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Ethnobotanical characterization of halophytes with medicinal virtues, Case of the Macta wetland flora: North-West Algeria

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Abstract

Here is an ethnobotanical study on halophytic plants with medicinal virtues traditionally used by the populations surrounding the Macta wetland (north-western Algeria). An ethnobotanical survey was carried out and the data collected were statistically analyzed by using the *R* software and 150 questionnaire sheets. The results obtained allowed the identification of 53 plants including 32 halophytic species with medicinal virtues belonging to 28 genera and 17 botanical families. On the basis of the ethnobotanical survey, we identified 43.75% of the species that are used as anti-inflammatory, 28% to treat diuretic disorders, 21.87% to treat uro-genital disorders, 18.75% for their effects on the digestive system, and 15% of the plants which are used against diabetes. Multifactorial analysis reveals a good correspondence between the ethnobotanical aspect of plant species and their therapeutic uses. The results obtained indicate the appearance of five typical use profiles specific to medicinal virtues.

Keywords: Ethnobotanical surveys, spontaneous medicinal plants, phytotherapy, Macta, North West Algeria.

Introduction

The valorization of natural resources is a concern that has become increasingly important in many countries in recent decades. Thus, since its General Assembly, the WHO has been recommending the evaluation of the safety and efficacy of plant-based medicines with a view to standardize their use and to integrate them into conventional health care systems (O.M.S. 2002).

In Algeria, traditional medicine has long been used thanks to the richness and diversity of its flora, which constitutes a real phylogenetic reservoir, with about 3000 species and subspecies of vascular plants, which enables it to occupy a privileged place among the Mediterranean countries that have a long medical tradition and traditional know-how based on medicinal plants (Bouzid et al., 2017). However, the Algerian medicinal forest remains little-known nowadays because, out of the few thousand plant species, the number of medicinal species does not exceed 600 (Mokkadem, 1999). That's to say 15% of the total Algerian forest. It certainly constitutes an integral part of the culture of the Algerian population. The halophytes are part of this reservoir thanks to their multiple ecological and agroalimentary interests (Batanouny, 1994). Some of them have been used in traditional medicine for centuries (Batanouny, 1994; Mokkadem, 1999; Paetzold, 1989; Squires, 1994). Currently and thanks to their richness in biologically active molecules, several halophytic species are used as remedies against certain diseases such as cancers, gastrointestinal diseases, urinary tract and liver problems, inflammations, diabetes and dental caries (Ksouri et al., 2008).

On one hand, in Algeria, many researchers have carried out in-depth studies on a large number of medicinal plants (Adjadj, 2009; Aissaoui, 2010; Hamimed, 2009), but on the other hand, no ethnobotanical studies have been carried out on spontaneous medicinal plants in wetlands and in particular the Ramsar site known as the Macta marshes.

The present work proposes to fill, at least in part, this gap in one of the most important Ramsar sites in Algeria. Thanks to its biogeographical position, its plant diversity, as well as the knowledge on the traditional use of certain plants in the treatment of diseases, the Macta wetland in the North-Western of Algeria, provides a very important field of work. In this perspective, the objectives of this work are (i) To list and count the halophytic plants with medicinal virtues in the Macta wetland, (ii) To evaluate the richness and diversity of this medicinal flora in the study area and (iii) To recall the therapeutic properties and traditional use of halophytes with medicinal virtues present in the study area.

Materials and methods

This article is part of an approach that aims, through an ethnobotanical survey (Annex) and a bibliographical study of biological activities, at studying the biodiversity of halophytes with medicinal virtues, at highlighting them and to offer researchers a research axis for better exploitation of halophytes.

Study region

The Macta wetland is a triangular depression covering an area of 44500 ha. It is located in North Western Algeria [latitude 35.607°N and longitude 0.0489°W] (Fig. 1). It is bounded to the North by the Mediterranean Sea, to the south by the mountains of Beni-Chougrane, to the East by the Mostaganem plateau and to the west by the Sebkha of Oran. The study area is fed by three main rivers: Wadi Sig, Wadi Habra and Wadi Tinn. On the geological level, there are four geological formations: the marine Pliocene, the continental Pliocene, the Calabrien and the continental Quaternary (Gaucher and Simmoneau, 1951).

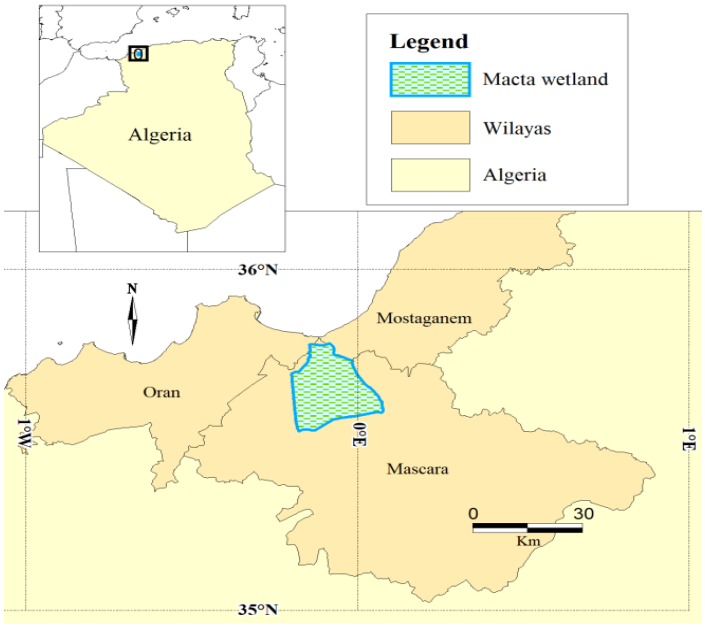

Figure 1. Location of the Macta wetland.

The bioclimate is semi-arid with a mean annual rainfall ranging from 380 to 450 mm, but rainfall can drop from 250 to 300 mm during deserted periods and a thermal regime ranging from 17 to 19°C (Megharbi, 2017). The soils are related to: (i) dune soils, (ii) alluvial soils where clay

texture dominates at the level of the plains and (iii) solontchaks and solonetzs for the rest of the wetland (Gaucher and Simmoneau 1951, Sitayeb and Benabdeli 2008). The spontaneous flora of the Macta wetland includes 477 species in 76 families and 282 genera, 45% of which are halophytes (Megharbi, 2009).

Sampling

Our work strategy consisted of the following two axes:

Species collection

We chose subjective sampling in five main habitats (Quezel and Santa, 1962, 1963). 50 floristic surveys were carried out on quadrates with a minimum area of about 100 m² (Le Floch et al., 2010). The taxonomic identification of the species was done with the help of specialists and plant catalogs (Barbault, 1992). The nomenclature adopted is that of the flora of Algeria and the Synonymous Catalogue of the flora of Tunisia (Simmoneau, 1952; Vidal, 1998).

Ethnobotanical data collection

The information was collected through semi structured interviews, questionnaires and personal observations. A questionnaire was administered to the local people, through face to face interviews. The mean age of the 150 respondents (50 men and 100 women) was 54.8 years (ranging from 20 to 90 years). During these interviews, only people who had knowledge regarding medicinal plants were invited to a survey study. The questioning is focused on the following information (age, sex, therapeutic practice).

Biodiversity indices

We have retained the Shannon-Weaver index in the different sitesin order to describe the specific diversity of medicinal halophytes. The evaluation of the specific diversity of the different groupings was completed by the equitability index (E). The Shannon-Weaver index varies from 0 to 5 bits, while equitability varies from 0 to 1. It tends towards 0 when almost all the numbers are concentrated on one species. It is 1 when all the species have the same abundance (Deil, 2005).

Statistical approach

Principal component analysis proposes, from a rectangular table of data, the values of quantitative variables (therapeutic properties) for *n* units (plant species). The factorial axes are interpreted from the contributions of the considered variables (Belouahem-Abed et al., 2009). The hierarchical ascending classification allows these properties to be grouped in the form of steps according to Euclidean distance. The collected data were processed using the R software (*version 3.4.1*).

Results

The ethnobotanical surveys carried out in the field allowed us to elaborate a catalog of 105 plant species. We present in this article 53 halophyte species among these, 32 of which were identified by the people who underwent our survey as species with medicinal virtues. The monographs of these 32 species are presented in alphabetical order of families, biological types and chorological types (Table 1). For each species, we have specified the local use and therapeutic properties (Table 2).

Table 1. List of species encountered in the field.

Species	Family	Biological forms	Chorology characteristic
Mesembryanthemum nodiflorum	Aizoaceae	TH	Mediterranean
Aizoon hispanicum	Aïzoaceae	TH	Mediterranean -Irano-Touranian
Mesembryanthemum crystallinum	Aïzoaceae	TH	Sub-Cosmopolitan
Arthrocnemum macrostachyum	Amaranthaceae	CH	Mediterranean
Atriplex halimus	Amaranthaceae	CH	Mediterranean
Atriplex prostrata	Amaranthaceae	TH	Circumboreal
Beta macrocarpa	Amaranthaceae	TH	Mediterranean
Caroxylon vermiculatum	Amaranthaceae	TH	Saharo-Sindian
Salsola kali	Amaranthaceae	TH	Palaeo-Temperate
Sarcocornia fruticosa	Amaranthaceae	CH	Cosmopolitan
Suaeda fruticosa	Amaranthaceae	CH	Cosmopolitan
Suaeda maritima	Amaranthaceae	CH	Cosmopolitan
Bupleurum semicompositum	Apiaceae	TH	Mediterranean
Chamaemelum fuscatum	Asteraceae	TH	North Africa
Lactuca saligna	Asteraceae	TH	Sub Mediterranean
Scorzoneroides muelleri	Asteraceae	TH	Mediterranean
Senecio glaucus	Asteraceae	TH	Mediterranean -Irano-Touranian-Saharo-Sindian
Hymenolobus procumbens	Brassicaceae	TH	Cosmopolitan
Silene rubella	Caryophyllaceae	TH	Mediterranean
Spergularia diandra	Caryophyllaceae	TH	Sah-Sind-Irano-Tour
Spergularia marina	Caryophyllaceae	TH	Mediterranean-Steppe
Chenopodium murale	Chenopodiaceae	TH	Cosmopolitan
Cressa cretica	Convolvulaceae	CH	Sub-Cosmopolitan
Carex divisa	Cuperaceae	G	Mediterraneo-Atlantic
Bolboschoenus glaucus	Cyperaceae	Hcri	Cosmopolitan
Frankenia laevis	Frankeniaceae	Hcri	Palaeo-Temperate
Frankenia pulverulenta	Frankeniaceae	TH	Mediterranean
Schenkia spicata	Gentianaceae	Hcri	Mediterranean
Juncus acutus	Juncaceae	G	Sub-Cosmopolitan
Juncus bufonius	Juncaceae	Hcri	Cosmopolitan
Juncus maritimus	Juncaceae	Hcri	Sub-Cosmopolitan
Juncus subulatus	Juncaceae	Hcri	Circum-Mediterranean
Teucrium pseudo-chamaepilys	Lamiaceae	CH	Mediterranean
Plantago coronopus	Plantaginaceae	Hcri	Palaeotemperate
Limonium delicatulum	Plumbaginaceae	Hcri	Mediterranean
Limonium duriaei	Plumbaginaceae	Hcri	Endemic
Limonium lobatum	Plumbaginaceae	TH	Mediterranean
Atropis convoluta	Poaceae	CH	Palaeotemperate
Festuca arundinacea	Poaceae	Hcri	Circumbor
Hainardia cylindrica	Poaceae	TH	Mediterranean
Phragmites australis	Poaceae	Hél	Cosmopolitan
Rostraria cristata	Poaceae	TH	SubCosmopolitan
Schismus arabicus	Poaceae	TH	Macar-Mediterranean
Aeluropus littoralis	Poaceae	Hcri	Circum-Mediterranean
Hordeum murinum	Poaceae	TH	Circum-Boreal
Parapholis incurva	Poaceae	TH	Mediterranean
Sphenopus divaricatus	Poaceae	TH	Paleo-Subtropical
Rumex crispus	Polygonaceae	CH	Cosmopolitan
Ranunculus aquatilis	Renonculaceae	Hél	Cosmopolitan
Limbarda crithmoides	Synantheraceae	CH	Mediterraneo-Atlantic
Tamarix africana	Tamaricaceae	PH	Mediterranean
Tamarix gallica	Tamaricaceae	PH	North Tropical

Legende : *Th :Therophytes ; PH : Phanerophytes ; Hél: Helophyte ; CH: Chamaephytes ;* Hcri : *Hemicryptophytes ; G: Geophyte. Cosm. Cosmopolitan ; Atl. Atlantique ; Irano-Tour : Iranian-Touranian. Sah-Sind. : Saharo-Sindian ; Eur. Europe ; End. Endemic ; Macar. : Macaronesian*.

Table 2. List of halophyte species with medicinal properties in the Macta wetland.

Species	Therapeutic properties	Part used
Aeluropus littoralis	Fever, Diarrhea	Leaf
Arthrocnemum macrostachyum	Anti-inflammatory, Fortifier	Leafs, Seed
Atriplex halimus	Digestive disorders, Dermal Disorders, Antidiabetic, Antiseptic, Anti-rheumatismal	Decoction
Atriplex prostrata	Anti-inflammatory	Whole plant
Bolboschoenus glaucus	Astringent, Antidiabetic, Diuretic	Rhizome
Caroxylon vermiculatum	Digestive disorders	Seed
Chamaemelum fuscatum	Anti-inflammatory	Leafs
Chenopodium murale	Anti-inflammatory, Anti-rhumatismal, Digestive disorders	Decoction, pass
Cressa cretica	Antidiabetic, Anti-inflammatory	Leafs
Festuca arundinacea	Genito-urinary disease	Bousses
Frankenia pulverulenta	Anti-inflammatory	Leafs
Hordeum murinum	Metabolic disorders, Fortifier	Whole plant
Juncus acutus	Diuretic, Anti-inflammatory, Colic, Genito-urinary disease, Sedative	Fruits Decoction
Juncus maritimus	Digestive disorders, antidiabetic	Fruits Decoction
Lactuca saligna	Fever, diahrée, Genito-urinary disease	Leafs
Limbarda crithmoides	Diuretic, Anti-inflammatory	Leafs
Limonium delicatulum	Anti-inflammatory, Liver diseases	Seed
Limonium lobatum	Astringent	Stem
Mesembryanthemum crystallinum	Antiseptic, Diuretic, Dermatological disordres, Anti-inflammatory, Genito-urinary disease, Respiratory disordres	Leafs
Mesembryanthemum nodiflorum	Digestive disorders, Anti-inflammatory	Leafs
Peganum harmala	anti-rheumatismal, Anti-inflammatory, Genito-urinary disease, Sedative	Seed
Phragmites australis	Antidiabetic, Diuretic	Leafs
Rumex crispus	Respiratory disordres	Seed
Salsola kali	Diuretic	Leafs
Sarcocornia fruticosa	Diuretic, Liver diseases, Digestive disorders, Fortifier	Fresh plant
Schenkia spicata	Dermatological disordres	Seed
Schismus arabicus	Astringent, Diuretic	Leafs
Silene rubella	Anti-inflammatory, Sedative	Seed
Spergularia diandra	Genito-urinary disease	Extract
Spergularia marina	Anti-inflammatory, Genito-urinary disease	Extract
Suaeda vera	Osteoarticular disorders, Antidiabetic, Liver diseases	Whole plant
Suaeda maritima	anti-rheumatismal, Anti-inflammatory	Extract
Tamarix africana	Astringent, Anti-inflammatory	Leafs
Tamarix gallica	Astringent, Diuretic, antidiabetic, Cardio-vasculaire disorders	Leafs, écorce
Teucrium pseudo-chamaepilys	Anti-inflammatory, Antiseptic, Digestive disorders	Leafs

Biological types

With an analyzing of Table 1, we found that Therophytes represent 49.05%, while Chamaephytes and Hemicryptophytes represent at least 20.75% of all species encountered. The percentage of Geophytes and Phanerophytes reaches 3.77% while Heliophytes constitute 1.88%.

Families with frequent use

The results obtained show that the medicinal halophytes identified in the study area are divided into 13 families and 20 genera. Among the 13 families identified those mostly represented in this region are: Amaranthaceae (33.33%), Poaceae (11.11%), Juncaceae (7.40%), Tamaricaceae (7.40%), Synantheraceae (7.40%) and Aïzoaceae (7.40%). The other families represent a rate of about 3.7% (Fig. 2).

Biogeographic Elements

While examining, we notice that the species are the Mediterranean species that predominate in this formation with 33.96%. The cosmopolitan species come in the second position with a portion of order 28.30%. In third position are the broadly distributed species with a portion of order 18.86%, followed by Nordic species 15.09%. Finally, two endemic halophytic species with medicinal virtues present a rate of 3.77%.

Biodiversity analysis

There are five main habitats in the Macta marshes; coastal sands, wet meadows, lawns, swamps, and succulent salt steppes (Quezel and Santa, 1962, 1963). The wet meadows contain a very important number of medicinal halophytes. This is the *Sarcocornia fruticosa* grouping (Table 3). Wet depressions occupy second place with ten medicinal halophytic species, dominated mainly by *Cressa cretica*. Coastal sands and marshes contain the same number of medicinal halophytic species. These two environments are dominated respectively by: *Mesembryanthemum crystallinum* and *Phragmites australis*. Finally, the salt steppes, an environment dominated by *Suaeda vera* contains three medicinal halophytes.

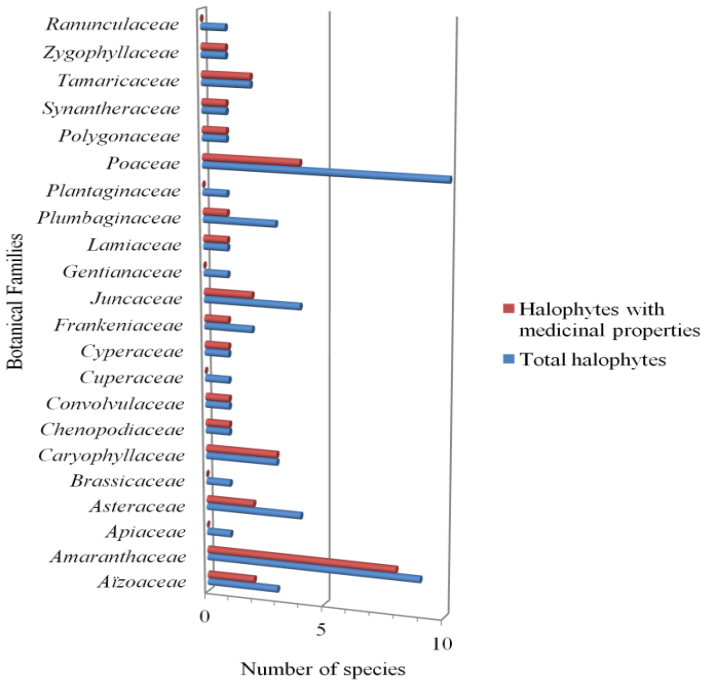

Figure 2. Comparative of botanical families with medicinal properties of Macta wetland halophyte.

Table 3. Biodiversity indices of medicinal halophytes

	Coastal sand	**Wet meadows**	**Wet depressions**	**Mashes**	**Salty steppes**
Medicinal Halophytes	4	14	7	4	3
	12.5%	43.75%	21.87%	12.5%	9.37%
Average richness	11.2	5.3	7.5	12.8	14
Shannon Index	1.272	1.331	1.620	1.613	1.902
Piélou Index	0.526	0.798	0.804	0.632	0.720

Biodiversity indices

Diversity index values are lower in near shore sands and wet grasslands than in the other three habitats (Table 3). The equitability of Pielou leads to the conclusion that wet depressions present a homogeneous and specialized environment.

Therapeutic properties

The hierarchical ascending classification reveals five classes of traditional therapy, which are the anti-inflammatory, astringent and diuretic properties, genitourinary affections, digestive affections and finally metabolic affections (Fig. 3).

The analysis of the main components of the therapeutic effects gave the results that we present in the two figures 4 and 5:

On the hand, on the positive side, at the end of axis 1, a group of species with strong contributions namely *Mesembryanthemum crystallinum*, *Juncus acutus*, *Tamarix africana* and *Peganum harmala* well correlated with anti-inflammatory properties (3.087) and those related to genitourinary disorders (1.043). On the other hand, on the negative side, we note the presence of *Bolboschoenus glaucus*, *Tamarix gallica* and *Schismus arabicus*, which are related to astringent activities (-0.849). The axis 2 remains explained in its positive side the species used as diuretic (+2.27) namely *Mesembryanthemum crystallinum* and *Lactuca saligna*. This axis opposes on its negative side the species effective against the digestive affections (-1.34) and which possess antirheumatic activities (-0.790) namely respectively *Atriplex halimus*, *Sarcocornia fruticosa* and *Teucrium pseudo-chamaepilys* (Figure 4).

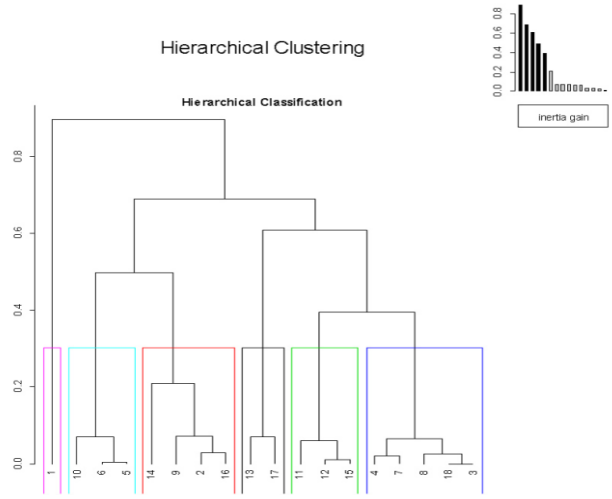

Figure 3. Dendrogram of the therapeutic properties of Macta halophytes.

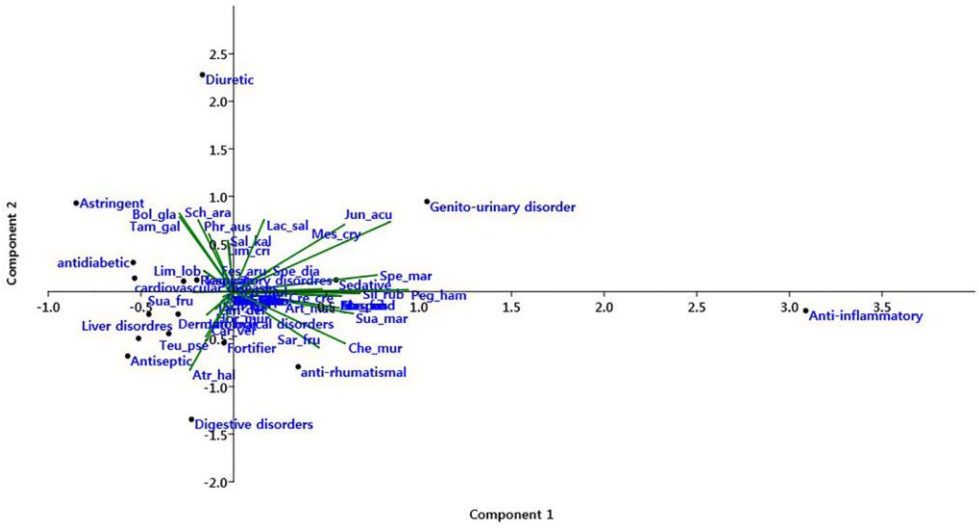

Figure 4. PCA factor A1-A2 design.

Axis 3 shows on its positive side the use of halophytes for endocrine disorders (diabetes) (+1.205) of which three species are included *Atriplex halimus*, *Teucrium pseudo-chamaepilys* and *Chenopodium murale*. The negative side of this axis explains the traditional application against genito-urinary affections (-1.374) and dermal affections (-0.730) and respiratory affections (-0.591). The species correlated by these uses are *Silene rubella*, *Spergularia marina*, *Atriplex halimus* and *Rumex crispus* (Fig. 5). It is distinguished that these halophytes play an important role in the regulation of the metabolism and can be used as vitamins.

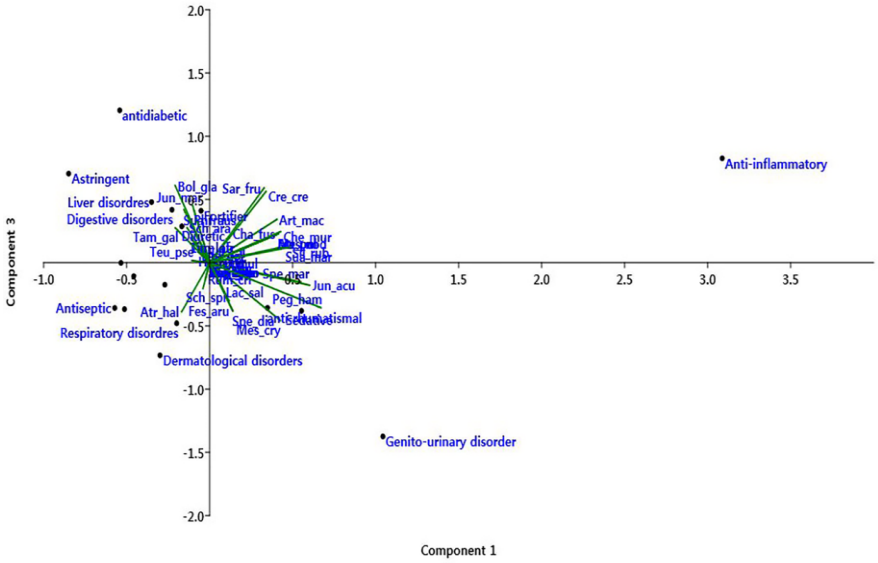

Figure 5. PCA factor A1-A3 design

Discussion

Therophytes mainly make up the biological spectrum. The dominance of annual species reflects the adaptation of communities to unpredictable environmental conditions (Tomaselli et al., 2011). Hemicryptophytes are also fairly well represented. Wetlands are generally favorable to their proliferation (Dargie and El Demerdash, 1991). The richest families are Amanranthaceae, Poaceae, Juncaceae, Tamaricaceae, Synantheraceae and Aïzoaceae, with respectively 33.33%, 11.11%, 7.4%, and 7.4% of taxa. This order is different from that recorded for the whole flora of salt marshes in Italy (Adi et al., 2016) and that of the Mediterranean coast of Sinai (Megharbi, 2017). Chorologically, the Mediterranean element dominates the other elements (Benwahhoud et al., 2001). The meadows and wet depressions shelter an important diversity of medicinal halophytes, which gives a strong chance for the multiplication of these species (Saidana et al., 2008, 2012).

Conclusion

The flora of halophytes with medicinal virtues in the wetland of the Macta is rich with 27 species among which we count 47% of Therophytes and 37% of Chamaephytes. The distribution of these species in the major taxonomic groups indicates that the dominant families are Amaranthaceae and Poaceae. These species are diversely distributed according to continent and more than 44% are Mediterranean. The Ethnobotanical investigations carried out in the Macta wetland show that the thirty-two medicinal halophytes species identified are used, in different forms of medicinal preparations, in the fight against various pathologies (diabetes, digestive problems, inflammation…etc.). The therapeutic effects of these halophytes are multiple and constitute a basis for the pharmaceutical industry.

Many halophyte species with medicinal virtues in the wetland of Macta, have become threatened

due to habitat loss caused by several factors (draining of marshes, rapid urbanization and pollution). Thus, the current result can be integrated into future management plans for the conservation of threatened medicinal plants, while local populations should be involved in the formulation of problems and in the decision-making process.

Despite the importance of these medicinal plants reported, much of this potential remains poorly and undervalued for a variety of reasons ranging from lack of knowledge to lack of efforts to conserve this heritage. This article constitutes a source of information / which contributes to knowledge of halophytes with medicinal virtues and to a safeguarding of the local popular know-how. It can also constitute a database for the valorization of medicinal halophytes of wetlands in Algeria with a view to the active principles that can be used in pharmacology.

Author's Contributions

Dr Megharbi Ahmed contribution: field trips, carrying out statistical processing.

Dr Kechairi Réda contribution: drafting and correspondence of the manuscript.

Ethics

No conflicts to report.

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