by the exogenous pathway of the coagulation on anormal plasma using a global test chronometric; the Quick time (QT).The blood is obtained from a young adult as voluntary healthy non treaty, whose QT is normal, by venipuncture in sodium citrate 3.2% tube (9:1 v/v, blood: anticoagulant). The blood is then centrifuged for 5 minutes at 2500 rpm to obtain platelet poor plasma.

2.4.1. Quicktime

The prothrombin time (PT), was developed by Armand Quick in1935 for investigating patients with liver disease **(Quick, 1935)**. PT measures the time to form the initial clot after tissue thromboplastin is added to the recalcified, citrated blood specimen, and is an expression of the extrinsic pathway. The PT is responsive to congenital or acquired deficiencies off actors VII, X, V, and II and fibrinogen **(Wiesner, 2003)**.An elongated time of coagulation compared to that of witness explained that the sample exercises an anticoagulant effect in this pathway of coagulation. The effect of olive polyphenols on the exogenous pathway of coagulation has been evaluated according to the protocol described by Athukorala and his collaborators, with some changes **(Athukorala et*al*.,2007).**

On the one hand, we put 100µl of plasma already obtained in a witness tube which is then incubated for 2 minutes at 37°C. On the other hand, 50 µl of the polyphenolic extracts diluted with distilled water to 50% (1:1 (v/v)) was added to 100µl of plasma in each of the analyzetubes, then incubated at 37°C during an optimal time of 15 minutes. After the incubation, thromboplastine (200µl) pre-incubated at 37°C for 15 minutes was added and clotting time was recorded. The results are expressed by the clotting time in second (s). The same operation was repeated three times in the same conditions for each organ.

2.5.Statistical analysis

Statistical analyses were performed by the SPSS 21 software. The results are expressed using means ± standard deviations (SDs). Parameters were compared between groups using analysis of variance (ANOVA) and the values of $p \leq 0.05$was considered statistically significant.

3. Results and Discussion

The anticoagulant capacity of the polyphenolic extracts of the seeds and leaves of *Centaurea macrocephala* L. against the exogenous pathway of coagulation by the TQ assay was evaluated at the fixed optimal incubation time of 15minutes.We used the prothromb in count (PT) test, which explores the extrinsic pathway of blood clotting where tissue factor (thromboplastin) is the trigger for this pathway **(Tripodi, 2009).**The results obtained for the anticoagulant activity are grouped together in the table1.

Table1. The results obtained for the anticoagulant activity (s)

macrocephala L.	**100%**	**50%**	**25%**	Witness
Leaves	65,55± 2,27	23,30± 2,30	19,18± 0,53	18,29
Seeds	47,52± 2,04	43,04± 0,63	21,03± 2,47	18,29
Signification(AVI)	001	000	274	

The analysis of these results reveals the existence of a large variability between the QT values of the seeds and leaves of *Centaurea macrocephala* L. This is confirmed by the analysis of variance (ANOVA); it emerges a highly significant difference in the QT in the presence of the polyphenolic extracts the seeds and leaves in al concentration ($p<0.001$). The results of polyphenolic extracts of the leaves, we note that there is a greater lengthening of TQ of the order of (47.26s) for the 100% concentration in compared to that of the control(18.29 s) and a less significant elongation of TQ of the order of (5.01s and 0.89s) for the 50%and 25% concentrations respective Moreover, for the polyphenolic extracts of the seeds, it is observed that the highest TQ elongations are recorded for 100% and 50% concentrations with the order of 29.23s and 24.75s and a less significant elongation of TQ of the order of 2.47s for the 25%concentration.

The blood coagulation cascade is a physiological phenomenon that comprises intrinsic, extrinsic, and common pathways. Briefly, the activation of the intrinsic pathway occurs because of trauma and contact between kininogen, prekallikrein, and factor XII with underlining collagen on endothelium **(Hood and Eby, 2008)** In addition, studies by **Lemaoui (2011)** concerning the evaluation of the anticoagulant *in vitro* activity of the essential oils of *Nigella sativa* L. seeds have shown that the seoils richin polyphenols may cause aprolongation at the level of the clotting time **(Abdallah et *al*.,2022)** mentioned that has in the results, *Centaurea hyalolepis* Boiss extracts prolonged a PTT values, which in contrast, demonstrated a pronounced decreasing effect on the a PTT at the studied concentration. The noticed anticoagulation effect of these plant species may be related to inhibition of the contact factors of intrinsic pathway **(HoodandEby, 2008).**

4. Conclusion

The present work is within the framework of *in vitro* evaluation of the anticoagulant activity of polyphenols extracted from leaves and seeds of *Centaurea macrocephala* L. The anticoagulant activity of the polyphenolic extracts was evaluated *in vitro* using the Test QT who says that the polyphenols exert a great anticoagulant activity on the exogenous pathway of the coagulation with a difference very highly significant between the four varieties studied. In effect, the results showed that the two extracts of *C. macrocephala* L. presents a good activity on the exogenous path of coagulation, with an elongation of the important time in the leaves (TQof47.26s) than the seeds (TQof29.23s).

Conflict of Interest

The authors declare that there are no conflicts of interest.

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Ethnobotanic study of medicinal plants in the Guerbes-Sanhadja wetland complex (North East of Algeria)

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Abstract

In order to inventory the medicinal flora and preserve the phytotherapeutic knowledge of the Guerbes-Sanhadja wetland complex, this study was undertaken on the basis of a sample made up of 400 users of medicinal plants, the majority of whom are aged between 40 and 60 years old, married, illiterate and unemployed or farmers. The analysis of the questionnaires allowed the census of 102 species with a clear predominance of *Myrtus communis* L. (158 citations), the results obtained have shown that the most used part of the plant is the leaf (58.25%). In addition, the decoction is the most used preparation method (52.28%). As for the diseases treated, gastrointestinal disorders dominate with the use of 59 species. Finally, the calculation of some ethnobotanical parameters allowed us to observe the wide use of *Pistacia lentiscus* L. (UV = 1.15), the specificity of *Eucalyptus globulus* Labill. to treat respiratory diseases (FL = 100%) and thus the consensus of users with respect to the treatment of gastrointestinal diseases (ICF = 0.91).

Key words: Ethnobotanical, medicinal plants, Wetland, Guerbes-Sanhadja

1. Introduction

The Mediterranean region has an exceptional biological diversity, its richness floristic estimated at 25 000 species of vascular plants, which corresponds to 9.2% of the flora worldwide, in a territory representing only 1.5% of the earth's surface **(Quézel 1997; Médail, 2008)**. This region is the third richest hot pot in the world in plant diversity **(Mittermeier *et al*., 2004).** With more than 3,139 species **(Quézel and Santa, 1962-63)**, the Algerian flora is one of the richest in North Africa **(Miara *et al*., 2018)**. Algeria has 254 wetlands of international importance, located mainly in the east of the country and occupies nearly three million hectares. The Guerbes-Sanhadja wetland complex is one of these Algerian wetlands, it is a site of great importance (classified as a Ramsar site 2001) which constitutes a reservoir of flora biodiversity

(334 species inventoried by Samraoui and **De Belair (1997)** Among this rich flora, several plants are used by the local population for phytotherapeutic purposes.

In Algeria, phytotherapy is an integral part of the local culture; the population has significant indigenous knowledge acquired empirically over generations **(Bouasla and Bouasla 2017)**. According to **Reguieg (2011)**, medicinal and aromatic plants have been used by the Algerian populations to treat several diseases for centuries. Traditional medicines, and more particularly herbal treatments, have been well developed in Algeria, but the use of conventional medicine has led to the abandonment of these ancestral practices which have not been forgotten **(Rebbas *et al*., 2012)**.

Despite the different ethnobotanical studies of medicinal plants published in Algeria **(Kaddem, 1990; Baba Aissa, 1991; Ould El Hadj *et al*., 2003; Hammiche and Maiza, 2015; Rebbas *et al*., 2012; Miara *et al*., 2013; Chermat and Gharzouli, 2015; Ouelbani *et al*., 2016; Bouredja *et al*., 2017; Souilah *et al*., (2018); Bendif *et al*. (2018); Miara *et al*., 2018; Miara *et al*., 2019a and 2019b),** and despite the remarkable floristic richness of the region which is reflected in the various floristic inventories carried out in the region and published **(Samraoui and De Belair, 1997; Belouahem-abed *et al*, 2009; Oumessaad *et al*., 2014)**.

This study represents the first ethnobotanical study initiative carried out in the Guerbes-Sanhadja wetland complex. Such an initiative could however fill this gap and bearing as objectives, the identification of these floristic potentialities, and the knowledge of different phytotherapeutic uses in order to contribute in the preservation of traditional knowledge relating to phytotherapy in the region, which allows by the following the development of these medicinal plants and the establishment of a preservation strategy for this complex, knowing that 60% of medicinal plants are taken from nature (often in an unsustainable way).

2. Materials and method

2.1. Study area

The Guerbès-Senhadja wetland complex (West Numidia), a vast territory that is part of Numidia **(Maire 1926, Quezel and Santa 1962-1963, Marre 1992).**The ecocomplex (36 ° 46'-37 ° 1 'N, 7 ° 8'-7 ° 25' E) is located in the northeast of Algeria and covers the eastern part of the wilaya of Skikda. It covers an area of 42,100 ha and bordered to the north by the Mediterranean Sea, to the east by the Edough forest massif, to the west by the Filfila forest massif and to the south by the forest massif of Boumaïza (Figure 1).

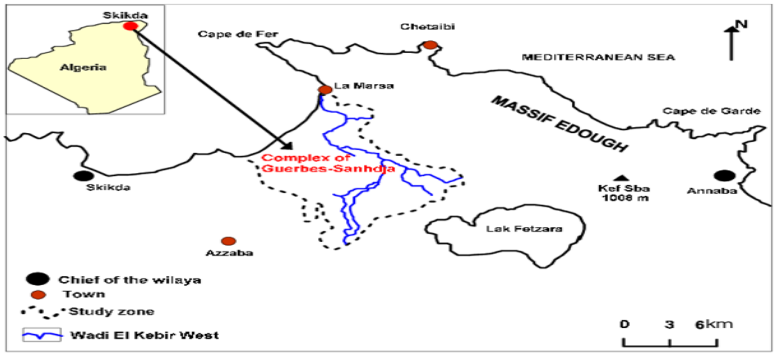

Figure 1. Location of the Guerbes-Sanhadja wetland complex (**Hedjal *et al*., 2014*).***

2.2. Ethnobotanical surveys

The stratified probability sampling technique is the sampling method adopted, this technique allows to have a more representative sample **(Kahouadji, 1986).**And which consists in dividing beforehand the studied population into eight (08) strata or localities, within each stratum (localities) we carried out a simple random sampling composed of 50 users of medicinal plants per stratum, hence a sample total of 400 surveyed (Table 1).

Ethnobotanical surveys were conducted face to face **(Martin, 1995).** The interview was conducted without pressure to allow the informants to answer questions naturally **(Akerreta *et al*., 2007),** according to the ISE code of ethics (with 2008 additions) (ethnobiology.net/code-of-ethics/). The survey form used includes information on the informant (sex, age, academic level, family situation, monthly income, function and source of information), and information on the plant and its phytotherapeutic uses (vernacular name, part used, method of preparation and diseases treated). The language used is the Arabic language, and at the end of the surveys, the plants were photographed on site, harvested, identified and dried to build the herbarium of the plants used. The botanical identification of the specimens was made using the following floras: **Maire (1959), Quézel and Santa (1962-63), Kaddem (1990), Baba Aissa (1991), Halimi, 1997, Samraoui and De belair, (1997), Toubal *et al*., (2014).** We also used the online data bases:www.tela-botanica.org and www.theplantlist.org for checking the scientific names and synonyms of plants (Table 2).

Table 1. Distribution of surveys by locality

Localities	Number of investigation
Ben azzouz	50
El marssa	50
Djendel	50
Guerbes	50
Ain nechma	50
Ezzaouia	50
El marssa-ZP	50
El hamma	50
Total	400

2.3. Measured parameters

- **Use Value (UV):** The relative importance of each plant species known locally for use as an herbal remedy is called as UV. It was calculated according to the following formula **(Barnert and Messmann, 2008)**: $UV = \Sigma U / n$
  U: number of use-reports cited by each informant for a given plant species, n: total number of informants interviewed for a given plant.

- **Fidelity level (FL):** it is used to determine the most frequent plant species used to treat a particular disease category by informants in the study area. The FL is calculated according to the following formula **(Martin, 1995)**: $FL= (Np/N) X 100$
  Np: number of use-reports cited for a given species for a category of diseases particular, N: total number of use-reports cited for a given species.

- **Informant Consensus Factor (ICF):** is used to see if there is agreement on the use plant in disease categories among plant users in the study area. The ICF was calculated according to the following formula **(Bağı, 2000)**: ICF = (Nur- Nt) / (Nur -1)
  Nur: refers to the number of use-reports for a particular disease category, Nt: refers to the number of taxa for a particular disease category by all Informants.

3. Results and discussions

3.1. Census of medicinal plants used by the local population of the complex

Table 2: list of medicinal plants used by the local population of the complex.

N°	Scientific name	Familly	Common name in French	Common name in English	Vernacular name in Arabic	Diseases treated	N	UV	*FL* (%)
01	*Acanthus mollis* L.	Acanthaceae	Acanthi	Bear's breeches	تفيفرة	Gastro-intestinal disorders	01	**1**	33.33
						Other diseases	01		33.33
02	*Adiantum capillus-veneris* L.	Pteridaceae	Capillaire de Montpellier	Southern maidenhair fern	الزياتة	respiratory diseases	01	**1**	33.33
03	*Ajuga iva* (L.) Schreb.	Lamiaceae	Ivette musquée	Ivette Musky	تشنڤدورة	gastro-intestinal disorders	03	**1**	50
						Genital diseases	01		16,67
						dermatological disorders	01		16,67
						Other diseases	01		16,67
04	*Allium cepa* L.	Amaryllidaceae	Oignon	Onion	البصل	Cardiovascular diseases	04	**1**	66,67
						Urinary diseases	01		11,11
						Fever and headache	01		11,11
						dermatological disorders	03		33,33
05	*Allium sativum* L.	Amaryllidaceae	Ail	Garlic	ثوم	Cardiovascular diseases	10	**1**	66,67
						Aesthetic	02		13,33
						Respiratory diseases	03		20
06	*Allium triquetrum* L.	Liliaceae	Ail à trois angles	Three-cornered leek	بيبراس	Other diseases	01	**1**	50
						Gastro-intestinal disorders	01		50
07	*Aloe succotrina All.*	Aloecaceae	Aloès	Fynbos aloe	الصبار	dermatological disorders	01	1	100
08	*Aloysia citriodora* Palau	Verbenaceae	Verveine odorante	Lemon Verbena	تيزانة, لويزة	respiratory diseases	03	1,17	42,86
						gastro-intestinal disorders	04		57,14
09	*Angelica officinalis* L.	Apiaceae	Angélique officinale	Angelic	ودن الحلوف	dermatological disorders	3**5**	1,1**4**	5**3**,**03**
						gastro-intestinal disorders	3**0**		4**5**,4**5**
						Other diseases	01		1,5**1**
10	*Anthyllis vulneraria* L.	Fabaceae	Vulnéraire trèfle jaune	Common kidneyvetch	عشبة الخياطة	gynecological diseases	01	**1**	12,5
						dermatological disorders	07		87,5
11	*Apium graveolens* L.	Apiaceae	Céleri	Celery		Cardiovascular diseases	01		50

					لكرافس	Gastro-intestinal disorders	01	**1**	50
12	*Arbutus unedo* L.	Ericaceae	Arbousier	Strawberry Tree	اللنج	Burns	01	**1**	100
13	*Artemisia absinthium* L.	Asteraceae	Absinthe	Wormwood	الشيبة	Cardiovascular diseases	04		66,67
					حشيشةمريم	endocrine diseases	02	**1**	33,33
14	*Artemisia herba-alba* Asso.	Asteraceae	Armoise	Wormwood	الشيح	Gastro-intestinal disorders	07	1,17	100
15	*Arum italicum* Mill.	Araceae	Arum d'Italie	Italian arum	قريوة	Cardiovascular diseases	13		68,42
						fever and headache	05	1	26,32
						Jaundice	01		5,26
16	*Asphodelus microcarpus* L.	Xanthorrhoeaceae	Asphodèle	Asphodel	البرواڤ	dermatological disorders	06		85,71
						O.R.L	01	1	14,29
17	*Avena sativa* L.	Asparagaceae	Avoine	Oat	الخرطال	Endocrine diseases	01	1	100
18	*Carlina gummifera* (L.) Less.	Asteraceae	Chardon à glu	Lectotype Atractylis	الدادة	dermatological disorders	04		57,14
						Burns	01	1	14,29
						Cardiovascular diseases	02		28,57
19	*Borago officinalis* L.	Boraginaceae	Bourrache officinale	Borage	الحرشة	Gastro-intestinal disorders	01	1	100
20	*Carpobrotus edulis* (L.) N.E.Br.	Aizoaceae	Doigt de sorcière	Hottentot-fig	الملاحة	Dermatological disorders	**01**	**1**	100
21	*Cassia abovata* collad.	Fabaceae	Séné du Sahara	Neutral henna	الفليت	Gastro-intestinal disorders	01	1	100
22	*Ceratonia siliqua* L.	Fabaceae	Caroubier	The carob	الخروب	Gastro-intestinal disorders	**01**	**1**	100
23	*Chamaemelum nobile* (L.) All.	Asteraceae	Camomille romaine	Roman Chamomile	البابونج	gastro-intestinal disorders	10		62.5
						Analgesics and sedatives diseases	02		12.5
						Aesthetic	01		6.25
						Endocrine diseases	01	1,14	6.25
						Urinary diseases	01		6.25
						Genital diseases	01		6.25
24	*Circaea lutetiana* L.	Onagraceae	Circeé de paris	Witches herbs	العشرق	Genital diseases	01	1	100
25	*Citrullus colocynthis* (L.) Schard.	Cucurbitaceae	Coloquinte officinale	Bitter Cucumber	الحنضل/ الحدج	Eye diseases	01	1	100
26	*Citrus limon (*L.) Osbeck	Rutaceae	Citron	Lemon	الليمون	Other diseases	01	1	100
27	*Citrus sirensus* (L.) Osbeck.	Rutaceae	Oranger	Orange	البرتقال	Dermatological disorders	01	1	100

28	*Crataegus monogyna* Jacq.	Rosaceae	Aubépine	Common hawthorn	الزعرور البري	Cardiovascular diseases	01		33,33
						Gastro-intestinal disorders	02	1	66,67
29	*Cucumis melon* L.	Cucurbitaceae	Melon jaune	Yellow melon	البطيخ	Gastro-intestinal disorders	01	1	100
30	*Cuminum cyminum* L.	Apiaceae	Cumin	Cumin	الكمون	Gastro-intestinal disorders	03	1	100
31	*Cupressus sempervirens* L.	Cupressaceae	Cypress	Mediterranean cypress	السرو	Dental diseases	06		85,71
						Hemorrhoids	**01**	1,17	14,29
32	*Cynara scolymus* L.	Asteraceae	Artichaut	Artichoke	الخرشف	Gastro-intestinal disorders	01	1	100
33	*Cytisus triflorus* Lam.	Fabaceae	Cytise allonge	Elongated laburnum	لقة	gastro-intestinal disorders	**3**8		6**3**,33
						Burns	12	1,05	20
						dermatological disorders	**10**		16,67
34	*Daphne gnidium* L.	Thymelaeaceae	Daphné garou	Daphne Were	الشرواخ اللزاز	Cardiovascular diseases	01		10
						Jaundice	0**7**	1,11	70
						fever and headache	01		10
						Dental diseases	01		10
35	*Dittrichia viscosa* (L.) Greuter	Asteraceae	Inule visqueuse	Viscous Inule	المقرمان	dermatological disorders	06	1	66,67
						Gastro-intestinal disorders	03		33.33
36	*Ecballium elateruim* L.	Cucurbitaceae	Concombre d'âne	Squirting cucumber	فقوس الحمير	Gastro-intestinal disorders	0**1**	1	50
						Jaundice	01		50
37	*Echinops ritro* L.	Asteraceae	Azurite	Outhern globethistle	الشوكة الزرقاء	Gastro-intestinal disorders	**01**	1	100
38	*Eucalyptus globulus* Labill.	Myrtaceae	Eucalyptus/ Gommier bleu	Australian Fever Tree	الكاليتوس	Respiratory diseases	73	1,01	100
39	*Euphorbia helioscopia* L.	Euphorbiacaea	Euphorbe réveil matin	sun spurge	حليب الدابة	Burns	01	1	100
40	*Ferula assa-foetida* L.	Apiaceae	Ase fédite	Heeng/ Asafoetida	الحنتيتة	Gastro-intestinal disorders	01	1	50
						fever and headache	01		50
41	*Ficus carica* L.	Moraceae	Figuier	Fig	الكرموز	dermatological disorders	01	1	100
42	*Foeniculum vulgare* Mill.	Apiaceae	Fenouil doux	Sweet Fennel	البسباس	Gastro-intestinal disorders	11	1	100
43	*Fraxinus angustifolia* Vahl	Oleaceae	Frêne	Narrow-leafed ash	الضرضار	Gastro-intestinal disorders	**01**	**1**	100
44	*Genista tricuspidata* Desf.	Fabaceae	Génêt à 3 points	Broom	القندول	Gastro-intestinal disorders	01	1	50
						Eye diseases	01		50
45	*Globularia alypum* L.	Plantaginaceae	Globulaire buissonnante	Globe Daisy	تسلغة	Gastro-intestinal disorders	**09**	1	100

46	*Glycyrrhiza glabra* L.	Fabaceae	Réglisse	Licorice	عرقالسوس	Gastro-intestinal disorders	01	1	100
47	*Heliotropium bacciferum* Forssk.	Boraginaceae	Héliotrope	Turn-sole	الرمرام	Gastro-intestinal disorders	07		87,5
						Dermatological disorders	01	1	12,5
48	*Hordeum vulgare* L.	Poaceae	Orge commun L.	Barley	الشعير	Gynecological diseases	1	1	25
						Urinary diseases	03		75
49	*Hyoscyamus albus* L.	Solanaceae	Jusquiame blanche	White henbane	صالح الدار / قنفيط	Other diseases	01	1	50
						Dermatological disorders	01		50
50	*Juniperus oxycedrus* L.	Cupressaceae	Genévrier oxycèdre	Oxycedre Juniper	العرعار	Gastro-intestinal disorders	01	1	100
51	*Laurus nobilis* L.	Lauraceae	Laurier sauce	Bay Laurel	الرند	Cardiovascular diseases	10		55,55
						Gastro-intestinal disorders	06	1	33,33
						Dermatological disorders	01		5,56
						Endocrine diseases	01		5,56
52	*Lavandula stoechas* L.	Lamiaceae	Lavande papillon	Lavender	الحلحالة / الخزامة / عرقالصفيرة	gastro-intestinal disorders	20	1.10	95,24
						Endocrine diseases	01		4,76
53	*Lawsonia inermis* L.	Lythraceae	Henné	Henna	الحناء	fever and headache	01	1	100
54	*Lens culinaris* Medik.	Fabaceae	lentille cultivée	Lentil	لعدس	Hematologic diseases	01	1	100
55	*Lepidium sativum* L.	Brassicaceae	Cresson alénois	Cress	حب الرشاد	Dermatological disorders	01	1	100
56	*Linum usitatissimum* L.	Linaceae	Lin cultivé	Flax	زريعةالكتان	Gastro-intestinal disorders	01	1	100
57	*Malva sylvestris* L.	Malvaceae	Grand mauve	Common Mallow	الخبايزة	Gynecological diseases	01		25
						Cardiovascular diseases	01		25
						Hematologic diseases	01	1	25
						Dermatological disorders	01		25
58	*Marrubium vulgare* L.	Lamiaceae	Marrube commun	White Horehound	تمريوت	Endocrine diseases	**07**		50
						Gastro-intestinal disorders	**04**		28,57
						Other diseases	0**2**	1	14,29
						Urinary diseases	01		7,14
59	*Mentha viridis* L.	Lamiaceae	Menthe verte	Green Mint	النعناع	Gastro-intestinal disorders	24	1,04	100
60	*Mentha pulegium* L.	Lamiaceae	Menthe pouliot	Mint	لفلايو	gastro-intestinal disorders	23		74,19
						Analgesics and sedatives diseases	05		16,13
						Respiratory diseases	01	1,11	3,23

						dermatological disorders	01		3,23
						Cardiovascular diseases	01		3,23
61	*Mespilus germanica* L.	Rosaceae	Néflier commun	Medlar	**الموز /الزعرور**	Gastro-intestinal disorders	03	1	100
62	*Myrtus communis* L.	Myrtaceae	Myrte commun	Myrtle	**الريحان**	gastro-intestinal disorders	140	1,04	88,61
						Analgesics and sedatives diseases	11		6,96
						Cardiovascular diseases	06		3,80
						Respiratory diseases	01		0,63
63	*Nerium oleander* L.	Apocynaceae	Laurier rose	Oleander	**الدفلة**	dermatological disorders	02	1	66,67
						Gastro-intestinal disorders	01		33,33
64	*Nicotiana tabacum* L.	Amaranthaceae	Tabac cultivé	Cultivated tobacco	**الدخان**	dermatological disorders	01	1	100
65	*Ocimum basilicum* L.	Lamiaceae	Basilic	Basil	**لحبق**	Cardiovascular diseases	01	1,33	25
						Analgesics and sedatives diseases	01		25
						Gastro-intestinal disorders	02		50
66	*Olea europaea* L.	Oleaceae	Olivier	Olive Tree	**الزيتون**	Gastro-intestinal disorders	05	1,40	35,71
						Oral diseases	04		28,57
						Cardiovascular diseases	02		14,29
						Respiratory diseases	01		7,14
						dermatological disorders	02		14,29
67	*Olea europaea* (L). Var sylvestris *(Mill.) Lehr*	Oleaceae	Oléastre	Oleaster	**الزبوش**	Cardiovascular diseases	08	1,05	40
						endocrine diseases	08		40
						dermatological disorders	02		10
						Gastro-intestinal disorders	01		5
						respiratory diseases	01		5
68	*Opuntia ficus-indica* (L.) Mill.	Cactaceae	Figuier de Barbarie	Prickly Pear	**الهندي**	respiratory diseases	08	1,4	57,14
						urinary diseases	02		14,29
						dermatological disorders	04		28,57
69	*Petroselinum crispum* (Mill.) Fuss.	Apiaceae	Persil cultivé	Parsley	**المعدنوس**	urinary diseases	10	1,17	71,43
						Hemorrhoids	**01**		7,14
						Gastro-intestinal disorders	03		21,43
70	*Phillyrea media L.*	Oleaceae	Filaire	Mock privet	**الفيلار /الكتم**	Antiseptic	01	01	100
	Pinus pinaster Aiton	Pinaceae	Pin maritime		**الصنوبر البحري**	respiratory diseases	01		33,33

71				the maritime pine		Gastro-intestinal disorders	02	01	66,67
72	*Pistacia lentiscus* L.	Anacardiaceae	Pistachier lentisque	Mastic	الضرو القضوم	Gastro-intestinal disorders	47	1,15	38,52
						respiratory diseases	34		27,87
						dermatological disorders	24		19,67
						burns	12		9,84
						eye diseases	03		2,46
						Analgesics and sedatives diseases	01		0,82
						hemorroïdes	01		0,82
73	*Populus alba* L.	Salicaceae	Peuplier blanc	White Poplar	الصفصاف	Cardiovascular diseases	01	1	33,33
						dental diseases	02		66,67
74	*Punica granatum* L.	Lythraceae	Grenadier commun	Pomegranate	الرمان	Gastro-intestinal disorders	13	1	100
75	*Pimpinella anisum L.*	Apiaceae	Anis cultivé	Anise	حبةحلاوة	Gastro-intestinal disorders	01	1	100
76	*Piper nigrum* L.	Piperaceae	Poivre noir	Black Pepper	الفلفل لكحل	respiratory diseases	01	1	100
77	*Quercus suber* L.	Fagaceae	Chêne liège	Cork Oak	البلوط/ الفرنان	gastro-intestinal disorders	24	1	92,32
						endocrine diseases	01		3,84
						hematologic diseases	01		3,84
78	*Rhamnus alaternus* L.	Rhamnaceae	Nerprun alaterne	Mediterranean Buckthorn	عودالخير	Jaundice	07	1	87,5
						endocrine diseases	01		12,5
79	*Rosa canina* L.	Rosaceae	Rosier des chiens	Dog-Rose	نابالكلب	Gastro-intestinal disorders	01	1	100
80	*Rosmarinus officinalis* L.	Lamiaceae	Romarin	Rosemary	لكليل	gastro-intestinal disorders	48	1	90,57
						respiratory diseases	02		3,76
						urinary diseases	01		1,89
						O.R.L	01		1,89
						endocrine diseases	01		1,89
81	*Rubus ulmifolius* J.Presl & C.Presl	Rosaceae	Roncier	Bramble	العليڤ /الحلس	burns	18	1,12	94,74
						oral diseases	01		5,26
82	*Ruta chalepensis* L.	Rutaceae	Rue	Commun Rue	الفيجل	respiratory diseases	04	1,07	26,67
						burns	04		26,67
						Gastro-intestinal disorders	03		20
						Cardiovascular diseases	02		13,33
						endocrine diseases	01		6,67
						Other diseases	01		6,67

83	*Salvia officinalis* L.	Lamiaceae	Sauge officinale	Sage	سواكالنبي	gastro-intestinal disorders oral diseases Gynecological diseases	01 01 02	1	25 25 50
84	*Scilla maritima* L.	Liliaceae	Scille maritime	Squill	العنصل	fever and headache burns dermatological disorders	01 01 01	1	33.33 33.33 33.33
85	*Silybum marianum* (L.) Gaerth.	Asteraceae	Chardon Marie	cardus marianus	الخرشف البري	Gastro-intestinal disorders urinary diseases endocrine diseases	02 01 01	1,33	50 25 25
86	*Spergularia rubra* (L.) J.Presl. & C.Presl	Caryophyllaceae	Sabline	Red Sandspurry	كسارةلحجر	Urinary diseases	17	1,06	100
87	*Spinacia oleracea* L.	Amaranthaceae	Epinard	Spinach	السلق	Hematologic diseases	01	1	100
88	*Syzygium aromaticum* (L.) Merr. & L. M. Perry	Myrtaceae	Giroflier	Cloves	الطيب	Dermatological disorders	01	01	100
89	*Tamarix aphylla* (L.) H.Karst.	Tamaricaceae	Tamarix	Tamarix	الطحطاح/ عرعار الواد	Dermatological disorders	01	1	100
90	*Thymus algeriensis* Boiss. et Reut.	Lamiaceae	Thym	Wild Thyme	زعترالجبل	gastro-intestinal disorders	15	1	100
91	*Thymus serphyllum* L	Lamiaceae	Serpolet	Breckland thyme	الزعتر البري	Gastro-intestinal disorders	01	1	100
92	*Thymus vulgaris* L.	Lamiaceae	Thym cultivé	Garden Thyme	الزعتر	gastro-intestinal disorders Respiratory diseases Analgesics and sedatives diseases	94 02 01	1,02	96,91 2,06 1,03
93	*Teucrium polium* L.	Lamiaceae	Germandrée tomenteuse	Felty germander	حشيشة الريح	Gastro-intestinal disorders	01	01	100
94	*Traganum nudatum* Delile	Amaranthaceae	Domrane	Domrane	الضمران	Gastro-intestinal disorders Dermatological disorders Hemorrhoids Other diseases Genital diseases Cardiovascular diseases Analgesics and sedatives diseases	33 05 05 03 02 01 01	1,04	 10 10 6 4 2 2

95	*Trigonella foenum-graecum* L.	Fabaceae	Fenugrec	Fenugreek	لحلبة	Gastro-intestinal disorders	10	1	91,67
						Analgesics and sedatives diseases	01		8,33
						Hematologic diseases	01		8,33
96	*Triticum durum* Desf.	Poaceae	Blé dur	Durum wheat	لقمح	Urinary diseases	01	1	100
97	*Triticum repens* L.	Poaceae	Chiendent rampant	Couch grass	نجم الأرض	Gastro-intestinal disorders	**01**	1	100
98	*Urtica dioica* L.	Urticaceae	Ortie commune	Common nettle	لحرايقة	Cardiovascular diseases	03	1	75
						Dermatological disorders	01		25
99	*Vitis vinifera* L.	Vitaceae	Vigne cultivée	Grape- Vine	لعنب	fever and headache	05	1	100
100	*Zea mays* L.	Poaceae	Mais	Maize	لمستورة	Urinary diseases	01	1	50
						Dermatological disorders	01		50
101	*Zingiber officinale* Roscoe	Zingiberaceae	Gingembre	Ginger	الزنجبيل	Other diseases	01	1	50
						Gastro-intestinal disorders	01		50
102	*Ziziphus lotus* (L.) Lam.	Rhamnaceae	Sedra	Sedra	السدرة	Respiratory diseases	02	1	50
						Rheumatic diseases	01		25
						Gastro-intestinal disorders	01		25

N: nombre total d'utilisation-rapports citées pour une espèce donnée, VU: valeur d'utilisation, FIC: Factor Informant Consensus.

3.2. Analysis of the socio-demographic profile of informants

Knowledge of the properties and use of medicinal plants are usually acquired through a scientific and experimental knowledge accumulated and passed from one generation to another **(Bouredja *et al*., 2017).**

The results obtained show that all users of different age groups use medicinal plants with different proportions, people aged between 40 and 60 years old dominate with a use rate of 44.06%, followed by the two age groups. [20-40 [and ≥ 60 with utilization rates of 29.95 and 25.49% respectively. While, young people under the age of 20 are not interested in herbal medicine with a fairly low rate of use of around 0.5%. This may endanger herbal medicine, and makes us fear for its future in the next generations, as young people today are not very dependent on this method of treatment and prefer modern medicine. Results similar to those of **Miara *et al*., (2018) and Souilah *et al*., (2018)** in Algeria **and Chaachouay *et al*., (2019)**, in the Rif region in Morocco**. Anyinam *et al*., (1995),** mention that knowledge of the properties and uses of medicinal plants are generally acquired with age and with long experience passed from one generation to the next. The transmission of this knowledge is in danger today because it is not always assured.

In the study region, the majority of herbal users are married with a percentage of (85.4%), compared to (13.36%) for single people, and (1.24%) for divorcees. This predominance is confirmed in Algeria by **Bouredja *et al*. (2017)** and in Morocco by **Chaachouay *et al*. (2019)**, this can be explained by the growing responsibilities of married couples towards their children and thus in order to minimize medical costs. Regarding the level of study of users, we notice the existence of a decreasing relationship between the academic level and the rate of use of medicinal plants, illiterates use plants more than others with a rate of 30.69%, followed by those with a fundamental level (28.22%). However academics have not shown much interest in medicinal plants with a rate of only 10.64%. Same observation by **Sadallah and Laidi, (2018)** in Bouira in Algeria and **Daoudi *et al*., (2015)** in the province of Khénifra in Morocco where illiterates use plants at 75.7% against 0.8% for academics.

The unemployed and farmers represent two thirds of all users with rates of 36.88% and 31.19% respectively, since farmers are in constant contact with plants and know them better than others, in addition to the herbal medicine allows the unemployed to minimize the various burdens generated by modern medicine.

The obtained results allow us to observe the existence of a decreasing relation between the monthly income in DA and the rate of use of medicinal plants, most of the users of these plants having an income of less than 25,000, including the unemployed., with a rate of (30.44%), however the lowest utilization rate is recorded by people with an income greater than 50,000 DA with a rate of around 0.5%. these results obtained are consistent with those of **Kerdous, (2002)** and **Amrouni, (2009), Souilah, (2018)** in eastern Algeria.

Finally, as regards the origin of the information, the majority of users have acquired phytotherapeutic information from the family or other people with a rate of 98.26%, while the other sources of information (reading, internet , and personal experiences) are less cited with a cumulative percentage of only 1.74%, this reflects the image of the transmission of therapeutic

practices from one generation to another and indicates the dependence of users on their families with regard to the phytotherapy. Observation similar to that of **Souilah *et al*. (2018)** in El Kala National Park in Algeria.

Table 3. Classification of informants according to several factors

Factor	Categories	%
Age	< 20	0,5
	[20-40[	29,95
	[**40-60**[	44,06
	≥ 60	25,49
Family situation	Single	13,36
	Married	85,4
	divorced / widowed	1,24
Study level	Illetrate	30,69
	Primary level	17,33
	Middle level	28,22
	Secondary level	13,12
	University level	10,64
Function	Unemployed	31,19
	officials / private	21,04
	Farmers	36,88
	Retirees	10,89
Income per month (AD)	<25 000	80,69
	[25000 - 35000[	10,64
	[35 000-50000[	8,16
	≥ 50 000	0,51
Origin of the information	family or others	98,26
	Reading	1,24
	personal experience	0,5

3.3. Use of medicinal plants according to the organ of the plant used

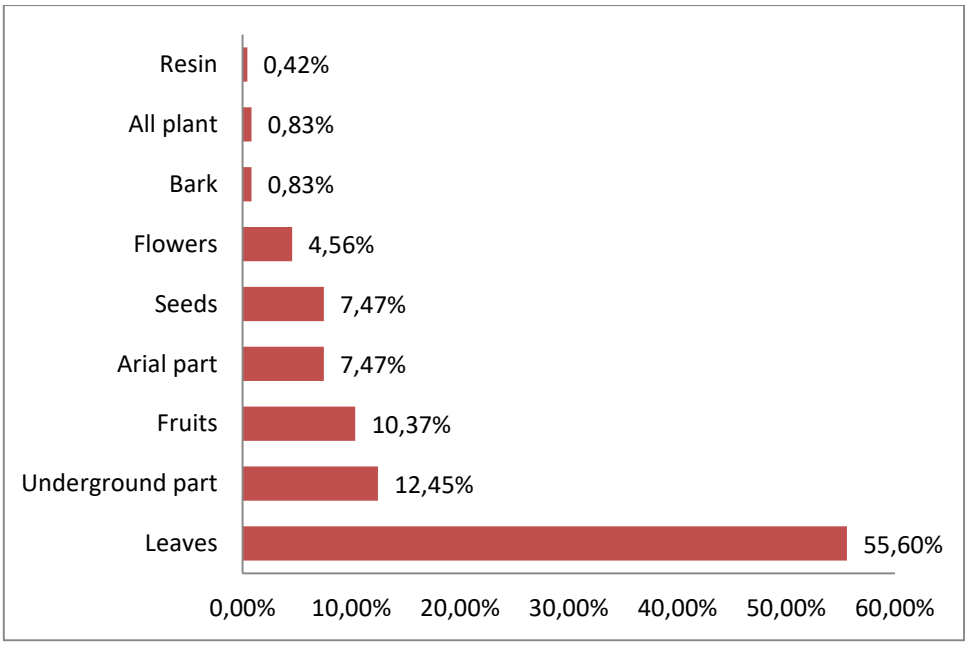

Figure 2. Use of medicinal plants according to their organs.

In general, the parts of plants used in traditional medicine are: the leaves, the underground part (roots, bulbs, tubers), the fruits, the seeds, the aerial part, the resin, and the bark. The results of this survey show that the leaf is the part of medicinal plants the most used (55.6%), a similar observation in the majority of ethnobotanical studies in Algeria such as; **Bouredja *et al.*, (2017)**, **Souilah, (2018)**; and even in Morocco cited by **Daoudi *et al.* (2015)**, followed by the underground part (12.45%) and fruits with 10.37%, against 0.83% for the bark and only 0.83% for the resin. (Figure. 2).

The high frequency of leaf use can be explained by the ease and speed of the harvest **(Bitsindou, 1986)** but also by the fact that they are the seat of photosynthesis and sometimes of the storage of secondary metabolites responsible for the biological properties of the plant **(Bigendako-Polygenis and Lejoly, 1990).** From an ecological point of view, the remarkable frequency of use of the leaves compared to the root parts, flowers and seeds, in reality avoid the excessive pulling out of the plants and therefore ensure their renewal and natural regeneration.

3.4. Use of medicinal plants according to the method of preparation

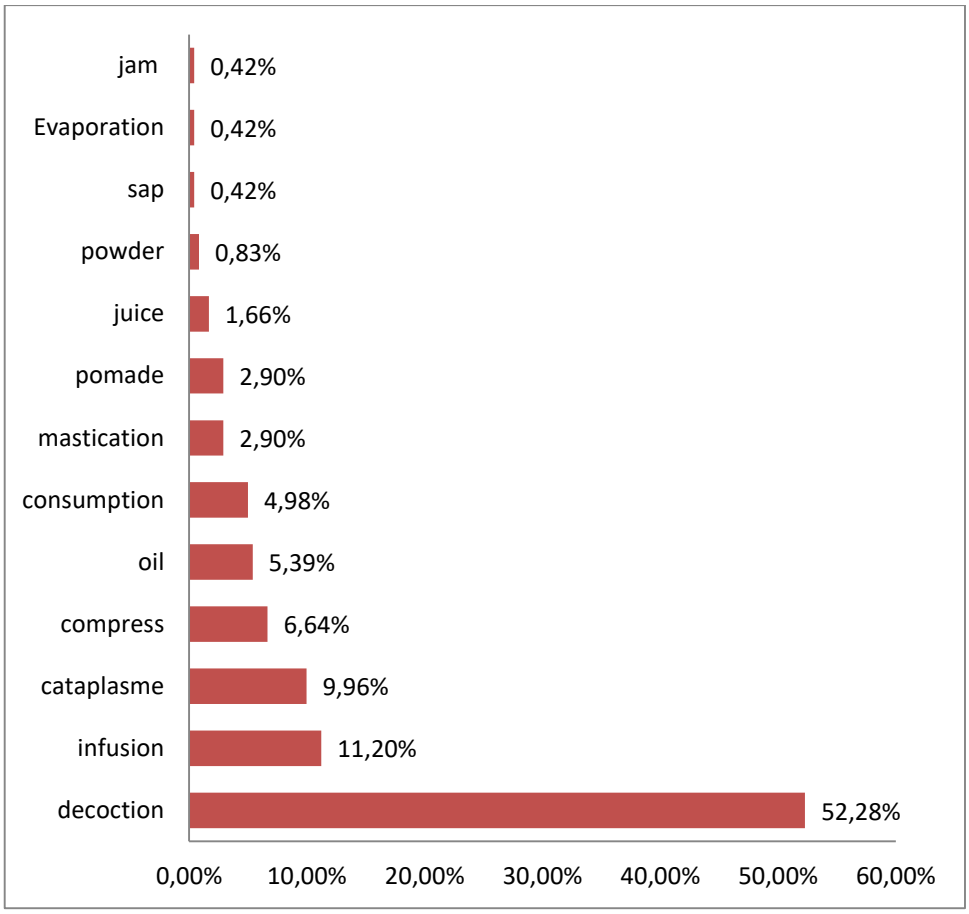

Figure 3. Use of medicinal plants according to the method of preparation.

In order to facilitate the administration of the active ingredients, several preparation methods are Used, in our study, the decoction method is the technique most used by the local population with a high rate of around 52.28%, a result conformed by **Miara *et al.*, (2019)** and **Bouredja *et al.*, (2017)** in Algeria and **Douira *et al.*, (2010)** in Morocco, Due to the conviction of users in the region that the decoction allows the sterization of the plant and the extraction of the active ingredients. The second method used is infusion (11, 20%) followed by poultice (9.96%), while the other methods namely; the compress, the oil, the consumption, the chewing, the ointment, the juice, the powder, the sap, the evaporation and finally the jam are used at rates varying from 6.64 and 0.42%.

3.5. Diseases treated in traditional medicine

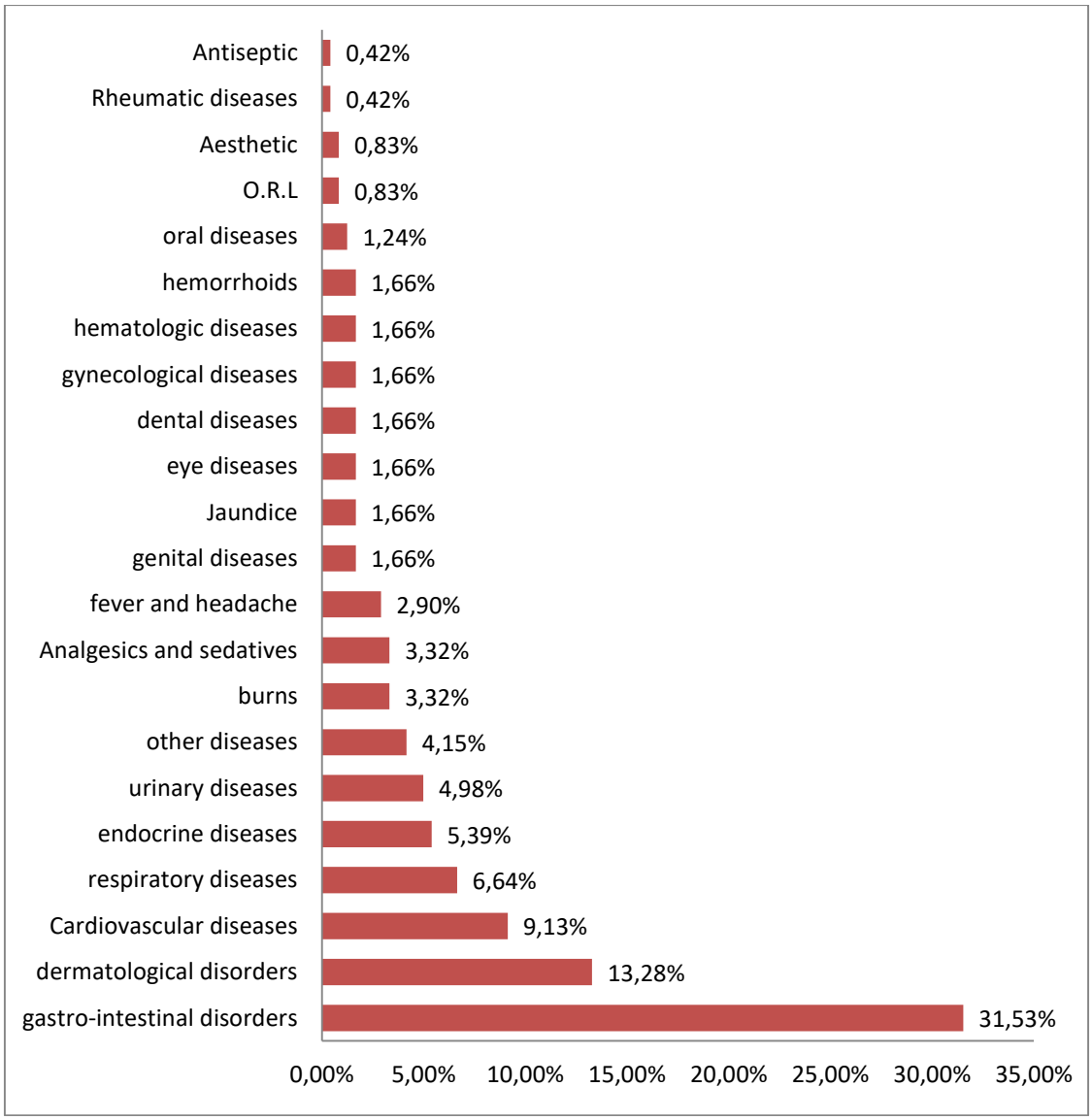

Figure 4. Use of medicinal plants according to treated diseases.

The ethnobotanical analysis revealed 22 categories of diseases treated by the inventoried plants, gastrointestinal disorders represent the most cited disease with a rate of 31.53%, followed by thermatological disorders (13.28%), cardiovascular (9.13%), and respiratory diseases (6.64). The remaining 18 diseases are less cited by the local population with low rates varying from 5.39% to 0.42%. The predominance of gastrointestinal disorders is very frequent in Algerian ethnobotanical studies with different rates such as; **Souilah *et al*., (2018)** (20%); **Ould El Hadj *et al*. (2003)** (26.38%); **Chermat and Gharzouli, (2015)** (34.41%), the same observation is also mentioned in Morocco by **Daoudi *et al*., (2016)** (38.9%) and **Douira *et al*. (2010)** (26.15 %). The results obtained can be explained by the poor eating habits answered in the region characterized by the excessive use of pasta and dried legumes.

3.6. Analysis of calculated paraeters

3.6.1. The most cited medicinal plants

Myrtus communis L. is the species with the highest citation number with a number of 158, followed by *Pistacia lentiscus* L. (121), *Thymus vulgaris* L. (96), this can be explained by the efficiency and the reliability of these plants against various categories of diseases.

Table 4. List of The most cited medicinal plants.

N°	Medicinal plants	Number of citation	%
01	*Myrtus communis L.*	158	12,77
02	*Pistacia lentiscus L.*	121	9,92
03	*Thymus vulgaris L.*	97	7,81
04	*Eucalyptus globulus Labill.*	73	5,78
05	*Angelica officinalis L.*	66	5,37
06	*Cytisus triflorus Lam.*	60	4,80
07	*Rosmarinus officinalis L.*	53	4,31
08	*Traganum nudatum Delile*	50	4,07
09	*Mentha pulegium L.*	31	2,52
10	*Quercus suber L.*	26	2,11

3.6.2. Use-value (UV)

According to the obtained results, the use values of the species are very close and vary from 1.15 to 1, however the highest is observed in *Pistacia lentiscus* L, with a use value of 1.15, which testifies to a wide use of this plant in traditional local medicine to treat seven (07) categories of diseases (Gastro-intestinal disorders, respiratory diseases, dermatological disorders, burns, eye diseases, Analgesics and sedatives diseases and hemorrhoids), this result confirms that of **Souilah *et al*., (2018)** in El kala National Park. The fruits used in Spain to treat dermatophytosis in cows **(Kivçakand Akay, 2005).** Presence of α-Pinene, myrcene, trans-caryophyllene and germacrene D and a-cadinol in the leaves may explain its remedial potential these compounds are known to have antioxidant properties **(Bozogri *et al*., 2013).** High VU indicate that local people are using the plant for many years. Many purposes to treat various categories of diseases **(Barnert and Messmann, 2008)**.

Table 5. use-value of the most cited medicinal plants.

N°	**Medicinal plants**	**N**	**VU**
01	*Pistacia lentiscus L.*	122	1,15
02	*Angelica officinalis L.*	66	1,14
03	*Mentha pulegium L.*	31	1,11
04	*Eucalyptus globulus Labill.*	73	1.01
05	*Cytisus triflorus Lam.*	60	1,05
06	*Traganum nudatum Delile*	50	1,04
07	*Myrtus communis L.*	158	1,04
08	*Thymus vulgaris L.*	97	1,02

09	*Rosmarinus officinalis L.*	53	1
10	*Quercus suber L.*	26	1

UV : Use value
N: total number of use-reports cited for a given species.

3.6.3. Fdelity level (FL)

Concerning the level of fidelity (LF), the calculations carried out clearly show that *Eucalyptus globulus* Labill. Possesses the highest fidelity level with a percentage of 100%, this indicates that this species is used by the local population specifically to treat a single category of disease (respiratory diseases). *Thymus vulgaris* L. comes in second position with a percentage by 96.88%, which is often used to treat gastrointestinal disorders. The low level of fidelity is recorded in *Pistacia lentiscus* L. because this species is used to treat seven (07) categories of diseases (Gastrointestinal disorders, respiratory diseases, dermatological disorders, burns, eye diseases, Analgesic and sedative diseases and hemorrhoids).

Table 6. Fidelity Level of the most cited medicinal plants.

N°	Medicinal plants	N	Np	FL (%)	Most frequent therapeutic use
01	*Eucalyptus globulus Labill.*	73	73	100	Respiratory diseases
02	*Thymus vulgaris L.*	97	94	96,91	Gastro-intestinal disorders
03	*Quercus suber L.*	26	24	92,32	Gastro-intestinal disorders
04	*Rosmarinus officinalis L.*	50	48	90,57	Gastro-intestinal disorders
05	*Myrtus communis L.*	158	140	88,60	Gastro-intestinal disorders
06	*Mentha pulegium L.*	31	23	74,19	Gastro-intestinal disorders
07	*Traganum nudatum Delile*	50	33	66	Gastro-intestinal disorders
08	*Cytisus triflorus Lam.*	60	39	65	Gastro-intestinal disorders
09	*Angelica officinalis L.*	6**6**	34	**51**,**5**1	Dermatological disorders
10	*Pistacia lentiscus L.*	12**1**	47	38,**84**	Gastro-intestinal disorders

NF: fidelity Level
Np: number of use-reports cited for a given species for a particular disease category.
N: total number of use-reports cited for a given species.

3.6.4. Informant consensus factor (ICF):

The higher value of the ICF indicates that the local population is in agreement with the use of the species in the treatment of a category of disease. This value, resulting in a well-defined selection criterion in the area studied or in information, is transmitted between the local populations. The lower FCI value indicates that the plants are chosen at random or that the local population does not exchange information about their use (**Kaya, 2006).** The highest value of the ICF recorded for gastrointestinal disorders (0.91) indicates that users of herbal remedies are agreed on the treatment of this disease, and the most frequently used species is *Myrtus communis* L. dermatology comes in second place with a value of 0.76, and Angelica officinalis L. represents the most used species for this category of diseases. And finally the users do not totally agree on the treatment of five types of diseases (Rheumatic diseases, antiseptic, gynecological diseases hematologic diseases and ENT). Because their ICF tends to zero.

Table 7. Informant consensus factor (ICF) for different disease categories.

N°	Medicinal plants	Nt	Nur	ICF	The most used species
01	gastro-intestinal disorders	59	670	0,91	*Myrtus communis L.*
02	dermatological disorders	30	124	0,76	*Angelica officinalis L.*
03	Cardiovascular diseases	19	72	0,75	*Arum italicum Mill.*
04	respiratory diseases	16	138	0,89	*Eucalyptus globulus Labill.*
05	endocrine diseases	12	25	0,54	*Olea europaea L. Var sylvsetris (Mill) Lehr*
06	urinary diseases	12	40	0,71	*Spergularia rubra (L.) J. Presl. & C. Presl.*
07	other diseases	10	13	0,25	*Traganum nudatum Delile.*
08	Burns	08	49	0,85	*Rubus ulmifolius J. Presl & C. Presl*
09	Analgesics and sedatives diseases	08	24	0,70	*Myrtus communis L.*
10	fever and headache	07	15	0,57	*Arum italicum Mill.*
11	genital diseases	04	05	0,25	*Traganum nudatum Delile.*
12	Jaundice	04	16	0,80	*Daphne gnidium L. Rhamnus alaternus L.*
13	eye diseases	03	05	0,50	*Pistacia lentiscus L.*
14	dental diseases	03	09	0,75	*Cupressus sempervirens L.*
15	gynecological diseases	05	05	0.00	*Salvia officinalis L.*
16	hematologic diseases	05	05	0.00	*Trigonella foenum-graecum L.*
17	Hemorrhoids	03	0**8**	0,71	*Traganum nudatum Delile.*
18	oral diseases	04	05	0,25	*Olea europaea L.*
19	O.R.L	02	02	0,00	*Asphodelus microcarpus L. Rosmarinus officinalis L.*
20	Aesthetic	02	03	0,50	*Chamaemelum nobile (L.) All.*
21	Rheumatic diseases	01	01	0,00	*Zizyfus lotus (L.) Lam*
22	Antiseptic	01	01	0,00	*Phillyrea media L.*

ICF: Informant Consensus Factor.
Nur: refers to the number of use-reports for a particular disease category
Nt: refers to the number of taxa for a particular disease category by all Informants.

4. Conclusion

Considered the first initiative for the ethnobotanical study of medicinal plants in the Guerbes-Sanhadja wetland complex (Ramsar site), this study, based on survey of 400 users of medicinal plants distributed in eight (08) localities, has reveals the diversity of the medicinal flora of the study area, with the census of 102 species, divided into 59 botanical families.

The ethnobotanical analyzes carried out show that the majority of surveyed are people; aged between 40 and 60 (44.06%), married (85.4%), illiterate or having a secondary level with a cumulative rate of 58.91% and finally farmers (36.88%) or unemployed (31, 19) whose monthly income is less than 15,000 DA

In addition, the leaf represents the most used part of medicinal plants with a remarkable rate of 58.25%, and the decoction the most common method of preparation with a percentage of 52.28%. As for the pathologies treated, gastrointestinal ones take precedence with the use of 59 species.

The main spontaneous medicinal species with very high frequency of use in the study area are in decreasing order; *Myrtus communis* L., *Pistacia lentiscus* L., *Thymus vulgaris* L., *Eucalyptus globulus* Labill., *Angelica officinalis* L. *Cytisus triflorus* Lam., *Rosmarinus officinalis* L., *Traganum nudatum* Delile, *Mentha pulegium* L., *Quercus suber* L.

The calculation of parameters UV, NF and ICF, led us to note that *Pistacia lentiscus* L. has the widest use, because it is cited to treat 07 categories of disease, with a utility value (VU) of the order of 1.15. the local people were very loyal to the species of *Eucalyptus globulus* Labill. to treat respiratory diseases with a precision level of 100%. In addition this population was agreed on the treatment of gastrointestinal disorders, with a value of the consensus informing factor (ICF) of the order of 0.91. And finally, this study, conducted in the Guerbes-Sanhadja wetland complex, allowed us to conclude that the local population of the study area remains very dependent on medicinal plants to treat various diseases despite the development of modern medicine. It can be set up a database for the valuation and conservation of medicinal plants in order to discover new active ingredients that can be used in pharmacology and to protect this wealth.

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Ethnobotanic study of medicinal plants in the Guerbes-Sanhadja wetland complex (North East of Algeria)

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Abstract

In order to inventory the medicinal flora and preserve the phytotherapeutic knowledge of the Guerbes-Sanhadja wetland complex, this study was undertaken on the basis of a sample made up of 400 users of medicinal plants, the majority of whom are aged between 40 and 60 years old, married, illiterate and unemployed or farmers. The analysis of the questionnaires allowed the census of 102 species with a clear predominance of *Myrtus communis* L. (158 citations), the results obtained have shown that the most used part of the plant is the leaf (58.25%). In addition, the decoction is the most used preparation method (52.28%). As for the diseases treated, gastrointestinal disorders dominate with the use of 59 species. Finally, the calculation of some ethnobotanical parameters allowed us to observe the wide use of *Pistacia lentiscus* L. (UV = 1.15), the specificity of *Eucalyptus globulus* Labill. to treat respiratory diseases (FL = 100%) and thus the consensus of users with respect to the treatment of gastrointestinal diseases (ICF = 0.91).

Key words: Ethnobotanical, medicinal plants, Wetland, Guerbes-Sanhadja

1. Introduction

The Mediterranean region has an exceptional biological diversity, its richness floristic estimated at 25 000 species of vascular plants, which corresponds to 9.2% of the flora worldwide, in a territory representing only 1.5% of the earth's surface **(Quézel 1997; Médail, 2008)**. This region is the third richest hot pot in the world in plant diversity **(Mittermeier *et al*., 2004).** With more than 3,139 species **(Quézel and Santa, 1962-63)**, the Algerian flora is one of the richest in North Africa **(Miara *et al*., 2018)**. Algeria has 254 wetlands of international importance, located mainly in the east of the country and occupies nearly three million hectares. The Guerbes-Sanhadja wetland complex is one of these Algerian wetlands, it is a site of great importance (classified as a Ramsar site 2001) which constitutes a reservoir of flora biodiversity

(334 species inventoried by Samraoui and **De Belair (1997)** Among this rich flora, several plants are used by the local population for phytotherapeutic purposes.

In Algeria, phytotherapy is an integral part of the local culture; the population has significant indigenous knowledge acquired empirically over generations **(Bouasla and Bouasla 2017)**. According to **Reguieg (2011)**, medicinal and aromatic plants have been used by the Algerian populations to treat several diseases for centuries. Traditional medicines, and more particularly herbal treatments, have been well developed in Algeria, but the use of conventional medicine has led to the abandonment of these ancestral practices which have not been forgotten **(Rebbas *et al*., 2012)**.

Despite the different ethnobotanical studies of medicinal plants published in Algeria **(Kaddem, 1990; Baba Aissa, 1991; Ould El Hadj *et al*., 2003; Hammiche and Maiza, 2015; Rebbas *et al*., 2012; Miara *et al*., 2013; Chermat and Gharzouli, 2015; Ouelbani *et al*., 2016; Bouredja *et al*., 2017; Souilah *et al*., (2018); Bendif *et al*. (2018); Miara *et al*., 2018; Miara *et al*., 2019a and 2019b),** and despite the remarkable floristic richness of the region which is reflected in the various floristic inventories carried out in the region and published **(Samraoui and De Belair, 1997; Belouahem-abed *et al*, 2009; Oumessaad *et al*., 2014)**.

This study represents the first ethnobotanical study initiative carried out in the Guerbes-Sanhadja wetland complex. Such an initiative could however fill this gap and bearing as objectives, the identification of these floristic potentialities, and the knowledge of different phytotherapeutic uses in order to contribute in the preservation of traditional knowledge relating to phytotherapy in the region, which allows by the following the development of these medicinal plants and the establishment of a preservation strategy for this complex, knowing that 60% of medicinal plants are taken from nature (often in an unsustainable way).

2. Materials and method

2.1. Study area

The Guerbès-Senhadja wetland complex (West Numidia), a vast territory that is part of Numidia **(Maire 1926, Quezel and Santa 1962-1963, Marre 1992).**The ecocomplex (36 ° 46'-37 ° 1 'N, 7 ° 8'-7 ° 25' E) is located in the northeast of Algeria and covers the eastern part of the wilaya of Skikda. It covers an area of 42,100 ha and bordered to the north by the Mediterranean Sea, to the east by the Edough forest massif, to the west by the Filfila forest massif and to the south by the forest massif of Boumaïza (Figure 1).

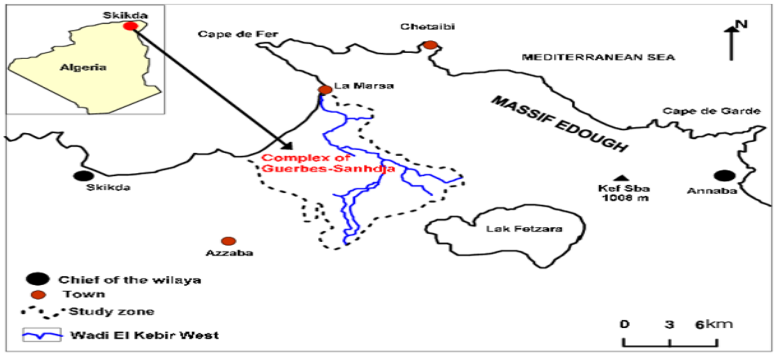

Figure 1. Location of the Guerbes-Sanhadja wetland complex (**Hedjal *et al*., 2014*).***

2.2. Ethnobotanical surveys

The stratified probability sampling technique is the sampling method adopted, this technique allows to have a more representative sample **(Kahouadji, 1986).**And which consists in dividing beforehand the studied population into eight (08) strata or localities, within each stratum (localities) we carried out a simple random sampling composed of 50 users of medicinal plants per stratum, hence a sample total of 400 surveyed (Table 1).

Ethnobotanical surveys were conducted face to face **(Martin, 1995).** The interview was conducted without pressure to allow the informants to answer questions naturally **(Akerreta *et al*., 2007),** according to the ISE code of ethics (with 2008 additions) (ethnobiology.net/code-of-ethics/). The survey form used includes information on the informant (sex, age, academic level, family situation, monthly income, function and source of information), and information on the plant and its phytotherapeutic uses (vernacular name, part used, method of preparation and diseases treated). The language used is the Arabic language, and at the end of the surveys, the plants were photographed on site, harvested, identified and dried to build the herbarium of the plants used. The botanical identification of the specimens was made using the following floras: **Maire (1959), Quézel and Santa (1962-63), Kaddem (1990), Baba Aissa (1991), Halimi, 1997, Samraoui and De belair, (1997), Toubal *et al*., (2014).** We also used the online data bases:www.tela-botanica.org and www.theplantlist.org for checking the scientific names and synonyms of plants (Table 2).

Table 1. Distribution of surveys by locality

Localities	Number of investigation
Ben azzouz	50
El marssa	50
Djendel	50
Guerbes	50
Ain nechma	50
Ezzaouia	50
El marssa-ZP	50
El hamma	50
Total	400

2.3. Measured parameters

- **Use Value (UV):** The relative importance of each plant species known locally for use as an herbal remedy is called as UV. It was calculated according to the following formula **(Barnert and Messmann, 2008)**: $UV = \Sigma U / n$
  U: number of use-reports cited by each informant for a given plant species, n: total number of informants interviewed for a given plant.

- **Fidelity level (FL):** it is used to determine the most frequent plant species used to treat a particular disease category by informants in the study area. The FL is calculated according to the following formula **(Martin, 1995)**: $FL= (Np/N) X 100$
  Np: number of use-reports cited for a given species for a category of diseases particular, N: total number of use-reports cited for a given species.

- **Informant Consensus Factor (ICF):** is used to see if there is agreement on the use plant in disease categories among plant users in the study area. The ICF was calculated according to the following formula **(Bağı, 2000)**: ICF = (Nur- Nt) / (Nur -1)
  Nur: refers to the number of use-reports for a particular disease category, Nt: refers to the number of taxa for a particular disease category by all Informants.

3. Results and discussions

3.1. Census of medicinal plants used by the local population of the complex

Table 2: list of medicinal plants used by the local population of the complex.

N°	Scientific name	Familly	Common name in French	Common name in English	Vernacular name in Arabic	Diseases treated	N	UV	*FL* (%)
01	*Acanthus mollis* L.	Acanthaceae	Acanthi	Bear's breeches	تفيفرة	Gastro-intestinal disorders	01	**1**	33.33
						Other diseases	01		33.33
02	*Adiantum capillus-veneris* L.	Pteridaceae	Capillaire de Montpellier	Southern maidenhair fern	الزياتة	respiratory diseases	01	**1**	33.33
03	*Ajuga iva* (L.) Schreb.	Lamiaceae	Ivette musquée	Ivette Musky	تشنڤدورة	gastro-intestinal disorders	03	**1**	50
						Genital diseases	01		16,67
						dermatological disorders	01		16,67
						Other diseases	01		16,67
04	*Allium cepa* L.	Amaryllidaceae	Oignon	Onion	البصل	Cardiovascular diseases	04	**1**	66,67
						Urinary diseases	01		11,11
						Fever and headache	01		11,11
						dermatological disorders	03		33,33
05	*Allium sativum* L.	Amaryllidaceae	Ail	Garlic	ثوم	Cardiovascular diseases	10	**1**	66,67
						Aesthetic	02		13,33
						Respiratory diseases	03		20
06	*Allium triquetrum* L.	Liliaceae	Ail à trois angles	Three-cornered leek	بيبراس	Other diseases	01	**1**	50
						Gastro-intestinal disorders	01		50
07	*Aloe succotrina All.*	Aloecaceae	Aloès	Fynbos aloe	الصبار	dermatological disorders	01	1	100
08	*Aloysia citriodora* Palau	Verbenaceae	Verveine odorante	Lemon Verbena	تيزانة, لويزة	respiratory diseases	03	1,17	42,86
						gastro-intestinal disorders	04		57,14
09	*Angelica officinalis* L.	Apiaceae	Angélique officinale	Angelic	ودن الحلوف	dermatological disorders	3**5**	1,1**4**	5**3**,**03**
						gastro-intestinal disorders	3**0**		4**5**,4**5**
						Other diseases	01		1,5**1**
10	*Anthyllis vulneraria* L.	Fabaceae	Vulnéraire trèfle jaune	Common kidneyvetch	عشبة الخياطة	gynecological diseases	01	**1**	12,5
						dermatological disorders	07		87,5
11	*Apium graveolens* L.	Apiaceae	Céleri	Celery		Cardiovascular diseases	01		50

					لكرافس	Gastro-intestinal disorders	01	**1**	50
12	*Arbutus unedo* L.	Ericaceae	Arbousier	Strawberry Tree	اللنج	Burns	01	**1**	100
13	*Artemisia absinthium* L.	Asteraceae	Absinthe	Wormwood	الشيبة	Cardiovascular diseases	04		66,67
					حشيشةمريم	endocrine diseases	02	**1**	33,33
14	*Artemisia herba-alba* Asso.	Asteraceae	Armoise	Wormwood	الشيح	Gastro-intestinal disorders	07	1,17	100
15	*Arum italicum* Mill.	Araceae	Arum d'Italie	Italian arum	قريوة	Cardiovascular diseases	13		68,42
						fever and headache	05	1	26,32
						Jaundice	01		5,26
16	*Asphodelus microcarpus* L.	Xanthorrhoeaceae	Asphodèle	Asphodel	البرواڤ	dermatological disorders	06		85,71
						O.R.L	01	1	14,29
17	*Avena sativa* L.	Asparagaceae	Avoine	Oat	الخرطال	Endocrine diseases	01	1	100
18	*Carlina gummifera* (L.) Less.	Asteraceae	Chardon à glu	Lectotype Atractylis	الدادة	dermatological disorders	04		57,14
						Burns	01	1	14,29
						Cardiovascular diseases	02		28,57
19	*Borago officinalis* L.	Boraginaceae	Bourrache officinale	Borage	الحرشة	Gastro-intestinal disorders	01	1	100
20	*Carpobrotus edulis* (L.) N.E.Br.	Aizoaceae	Doigt de sorcière	Hottentot-fig	الملاحة	Dermatological disorders	**01**	**1**	100
21	*Cassia abovata* collad.	Fabaceae	Séné du Sahara	Neutral henna	الفليت	Gastro-intestinal disorders	01	1	100
22	*Ceratonia siliqua* L.	Fabaceae	Caroubier	The carob	الخروب	Gastro-intestinal disorders	**01**	**1**	100
23	*Chamaemelum nobile* (L.) All.	Asteraceae	Camomille romaine	Roman Chamomile	البابونج	gastro-intestinal disorders	10		62.5
						Analgesics and sedatives diseases	02		12.5
						Aesthetic	01		6.25
						Endocrine diseases	01	1,14	6.25
						Urinary diseases	01		6.25
						Genital diseases	01		6.25
24	*Circaea lutetiana* L.	Onagraceae	Circeé de paris	Witches herbs	العشرق	Genital diseases	01	1	100
25	*Citrullus colocynthis* (L.) Schard.	Cucurbitaceae	Coloquinte officinale	Bitter Cucumber	الحنضل/ الحدج	Eye diseases	01	1	100
26	*Citrus limon (*L.) Osbeck	Rutaceae	Citron	Lemon	الليمون	Other diseases	01	1	100
27	*Citrus sirensus* (L.) Osbeck.	Rutaceae	Oranger	Orange	البرتقال	Dermatological disorders	01	1	100

28	*Crataegus monogyna* Jacq.	Rosaceae	Aubépine	Common hawthorn	الزعرور البري	Cardiovascular diseases	01		33,33
						Gastro-intestinal disorders	02	1	66,67
29	*Cucumis melon* L.	Cucurbitaceae	Melon jaune	Yellow melon	البطيخ	Gastro-intestinal disorders	01	1	100
30	*Cuminum cyminum* L.	Apiaceae	Cumin	Cumin	الكمون	Gastro-intestinal disorders	03	1	100
31	*Cupressus sempervirens* L.	Cupressaceae	Cypress	Mediterranean cypress	السرو	Dental diseases	06		85,71
						Hemorrhoids	**01**	1,17	14,29
32	*Cynara scolymus* L.	Asteraceae	Artichaut	Artichoke	الخرشف	Gastro-intestinal disorders	01	1	100
33	*Cytisus triflorus* Lam.	Fabaceae	Cytise allonge	Elongated laburnum	لقة	gastro-intestinal disorders	**3**8		6**3**,33
						Burns	12	1,05	20
						dermatological disorders	**10**		16,67
34	*Daphne gnidium* L.	Thymelaeaceae	Daphné garou	Daphne Were	الشرواخ اللزاز	Cardiovascular diseases	01		10
						Jaundice	0**7**	1,11	70
						fever and headache	01		10
						Dental diseases	01		10
35	*Dittrichia viscosa* (L.) Greuter	Asteraceae	Inule visqueuse	Viscous Inule	المقرمان	dermatological disorders	06	1	66,67
						Gastro-intestinal disorders	03		33.33
36	*Ecballium elateruim* L.	Cucurbitaceae	Concombre d'âne	Squirting cucumber	فقوس الحمير	Gastro-intestinal disorders	0**1**	1	50
						Jaundice	01		50
37	*Echinops ritro* L.	Asteraceae	Azurite	Outhern globethistle	الشوكة الزرقاء	Gastro-intestinal disorders	**01**	1	100
38	*Eucalyptus globulus* Labill.	Myrtaceae	Eucalyptus/ Gommier bleu	Australian Fever Tree	الكاليتوس	Respiratory diseases	73	1,01	100
39	*Euphorbia helioscopia* L.	Euphorbiacaea	Euphorbe réveil matin	sun spurge	حليب الدابة	Burns	01	1	100
40	*Ferula assa-foetida* L.	Apiaceae	Ase fédite	Heeng/ Asafoetida	الحنتيتة	Gastro-intestinal disorders	01	1	50
						fever and headache	01		50
41	*Ficus carica* L.	Moraceae	Figuier	Fig	الكرموز	dermatological disorders	01	1	100
42	*Foeniculum vulgare* Mill.	Apiaceae	Fenouil doux	Sweet Fennel	البسباس	Gastro-intestinal disorders	11	1	100
43	*Fraxinus angustifolia* Vahl	Oleaceae	Frêne	Narrow-leafed ash	الضرضار	Gastro-intestinal disorders	**01**	**1**	100
44	*Genista tricuspidata* Desf.	Fabaceae	Génêt à 3 points	Broom	القندول	Gastro-intestinal disorders	01	1	50
						Eye diseases	01		50
45	*Globularia alypum* L.	Plantaginaceae	Globulaire buissonnante	Globe Daisy	تسلغة	Gastro-intestinal disorders	**09**	1	100

46	*Glycyrrhiza glabra* L.	Fabaceae	Réglisse	Licorice	عرقالسوس	Gastro-intestinal disorders	01	1	100
47	*Heliotropium bacciferum* Forssk.	Boraginaceae	Héliotrope	Turn-sole	الرمرام	Gastro-intestinal disorders	07		87,5
						Dermatological disorders	01	1	12,5
48	*Hordeum vulgare* L.	Poaceae	Orge commun L.	Barley	الشعير	Gynecological diseases	1	1	25
						Urinary diseases	03		75
49	*Hyoscyamus albus* L.	Solanaceae	Jusquiame blanche	White henbane	صالح الدار / قنفيط	Other diseases	01	1	50
						Dermatological disorders	01		50
50	*Juniperus oxycedrus* L.	Cupressaceae	Genévrier oxycèdre	Oxycedre Juniper	العرعار	Gastro-intestinal disorders	01	1	100
51	*Laurus nobilis* L.	Lauraceae	Laurier sauce	Bay Laurel	الرند	Cardiovascular diseases	10		55,55
						Gastro-intestinal disorders	06	1	33,33
						Dermatological disorders	01		5,56
						Endocrine diseases	01		5,56
52	*Lavandula stoechas* L.	Lamiaceae	Lavande papillon	Lavender	الحلحالة / الخزامة / عرقالصفيرة	gastro-intestinal disorders	20	1.10	95,24
						Endocrine diseases	01		4,76
53	*Lawsonia inermis* L.	Lythraceae	Henné	Henna	الحناء	fever and headache	01	1	100
54	*Lens culinaris* Medik.	Fabaceae	lentille cultivée	Lentil	لعدس	Hematologic diseases	01	1	100
55	*Lepidium sativum* L.	Brassicaceae	Cresson alénois	Cress	حب الرشاد	Dermatological disorders	01	1	100
56	*Linum usitatissimum* L.	Linaceae	Lin cultivé	Flax	زريعةالكتان	Gastro-intestinal disorders	01	1	100
57	*Malva sylvestris* L.	Malvaceae	Grand mauve	Common Mallow	الخبايزة	Gynecological diseases	01		25
						Cardiovascular diseases	01		25
						Hematologic diseases	01	1	25
						Dermatological disorders	01		25
58	*Marrubium vulgare* L.	Lamiaceae	Marrube commun	White Horehound	تمريوت	Endocrine diseases	**07**		50
						Gastro-intestinal disorders	**04**		28,57
						Other diseases	0**2**	1	14,29
						Urinary diseases	01		7,14
59	*Mentha viridis* L.	Lamiaceae	Menthe verte	Green Mint	النعناع	Gastro-intestinal disorders	24	1,04	100
60	*Mentha pulegium* L.	Lamiaceae	Menthe pouliot	Mint	لفلايو	gastro-intestinal disorders	23		74,19
						Analgesics and sedatives diseases	05		16,13
						Respiratory diseases	01	1,11	3,23

						dermatological disorders	01		3,23
						Cardiovascular diseases	01		3,23
61	*Mespilus germanica* L.	Rosaceae	Néflier commun	Medlar	**الموز /الزعرور**	Gastro-intestinal disorders	03	1	100
62	*Myrtus communis* L.	Myrtaceae	Myrte commun	Myrtle	**الريحان**	gastro-intestinal disorders	140	1,04	88,61
						Analgesics and sedatives diseases	11		6,96
						Cardiovascular diseases	06		3,80
						Respiratory diseases	01		0,63
63	*Nerium oleander* L.	Apocynaceae	Laurier rose	Oleander	**الدفلة**	dermatological disorders	02	1	66,67
						Gastro-intestinal disorders	01		33,33
64	*Nicotiana tabacum* L.	Amaranthaceae	Tabac cultivé	Cultivated tobacco	**الدخان**	dermatological disorders	01	1	100
65	*Ocimum basilicum* L.	Lamiaceae	Basilic	Basil	**لحبق**	Cardiovascular diseases	01	1,33	25
						Analgesics and sedatives diseases	01		25
						Gastro-intestinal disorders	02		50
66	*Olea europaea* L.	Oleaceae	Olivier	Olive Tree	**الزيتون**	Gastro-intestinal disorders	05	1,40	35,71
						Oral diseases	04		28,57
						Cardiovascular diseases	02		14,29
						Respiratory diseases	01		7,14
						dermatological disorders	02		14,29
67	*Olea europaea* (L). Var sylvestris *(Mill.) Lehr*	Oleaceae	Oléastre	Oleaster	**الزبوش**	Cardiovascular diseases	08	1,05	40
						endocrine diseases	08		40
						dermatological disorders	02		10
						Gastro-intestinal disorders	01		5
						respiratory diseases	01		5
68	*Opuntia ficus-indica* (L.) Mill.	Cactaceae	Figuier de Barbarie	Prickly Pear	**الهندي**	respiratory diseases	08	1,4	57,14
						urinary diseases	02		14,29
						dermatological disorders	04		28,57
69	*Petroselinum crispum* (Mill.) Fuss.	Apiaceae	Persil cultivé	Parsley	**المعدنوس**	urinary diseases	10	1,17	71,43
						Hemorrhoids	**01**		7,14
						Gastro-intestinal disorders	03		21,43
70	*Phillyrea media L.*	Oleaceae	Filaire	Mock privet	**الفيلار /الكتم**	Antiseptic	01	01	100
	Pinus pinaster Aiton	Pinaceae	Pin maritime		**الصنوبر البحري**	respiratory diseases	01		33,33

71				the maritime pine		Gastro-intestinal disorders	02	01	66,67
72	*Pistacia lentiscus* L.	Anacardiaceae	Pistachier lentisque	Mastic	الضرو القضوم	Gastro-intestinal disorders	47	1,15	38,52
						respiratory diseases	34		27,87
						dermatological disorders	24		19,67
						burns	12		9,84
						eye diseases	03		2,46
						Analgesics and sedatives diseases	01		0,82
						hemorroïdes	01		0,82
73	*Populus alba* L.	Salicaceae	Peuplier blanc	White Poplar	الصفصاف	Cardiovascular diseases	01	1	33,33
						dental diseases	02		66,67
74	*Punica granatum* L.	Lythraceae	Grenadier commun	Pomegranate	الرمان	Gastro-intestinal disorders	13	1	100
75	*Pimpinella anisum L.*	Apiaceae	Anis cultivé	Anise	حبةحلاوة	Gastro-intestinal disorders	01	1	100
76	*Piper nigrum* L.	Piperaceae	Poivre noir	Black Pepper	الفلفل لكحل	respiratory diseases	01	1	100
77	*Quercus suber* L.	Fagaceae	Chêne liège	Cork Oak	البلوط/ الفرنان	gastro-intestinal disorders	24	1	92,32
						endocrine diseases	01		3,84
						hematologic diseases	01		3,84
78	*Rhamnus alaternus* L.	Rhamnaceae	Nerprun alaterne	Mediterranean Buckthorn	عودالخير	Jaundice	07	1	87,5
						endocrine diseases	01		12,5
79	*Rosa canina* L.	Rosaceae	Rosier des chiens	Dog-Rose	نابالكلب	Gastro-intestinal disorders	01	1	100
80	*Rosmarinus officinalis* L.	Lamiaceae	Romarin	Rosemary	لكليل	gastro-intestinal disorders	48	1	90,57
						respiratory diseases	02		3,76
						urinary diseases	01		1,89
						O.R.L	01		1,89
						endocrine diseases	01		1,89
81	*Rubus ulmifolius* J.Presl & C.Presl	Rosaceae	Roncier	Bramble	العليڤ /الحلس	burns	18	1,12	94,74
						oral diseases	01		5,26
82	*Ruta chalepensis* L.	Rutaceae	Rue	Commun Rue	الفيجل	respiratory diseases	04	1,07	26,67
						burns	04		26,67
						Gastro-intestinal disorders	03		20
						Cardiovascular diseases	02		13,33
						endocrine diseases	01		6,67
						Other diseases	01		6,67

83	*Salvia officinalis* L.	Lamiaceae	Sauge officinale	Sage	سواكالنبي	gastro-intestinal disorders oral diseases Gynecological diseases	01 01 02	1	25 25 50
84	*Scilla maritima* L.	Liliaceae	Scille maritime	Squill	العنصل	fever and headache burns dermatological disorders	01 01 01	1	33.33 33.33 33.33
85	*Silybum marianum* (L.) Gaerth.	Asteraceae	Chardon Marie	cardus marianus	الخرشف البري	Gastro-intestinal disorders urinary diseases endocrine diseases	02 01 01	1,33	50 25 25
86	*Spergularia rubra* (L.) J.Presl. & C.Presl	Caryophyllaceae	Sabline	Red Sandspurry	كسارةلحجر	Urinary diseases	17	1,06	100
87	*Spinacia oleracea* L.	Amaranthaceae	Epinard	Spinach	السلق	Hematologic diseases	01	1	100
88	*Syzygium aromaticum* (L.) Merr. & L. M. Perry	Myrtaceae	Giroflier	Cloves	الطيب	Dermatological disorders	01	01	100
89	*Tamarix aphylla* (L.) H.Karst.	Tamaricaceae	Tamarix	Tamarix	الطحطاح/ عرعار الواد	Dermatological disorders	01	1	100
90	*Thymus algeriensis* Boiss. et Reut.	Lamiaceae	Thym	Wild Thyme	زعترالجبل	gastro-intestinal disorders	15	1	100
91	*Thymus serphyllum* L	Lamiaceae	Serpolet	Breckland thyme	الزعتر البري	Gastro-intestinal disorders	01	1	100
92	*Thymus vulgaris* L.	Lamiaceae	Thym cultivé	Garden Thyme	الزعتر	gastro-intestinal disorders Respiratory diseases Analgesics and sedatives diseases	94 02 01	1,02	96,91 2,06 1,03
93	*Teucrium polium* L.	Lamiaceae	Germandrée tomenteuse	Felty germander	حشيشة الريح	Gastro-intestinal disorders	01	01	100
94	*Traganum nudatum* Delile	Amaranthaceae	Domrane	Domrane	الضمران	Gastro-intestinal disorders Dermatological disorders Hemorrhoids Other diseases Genital diseases Cardiovascular diseases Analgesics and sedatives diseases	33 05 05 03 02 01 01	1,04	 10 10 6 4 2 2

95	*Trigonella foenum-graecum* L.	Fabaceae	Fenugrec	Fenugreek	لحلبة	Gastro-intestinal disorders	10	1	91,67
						Analgesics and sedatives diseases	01		8,33
						Hematologic diseases	01		8,33
96	*Triticum durum* Desf.	Poaceae	Blé dur	Durum wheat	لقمح	Urinary diseases	01	1	100
97	*Triticum repens* L.	Poaceae	Chiendent rampant	Couch grass	نجم الأرض	Gastro-intestinal disorders	**01**	1	100
98	*Urtica dioica* L.	Urticaceae	Ortie commune	Common nettle	لحرايقة	Cardiovascular diseases	03	1	75
						Dermatological disorders	01		25
99	*Vitis vinifera* L.	Vitaceae	Vigne cultivée	Grape- Vine	لعنب	fever and headache	05	1	100
100	*Zea mays* L.	Poaceae	Mais	Maize	لمستورة	Urinary diseases	01	1	50
						Dermatological disorders	01		50
101	*Zingiber officinale* Roscoe	Zingiberaceae	Gingembre	Ginger	الزنجبيل	Other diseases	01	1	50
						Gastro-intestinal disorders	01		50
102	*Ziziphus lotus* (L.) Lam.	Rhamnaceae	Sedra	Sedra	السدرة	Respiratory diseases	02	1	50
						Rheumatic diseases	01		25
						Gastro-intestinal disorders	01		25

N: nombre total d'utilisation-rapports citées pour une espèce donnée, VU: valeur d'utilisation, FIC: Factor Informant Consensus.

3.2. Analysis of the socio-demographic profile of informants

Knowledge of the properties and use of medicinal plants are usually acquired through a scientific and experimental knowledge accumulated and passed from one generation to another **(Bouredja *et al*., 2017).**

The results obtained show that all users of different age groups use medicinal plants with different proportions, people aged between 40 and 60 years old dominate with a use rate of 44.06%, followed by the two age groups. [20-40 [and ≥ 60 with utilization rates of 29.95 and 25.49% respectively. While, young people under the age of 20 are not interested in herbal medicine with a fairly low rate of use of around 0.5%. This may endanger herbal medicine, and makes us fear for its future in the next generations, as young people today are not very dependent on this method of treatment and prefer modern medicine. Results similar to those of **Miara *et al*., (2018) and Souilah *et al*., (2018)** in Algeria **and Chaachouay *et al*., (2019)**, in the Rif region in Morocco**. Anyinam *et al*., (1995),** mention that knowledge of the properties and uses of medicinal plants are generally acquired with age and with long experience passed from one generation to the next. The transmission of this knowledge is in danger today because it is not always assured.

In the study region, the majority of herbal users are married with a percentage of (85.4%), compared to (13.36%) for single people, and (1.24%) for divorcees. This predominance is confirmed in Algeria by **Bouredja *et al*. (2017)** and in Morocco by **Chaachouay *et al*. (2019)**, this can be explained by the growing responsibilities of married couples towards their children and thus in order to minimize medical costs. Regarding the level of study of users, we notice the existence of a decreasing relationship between the academic level and the rate of use of medicinal plants, illiterates use plants more than others with a rate of 30.69%, followed by those with a fundamental level (28.22%). However academics have not shown much interest in medicinal plants with a rate of only 10.64%. Same observation by **Sadallah and Laidi, (2018)** in Bouira in Algeria and **Daoudi *et al*., (2015)** in the province of Khénifra in Morocco where illiterates use plants at 75.7% against 0.8% for academics.

The unemployed and farmers represent two thirds of all users with rates of 36.88% and 31.19% respectively, since farmers are in constant contact with plants and know them better than others, in addition to the herbal medicine allows the unemployed to minimize the various burdens generated by modern medicine.

The obtained results allow us to observe the existence of a decreasing relation between the monthly income in DA and the rate of use of medicinal plants, most of the users of these plants having an income of less than 25,000, including the unemployed., with a rate of (30.44%), however the lowest utilization rate is recorded by people with an income greater than 50,000 DA with a rate of around 0.5%. these results obtained are consistent with those of **Kerdous, (2002)** and **Amrouni, (2009), Souilah, (2018)** in eastern Algeria.

Finally, as regards the origin of the information, the majority of users have acquired phytotherapeutic information from the family or other people with a rate of 98.26%, while the other sources of information (reading, internet , and personal experiences) are less cited with a cumulative percentage of only 1.74%, this reflects the image of the transmission of therapeutic

practices from one generation to another and indicates the dependence of users on their families with regard to the phytotherapy. Observation similar to that of **Souilah *et al*. (2018)** in El Kala National Park in Algeria.

Table 3. Classification of informants according to several factors

Factor	Categories	%
Age	< 20	0,5
	[20-40[	29,95
	[**40-60**[	44,06
	≥ 60	25,49
Family situation	Single	13,36
	Married	85,4
	divorced / widowed	1,24
Study level	Illetrate	30,69
	Primary level	17,33
	Middle level	28,22
	Secondary level	13,12
	University level	10,64
Function	Unemployed	31,19
	officials / private	21,04
	Farmers	36,88
	Retirees	10,89
Income per month (AD)	<25 000	80,69
	[25000 - 35000[	10,64
	[35 000-50000[	8,16
	≥ 50 000	0,51
Origin of the information	family or others	98,26
	Reading	1,24
	personal experience	0,5

3.3. Use of medicinal plants according to the organ of the plant used

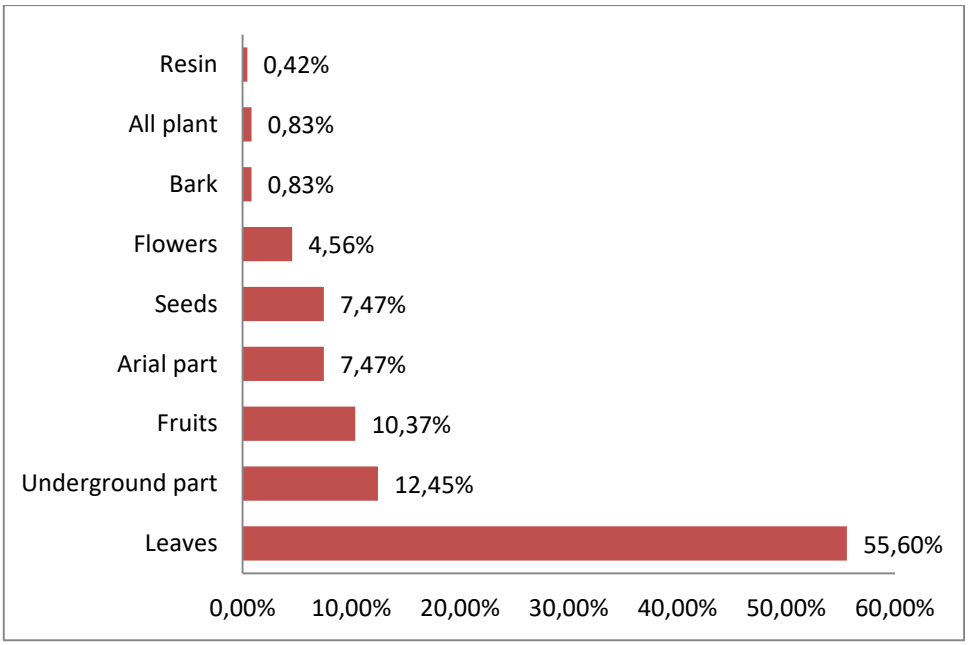

Figure 2. Use of medicinal plants according to their organs.

In general, the parts of plants used in traditional medicine are: the leaves, the underground part (roots, bulbs, tubers), the fruits, the seeds, the aerial part, the resin, and the bark. The results of this survey show that the leaf is the part of medicinal plants the most used (55.6%), a similar observation in the majority of ethnobotanical studies in Algeria such as; **Bouredja *et al.*, (2017)**, **Souilah, (2018)**; and even in Morocco cited by **Daoudi *et al.* (2015)**, followed by the underground part (12.45%) and fruits with 10.37%, against 0.83% for the bark and only 0.83% for the resin. (Figure. 2).

The high frequency of leaf use can be explained by the ease and speed of the harvest **(Bitsindou, 1986)** but also by the fact that they are the seat of photosynthesis and sometimes of the storage of secondary metabolites responsible for the biological properties of the plant **(Bigendako-Polygenis and Lejoly, 1990).** From an ecological point of view, the remarkable frequency of use of the leaves compared to the root parts, flowers and seeds, in reality avoid the excessive pulling out of the plants and therefore ensure their renewal and natural regeneration.

3.4. Use of medicinal plants according to the method of preparation

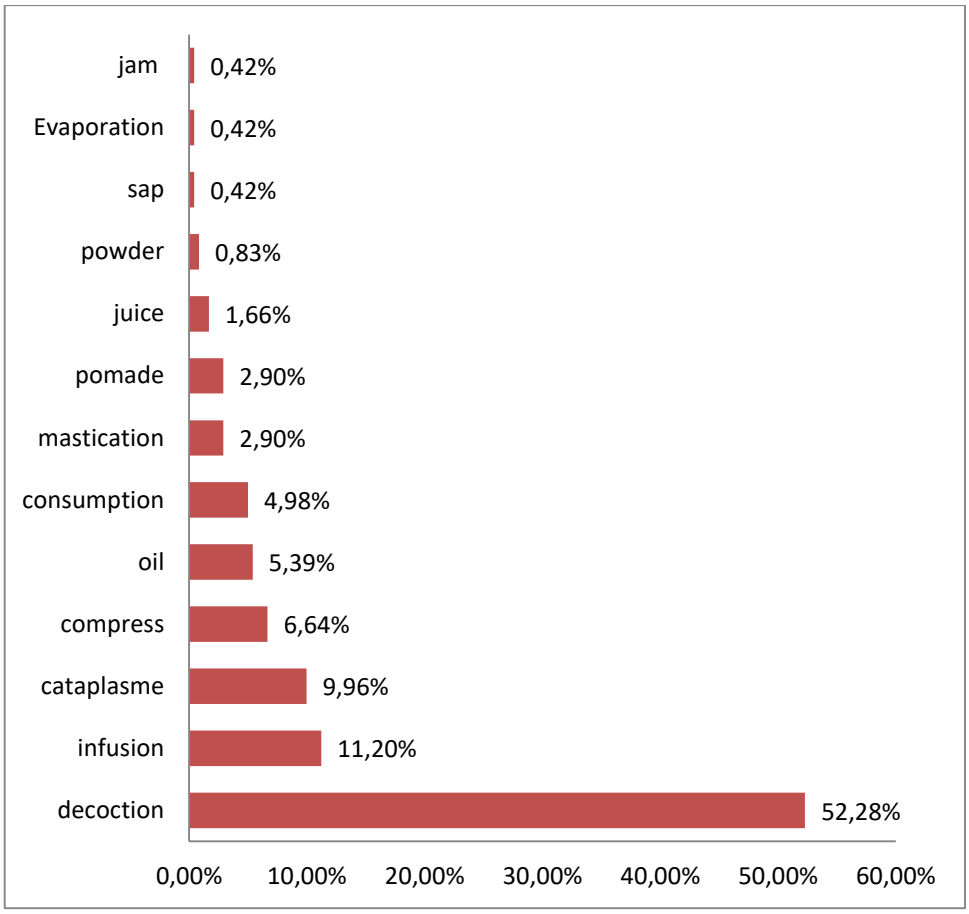

Figure 3. Use of medicinal plants according to the method of preparation.

In order to facilitate the administration of the active ingredients, several preparation methods are Used, in our study, the decoction method is the technique most used by the local population with a high rate of around 52.28%, a result conformed by **Miara *et al.*, (2019)** and **Bouredja *et al.*, (2017)** in Algeria and **Douira *et al.*, (2010)** in Morocco, Due to the conviction of users in the region that the decoction allows the sterization of the plant and the extraction of the active ingredients. The second method used is infusion (11, 20%) followed by poultice (9.96%), while the other methods namely; the compress, the oil, the consumption, the chewing, the ointment, the juice, the powder, the sap, the evaporation and finally the jam are used at rates varying from 6.64 and 0.42%.

3.5. Diseases treated in traditional medicine

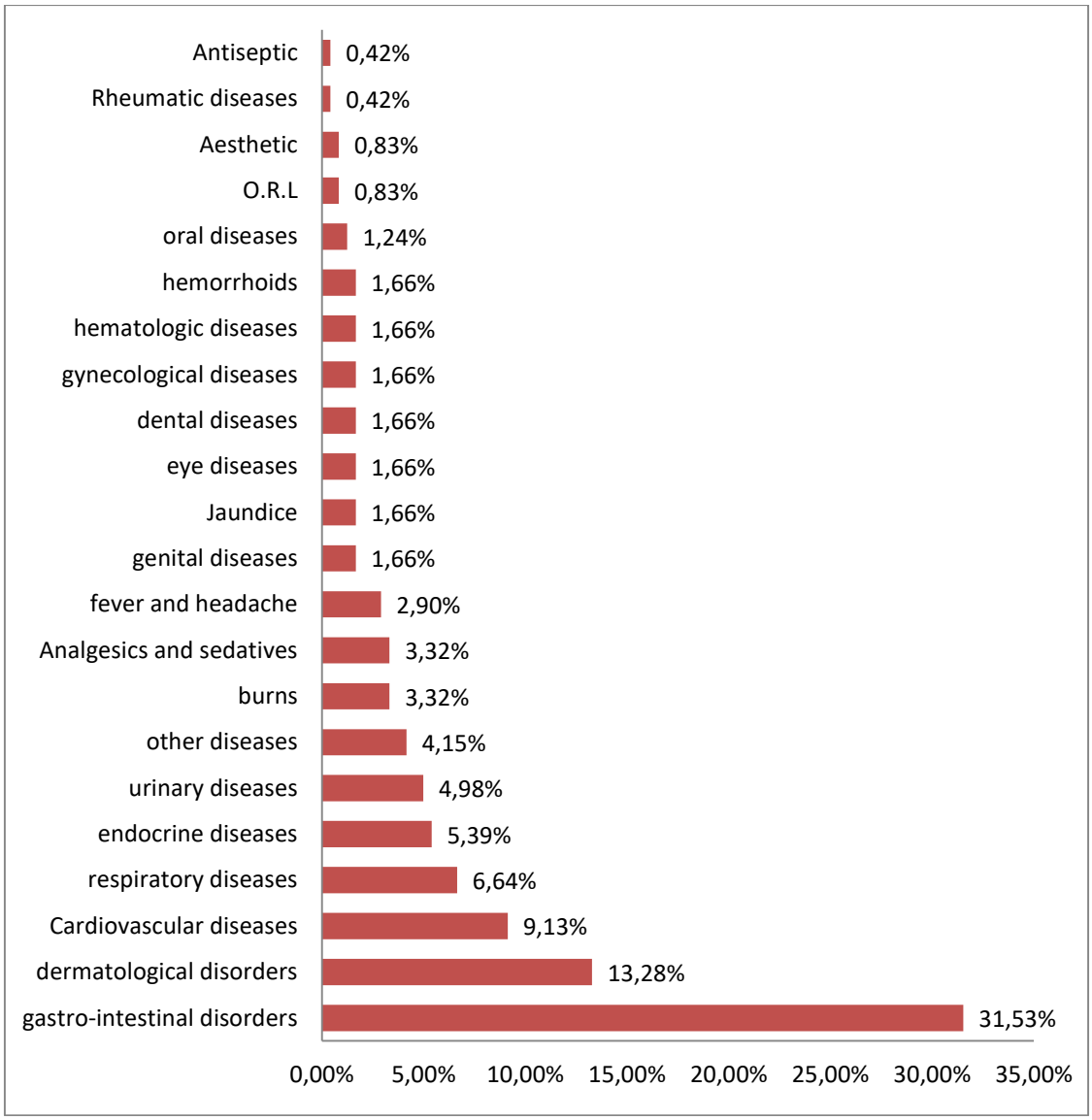

Figure 4. Use of medicinal plants according to treated diseases.

The ethnobotanical analysis revealed 22 categories of diseases treated by the inventoried plants, gastrointestinal disorders represent the most cited disease with a rate of 31.53%, followed by thermatological disorders (13.28%), cardiovascular (9.13%), and respiratory diseases (6.64). The remaining 18 diseases are less cited by the local population with low rates varying from 5.39% to 0.42%. The predominance of gastrointestinal disorders is very frequent in Algerian ethnobotanical studies with different rates such as; **Souilah *et al*., (2018)** (20%); **Ould El Hadj *et al*. (2003)** (26.38%); **Chermat and Gharzouli, (2015)** (34.41%), the same observation is also mentioned in Morocco by **Daoudi *et al*., (2016)** (38.9%) and **Douira *et al*. (2010)** (26.15 %). The results obtained can be explained by the poor eating habits answered in the region characterized by the excessive use of pasta and dried legumes.

3.6. Analysis of calculated paraeters

3.6.1. The most cited medicinal plants

Myrtus communis L. is the species with the highest citation number with a number of 158, followed by *Pistacia lentiscus* L. (121), *Thymus vulgaris* L. (96), this can be explained by the efficiency and the reliability of these plants against various categories of diseases.

Table 4. List of The most cited medicinal plants.

N°	Medicinal plants	Number of citation	%
01	*Myrtus communis L.*	158	12,77
02	*Pistacia lentiscus L.*	121	9,92
03	*Thymus vulgaris L.*	97	7,81
04	*Eucalyptus globulus Labill.*	73	5,78
05	*Angelica officinalis L.*	66	5,37
06	*Cytisus triflorus Lam.*	60	4,80
07	*Rosmarinus officinalis L.*	53	4,31
08	*Traganum nudatum Delile*	50	4,07
09	*Mentha pulegium L.*	31	2,52
10	*Quercus suber L.*	26	2,11

3.6.2. Use-value (UV)

According to the obtained results, the use values of the species are very close and vary from 1.15 to 1, however the highest is observed in *Pistacia lentiscus* L, with a use value of 1.15, which testifies to a wide use of this plant in traditional local medicine to treat seven (07) categories of diseases (Gastro-intestinal disorders, respiratory diseases, dermatological disorders, burns, eye diseases, Analgesics and sedatives diseases and hemorrhoids), this result confirms that of **Souilah *et al*., (2018)** in El kala National Park. The fruits used in Spain to treat dermatophytosis in cows **(Kivçakand Akay, 2005).** Presence of α-Pinene, myrcene, trans-caryophyllene and germacrene D and a-cadinol in the leaves may explain its remedial potential these compounds are known to have antioxidant properties **(Bozogri *et al*., 2013).** High VU indicate that local people are using the plant for many years. Many purposes to treat various categories of diseases **(Barnert and Messmann, 2008)**.

Table 5. use-value of the most cited medicinal plants.

N°	**Medicinal plants**	**N**	**VU**
01	*Pistacia lentiscus L.*	122	1,15
02	*Angelica officinalis L.*	66	1,14
03	*Mentha pulegium L.*	31	1,11
04	*Eucalyptus globulus Labill.*	73	1.01
05	*Cytisus triflorus Lam.*	60	1,05
06	*Traganum nudatum Delile*	50	1,04
07	*Myrtus communis L.*	158	1,04
08	*Thymus vulgaris L.*	97	1,02

09	*Rosmarinus officinalis L.*	53	1
10	*Quercus suber L.*	26	1

UV : Use value
N: total number of use-reports cited for a given species.

3.6.3. Fdelity level (FL)

Concerning the level of fidelity (LF), the calculations carried out clearly show that *Eucalyptus globulus* Labill. Possesses the highest fidelity level with a percentage of 100%, this indicates that this species is used by the local population specifically to treat a single category of disease (respiratory diseases). *Thymus vulgaris* L. comes in second position with a percentage by 96.88%, which is often used to treat gastrointestinal disorders. The low level of fidelity is recorded in *Pistacia lentiscus* L. because this species is used to treat seven (07) categories of diseases (Gastrointestinal disorders, respiratory diseases, dermatological disorders, burns, eye diseases, Analgesic and sedative diseases and hemorrhoids).

Table 6. Fidelity Level of the most cited medicinal plants.

N°	Medicinal plants	N	Np	FL (%)	Most frequent therapeutic use
01	*Eucalyptus globulus Labill.*	73	73	100	Respiratory diseases
02	*Thymus vulgaris L.*	97	94	96,91	Gastro-intestinal disorders
03	*Quercus suber L.*	26	24	92,32	Gastro-intestinal disorders
04	*Rosmarinus officinalis L.*	50	48	90,57	Gastro-intestinal disorders
05	*Myrtus communis L.*	158	140	88,60	Gastro-intestinal disorders
06	*Mentha pulegium L.*	31	23	74,19	Gastro-intestinal disorders
07	*Traganum nudatum Delile*	50	33	66	Gastro-intestinal disorders
08	*Cytisus triflorus Lam.*	60	39	65	Gastro-intestinal disorders
09	*Angelica officinalis L.*	6**6**	34	**51**,**5**1	Dermatological disorders
10	*Pistacia lentiscus L.*	12**1**	47	38,**84**	Gastro-intestinal disorders

NF: fidelity Level
Np: number of use-reports cited for a given species for a particular disease category.
N: total number of use-reports cited for a given species.

3.6.4. Informant consensus factor (ICF):

The higher value of the ICF indicates that the local population is in agreement with the use of the species in the treatment of a category of disease. This value, resulting in a well-defined selection criterion in the area studied or in information, is transmitted between the local populations. The lower FCI value indicates that the plants are chosen at random or that the local population does not exchange information about their use (**Kaya, 2006).** The highest value of the ICF recorded for gastrointestinal disorders (0.91) indicates that users of herbal remedies are agreed on the treatment of this disease, and the most frequently used species is *Myrtus communis* L. dermatology comes in second place with a value of 0.76, and Angelica officinalis L. represents the most used species for this category of diseases. And finally the users do not totally agree on the treatment of five types of diseases (Rheumatic diseases, antiseptic, gynecological diseases hematologic diseases and ENT). Because their ICF tends to zero.

Table 7. Informant consensus factor (ICF) for different disease categories.

N°	Medicinal plants	Nt	Nur	ICF	The most used species
01	gastro-intestinal disorders	59	670	0,91	*Myrtus communis L.*
02	dermatological disorders	30	124	0,76	*Angelica officinalis L.*
03	Cardiovascular diseases	19	72	0,75	*Arum italicum Mill.*
04	respiratory diseases	16	138	0,89	*Eucalyptus globulus Labill.*
05	endocrine diseases	12	25	0,54	*Olea europaea L. Var sylvsetris (Mill) Lehr*
06	urinary diseases	12	40	0,71	*Spergularia rubra (L.) J. Presl. & C. Presl.*
07	other diseases	10	13	0,25	*Traganum nudatum Delile.*
08	Burns	08	49	0,85	*Rubus ulmifolius J. Presl & C. Presl*
09	Analgesics and sedatives diseases	08	24	0,70	*Myrtus communis L.*
10	fever and headache	07	15	0,57	*Arum italicum Mill.*
11	genital diseases	04	05	0,25	*Traganum nudatum Delile.*
12	Jaundice	04	16	0,80	*Daphne gnidium L. Rhamnus alaternus L.*
13	eye diseases	03	05	0,50	*Pistacia lentiscus L.*
14	dental diseases	03	09	0,75	*Cupressus sempervirens L.*
15	gynecological diseases	05	05	0.00	*Salvia officinalis L.*
16	hematologic diseases	05	05	0.00	*Trigonella foenum-graecum L.*
17	Hemorrhoids	03	0**8**	0,71	*Traganum nudatum Delile.*
18	oral diseases	04	05	0,25	*Olea europaea L.*
19	O.R.L	02	02	0,00	*Asphodelus microcarpus L. Rosmarinus officinalis L.*
20	Aesthetic	02	03	0,50	*Chamaemelum nobile (L.) All.*
21	Rheumatic diseases	01	01	0,00	*Zizyfus lotus (L.) Lam*
22	Antiseptic	01	01	0,00	*Phillyrea media L.*

ICF: Informant Consensus Factor.
Nur: refers to the number of use-reports for a particular disease category
Nt: refers to the number of taxa for a particular disease category by all Informants.

4. Conclusion

Considered the first initiative for the ethnobotanical study of medicinal plants in the Guerbes-Sanhadja wetland complex (Ramsar site), this study, based on survey of 400 users of medicinal plants distributed in eight (08) localities, has reveals the diversity of the medicinal flora of the study area, with the census of 102 species, divided into 59 botanical families.

The ethnobotanical analyzes carried out show that the majority of surveyed are people; aged between 40 and 60 (44.06%), married (85.4%), illiterate or having a secondary level with a cumulative rate of 58.91% and finally farmers (36.88%) or unemployed (31, 19) whose monthly income is less than 15,000 DA

In addition, the leaf represents the most used part of medicinal plants with a remarkable rate of 58.25%, and the decoction the most common method of preparation with a percentage of 52.28%. As for the pathologies treated, gastrointestinal ones take precedence with the use of 59 species.

The main spontaneous medicinal species with very high frequency of use in the study area are in decreasing order; *Myrtus communis* L., *Pistacia lentiscus* L., *Thymus vulgaris* L., *Eucalyptus globulus* Labill., *Angelica officinalis* L. *Cytisus triflorus* Lam., *Rosmarinus officinalis* L., *Traganum nudatum* Delile, *Mentha pulegium* L., *Quercus suber* L.

The calculation of parameters UV, NF and ICF, led us to note that *Pistacia lentiscus* L. has the widest use, because it is cited to treat 07 categories of disease, with a utility value (VU) of the order of 1.15. the local people were very loyal to the species of *Eucalyptus globulus* Labill. to treat respiratory diseases with a precision level of 100%. In addition this population was agreed on the treatment of gastrointestinal disorders, with a value of the consensus informing factor (ICF) of the order of 0.91. And finally, this study, conducted in the Guerbes-Sanhadja wetland complex, allowed us to conclude that the local population of the study area remains very dependent on medicinal plants to treat various diseases despite the development of modern medicine. It can be set up a database for the valuation and conservation of medicinal plants in order to discover new active ingredients that can be used in pharmacology and to protect this wealth.

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