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Floristic composition of the halophilic and salt-resistant plant population in Hammam-Boughrara (Oran-Algeria)

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ABSTRACT

This phyto-ecological study is on halophilic and salt-resistant vegetation of Oran region. The semi-arid and sometimes arid climate has been defined and confirmed from a bioclimatic point of view. The pedological approach used shows a soil with sandy to silty-sandy texture, favoring regression of the vegetation and a halophilic vegetation set up. In this study, we analyze the floristic composition of the northern region of Hammam Boughrara using multiple floristic surveys conducted at three stations along the Tafna wadi. Dominated by Mediterranean and Saharo-Sindian elements, the relatively poor flora (88 species in total) is biologically characterized by a clear dominance of therophytes (>33%) and chamaephytes (>19%) to the detriment of phanerophytes.

Keywords: Phyto-Ecology; Salt-Resistant Vegetation; Halophilic Vegetation; Botanical Characterization; Bioclimate; Hammam Boughrara; Oran (Algeria)

1. INTRODUCTION

The Maghreb has one of the most remarkable floras of the Mediterranean basin. This may explain its climatic, geographic and geological diversity. Algeria in general and Oran in particular, is an area characterized by significant plant diversity.

For a long time, the flora and landscape of this region have been coveted and reshaped by the cultivation and grazing. The area is located solely in a semi-arid and arid bioclimate, with a temperate winter; the area is also subject to problems related to continentality in western Algeria.

The vegetation of the Oranian saline soils has been studied by Simonneau [1], Dubuis and Simonneau [2,3] and Quézel and Simonneau [4], and its distribution relates to the soil salinity. The dominant plants are annual or perennial Salsolacea, forming either pure populations or associations, comparable to those described in the south of France [5].

In the Hammam-Boughrara region, vast areas of both Tafna wadi shores, unsuitable for cultivation, are covered with halophytes. These soils, saturated with Na^+ ions, are classified among Solonchak soils [6]. Their appearance is due to the phreatic water which deposits its salts on the surface during evaporation [2,7].

Knowledge of the natural vegetation, as a reflection of environmental conditions, should allow a diagnosis of the first face plant in these ecosystems.

The works in the region remain somewhat fragmented. We intend contribute floristic surveys that may be useful. The interpretation of the Oran halophilic populations is possible and effective in light of pre-forest formations derived from, because of the strong anthropic pressure exerted in the region. The area was also affected by drought from 1970 to 2000.

Through the various works done on this region [8,9], we have tried to identify the halophytes phytoecology aspects in the Northwest of Algeria (North of Hammam-Boughrara). Can these aspects give us some suggestions for improving the disrupted flora capital? Do halophilic populations expanse exclusively on the North banks of Tafna wadi? In an attempt to answer to these questions, we will deal in this paper successively through:

Description of the physical environment;
Bioclimatic and edaphologic characters;
Floristic analysis.

2. SITES AND METHODS

2.1. Location and Choice of Sites of Study (Figure 1)

The study area is located in western Algeria and be-

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longs administratively to the wilaya of Tlemcen. It is naturally confined by the Traras Mountains on the northwest and the Tlemcen Mountains on the south. The Hammam Boughrara municipality (study area) is limited administratively:

- To the west by the municipalities of Maghnia and Djabala.
- To the south by the municipalities of Remchi and Sabra;
- To the east by the municipalities of Hennaya and Tlemcen;
- And to the north by those of Zenata and Remchi.

The choice of stations considered to be representative was made to reflect the greatest plant diversity of the study area and was directed by the presence of salt tolerant populations. Three sites were selected through a stratified sampling: Zenata, Remchi and Hammam Boughrara (**Table 1**).

These sites differ from each other by geographic location, topography, soil, anthropogenic factors and vegetal diversity.

2.2. Bioclimatic Situation

Belonging to the Mediterranean bioclimate, the northern region of Hammam Boughrara is characterized by dry periods that can last 6 to 7 months. The bioclimate of the region has been studied by Ghezlaoui [8,10] and Bemmoussat [11]. The area receives winter Mediterranean drizzling rains which last longer than those in the summer. March and April rains are heavy and frequent, whereas January and February rainfalls are lighter, but more frequent.

Annual rainfall varies between 280 mm and 300 mm (with a maximum of 49 mm in March and a minimum of 1.5 mm in July). This shows important variability between months and places.

The climate is semi-continental with a temperature range of about 27˚C. January is the coldest month (9.5˚C), and August the hottest (29.2˚C) [11].

The pluviothermic Emberger quotient (Q_2) [12] permits the halophilic populations to establish in the lower semi-arid and higher arid bioclimates with cool to temperate winter variation.

2.3. Soils of the Region

Soil studies, in North Africa in general and in this particular region, were carried out by Simonneau [13], Ruellan [14], Pouget [15], Alcaraz [16], Aimé [17] and Benabadji *et al.* [18].

The analytical results obtained on some soil samples in the three sites show:

- A sandy texture in Hammam Boughrara (72% sand) and silty-sandy texture (17% silt, 68% sand) in Remchi and Zenata.
- A total lime content between 2.52% and 18.80% in the region of Remchi. Hammam Boughrara soils have higher $CaCO_3$ content (above 25%).
- The pH is basic in all the sites. It also records a value greater than 7 in all the samples.
- Salinity (electrical conductivity) varies from slightly salty to salty. The minimum thresholds are reached in Zenata region (0.7 and 0.8 mS/cm), the upper limits are obtained in Hammam Boughrara with 1.21 mS/cm.
- Organic matter is relatively low for all stations (0.104% to 2.21%.
- The color according to the Munsell code ranges from 5YR 5/6, 7.5 YR 6/6 and 10YR 6/4 for all the stations.

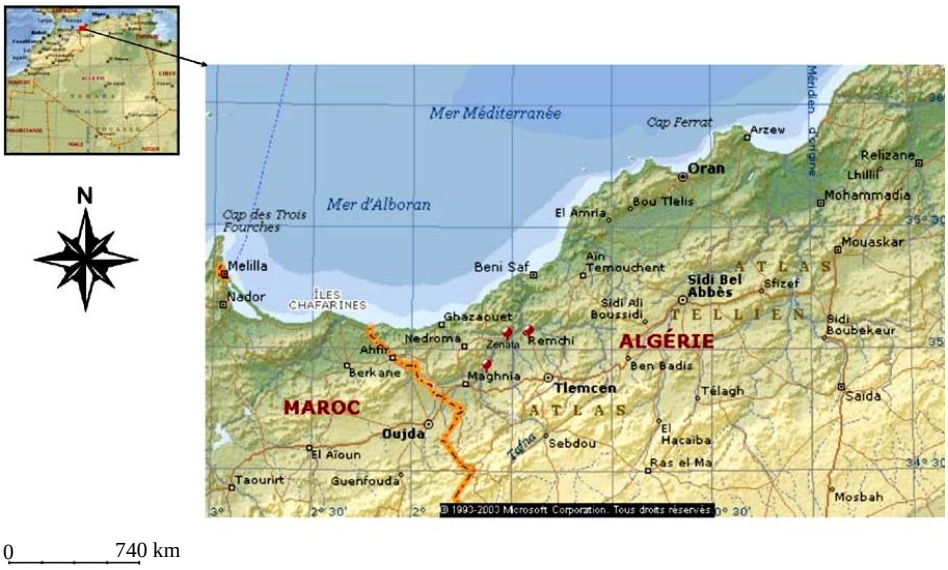

Figure 1. Geographical location of study sites.

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3. METHODOLOGY

Floristic Surveys

The vegetation of the study station indicates a pre-forest and halophilic physiognomy, except on some mountain slopes located further north (Traras Mountains). In this area, rainfalls may reach 400 mm annually. It also contains degraded remnant forests, formed by *Pinus halepensis*, *Juniperus oxycedrus* and *Pistacia atlantica*.

Floristic surveys were conducted in spring periods, in spaces occupied by the Chenopodiaceous, which spread over the borders of Tafna wadi and near cultivations.

The surface records must be sufficient to obtain almost all the species present, in the floristically homogeneous station, corresponding to the minimum area [19].

According to Quézel *et al.* [20] areas are from 100 to 400 m^2 for forest communities, from 50 to 100 m^2 for the scrubland formations and 20 to 50 m^2 for herbaceous vegetation. For this survey we deliberately chose a 100 m^2 area (minimum area).

During the survey, each identified species was affected by two indices; the first reflects the abundance-dominance and the second sociability. The presence and the number of individuals were also noted, using the Braun Blanquet method [21].

The determination of biological types of the 88 species recorded was based on the Raunkiaer method [22]. All life forms were considered, regardless of the different subdivisions for the size variation, morphology and arrangement of the various organs. We also determined morphological and biogeographic types. Inventoried taxa were identified from the Flora of Algeria [23], Sahara [24,25] and France [26].

4. RESULTS AND INTERPRETATIONS

4.1. Floristic Surveys

- **Zenata station (Table 1 in appendix)**

The conducted surveys allowed us to distinguish 02 major categories of plant species; nitratophiles and halophytes. Nitratophiles are mostly annual (*Erodium moschatum*, *Sanguisorba minor*, *Papaver rhoeas*, *Avena sterilis*…), and were strongly present in all surveys. They constituted grass areas, and infiltrated cultivated zones and *Atriplex* areas. Rich and varied, the halophilic group is dominated *by Atriplex halimus*, *Salsola vermiculata*, *Suaeda fruticosa*, *Lygeum spartum* and *Arthrophytum scoparium*. It is characteristic of Atriplico halimi-Suaedetum fruticosae ass. nov. *in* Aimé [17] and Salsolo-Peganion alliance. The rate of recovery varies from one place to another. In depressions, these populations reach 30% and become rare on the wadi beds. *Malva sylvestris*, *Ziziphus lotus*, *Pallenis spinosa* and companion species are poorly represented in the surveys.

- **Remchi station, Tafna wadi (Table 2 in appendix)**

At first glance, in this clump, an asymmetry emerges, resulting in a wooded, slightly inclined station and another with steep cleared slopes.

Surveys conducted along the banks of Tafna wadi show a diversified landscape infiltrated by pre-forest populations (*Teucrium polium*, *Ampelodesma mauritanicum*, *Cistus albidus* and *Thymus ciliatus*. Classes of Thero-Brachypodietea [27] and Stellarietea mediae [28] are well represented with the following species: *Muricaria prostrata*, *Aegilops triuncialis*, *Astragalus pentaglottis*, *Salvia verbenaca*, *Calendula arvensis*, *Plantago ovata* etc. These species are mostly annual therophytes said nitratophiles. The use of fertilizers eliminates the most sensitive species and promotes the development of the nitratophilic ones. In this region, greenhouse crops are taking considerable hold. We distinguished these species, mixed in with those belonging to the Salsolatea vermiculatae class, the Atriplico halimi-Suaedetum fruticosae ass. nov. *in* Aimé [17] association and the Salsolo-Peganion alliance. They are halophytes as *Atriplex halimus*, *Salsola vermiculata*, *Lygeum spartum*, *Tamarix gallica* and *Suaeda fruticosa*. The average height of *Atriplex halimus* shrubs may reach 2 meters high. The therophytes take place between *Salsola* and *Atriplex* shrubs; their size does not exceed 12 cm. The *Tamarix gallica* species, surrounding the wadi edges, reaches 4 to 5 m high.

- **Hammam Boughrara station (Table 3 in appendix)**

The surveys were done at a study site in the immediate vicinity of an agricultural plain, part of the great plain of Angad extending to Fez in Morocco. Only this station has a tree stratum. Thin, but relatively diversified with *Olea europea* and *Ceratonia silica*, forming the Oleo-ceratonion alliance, and *Acacia albida called now Faidherbia albida* and *Tamarix gallica*. It is very likely that a regressive evolution of this ecosystem is occurring. The

Table 1. Location of study sites.

Study sites	Latitude	Longitude	Altitude	Municipality	Wilaya
Zenata	35˚02'N	1˚33'W	249 m	Zenata	Tlemcen
Remchi	34˚03'N	1˚24'W	200 m	Remchi	Tlemcen
Hammam-Boughrara	34˚54'N	1˚37'W	280 m	Maghnia	Tlemcen

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number of encountered shrubs and bushes species, however, remains positive in this regressive dynamic state. The classes of Thero-Brachypodietea [26] and Stellarietea mediae [27] are well represented in this study station; they are annual or perennial grasses. An arid climate and the anthropozoogenic pressure means that halophytes are present with the Salsoletea vermiculatae class. We found, in particular, *Atriplex halimus* appearing in dense shrub forms. We also noticed *Salsola vermiculata*, *Tamarix gallica*, *Frankenia corymbosa* and *Frankenia laevis*.

4.2. Floristic Analysis

The study of vegetation (**Table 2**) is divided into 33 families. **Figure 2** shows the distribution of these families for each station. In Remchi and Zenata stations, the plant family having the greatest diversity of flora was Chenopodiaceae, followed by the Poaceae family. Hammam Boughrara is essentially characterized by the Asteraceae and Poaceae families (9 species).

- **Biological types**

In the literature [29-31] biological types are considered as a biological experience of the flora and vegetation adaptive strategy to environmental conditions. In each study station, the most dominant biological type corresponded to therophytes (**Th**) (**Table 3**).

The chamæphytes took the second dominant position. This chamæphytisation occurs due to the phenomenon of aridification [22,32,33]. In these halophilic and salt-resistant vegetations, the majority of the chamæphytes (**Ch**) met are *Salsola vermiculata*, *Salsola foetida*, *Salsola sieberi*, *Arthrophytum scoparium*, *Atriplex halimus* and *Suaeda fruticosa*.

Table 2. List of species present in North of Hammam Boughrara (Remchi, Zenata, Hammam-Boughrara).

Dobignard "2007"	Quézel & Santa 1962-1963	Families Q & S	Biologic types	Morphological types	Biogeographic types Q & S
Faidherbia albida (Delile) A.Chev.	*Acacia albida*	Mimosées	Ph	L.V	Afr. Trop.
Aegilops cf. triuncialis L.	*Aegilops triuncialis*	Graminées	Th	H.A	Méd. Irano. Tour.
Aeluropus cf. littoralis (Gouan) Parl.	*Aeluropus littoralis*	Graminées	Ge	H.V	Circumméd.
Agave americana L.	*Agave americana*	Amaryllidacées	Ge	L.V	Naturalisé
Elytrigia atherica (Link) M.A.Carreras ex Kergu	*Agropyrum littorale*	Graminées	Ge	H.V	End.
Allium roseum L.	*Allium roseum*	Liliacées	Ge	H.V	Méd.
Ammoides pusilla (Brot.) Breistr.	*Ammoides verticillata*	Ombellifères	Th	H.A	Méd.
Ampelodesmos mauritanicus (Poir.) Durand & Schinz	*Ampelodesma mauritanicum*	Graminées	Ch	H.V	W. Méd.
Anagallis cf. arvensis L.	*Anagalis arvensis*	Primulacées	Th	H.A	Sub. Cosmop.
Artemisia herba-alba Asso	*Artemisia herba-alba*	Composées	Ch	L.V	Esp. des canaries à l'Égypte, Asie Occ.
Hammada scoparia (Pomel) Iljin	*Arthrophytum scoparium*	Chénopodiacées	Ch	H.V	Sah. Méd.
Asparagus acutifolius L.	*Asparagus acutifolius*	Liliacées	Ge	L.V	Méd.
Asparagus albus L.	*Asparagus albus*	Liliacées	Ge	L.V	W. Méd.
Asparagus stipularis Forssk.	*Asparagus stipularis*	Liliacées	Ge	L.V	Macar.-Méd.
Pallenis maritima (L.) Greuter	*Asteriscus maritimus*	composées	Ge	H.V	Canaries, Eur. mérid. A.N.
Astragalus echinatus Murray	*Astragalus pentaglottis*	Papilionacées	Th	H.A	Méd.
Atractylis carduus (Forssk.) H.Christ	*Atractylis carduus*	Composées	Ch	H.V	Sah.
Atriplex dimorphostegia Kar. & Kir.	*Atriplex dimorphostegia*	Chénopodiacées	Th	H.A	Sah-Sind
Atriplex glauca L.	*Atriplex glauca*	Chénopodiacées	Ch	L.V	Sah-Méd.
Atriplex halimus L.	*Atriplex halimus*	Chénopodiacées	Ch	L.V	Cosmop.
Avena cf. barbata Pott ex Link	*Avena alba*	Graminées	Th	H.A	Méd-Irano-Tour.
Avena sterilis L.	*Avena sterilis*	Graminées	Th	H.A	Macar-Méd-Irano-Tour.

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Ballota hirsuta Benth.	*Ballota hirsuta*	Labiées	Ch	H.V	Ibéro-Maur.
Bellis annua L.	*Bellis annua*	Composées	Th	H.A	Circumméd.
Brachypodium distachyon (L.) P.Beauv.	*Brachypodium distachyum*	Graminées	Th	H.A	Paléo-Subtrop.
Brassica nigra (L.) W.D.J.Koch	*Brassica nigra*	Crucifères	Th	H.A	Euras.
Anisantha rubens (L.) Nevski	*Bromus rubens*	Graminées	Th	H.A	Paléo. Subtrop.
Calendula cf. arvensis L.	*Calendula arvensis*	Composées	Th	H.A	Sub-Méd.
Calicotome intermedia (Salzm.) C.Presl	*Calycotome intermedia*	Papilionacées	Ch	L.V	W. Méd.
Ceratonia siliqua L.	*Ceratonia siliqua*	Césalpiniées	Ph	L.V	Méd.
Chamaerops humilis L.	*Chamaerops humilis subsp argentea*	Palmacées	Ph	L.V	W. Méd.
Plagius grandis (L.) Alavi & Heywood	*Chrysanthemum grandiflorum*	Composées	He	H.V	End.
Cistus albidus L.	*Cistus albidus*	Cistacées	Ch	H.V	Méd.
Convolvulus cf. althaeoides L.	*Convolvulus althaeoides*	Convolvulacées	Th	H.A	Macar-Méd.
Daphne gnidium L.	*Daphne gnidium*	Thymelaeacées	Ch	H.V	Méd.
Delphinium peregrinum L.	*Delphinium peregrinum*	Renonculacées	Th	H.A	Méd.
Echinops spinosissimus Turra	*Echinops spinosus*	Composées	He	H.V	S. Méd. Sah.
Echium	*Echium "vulgare"*	Boraginacées	He	H.V	Méd.
Erodium moschatum (L.) L'Hér.	*Erodium moschatum*	Géraniacées	Th	H.A	Méd.
Erucaria pinnata subsp. uncata (Viv.) Täckh. & Boulos	*Erucaria uncata*	Crucifères	Th	H.A	Sah-Sind.
Fagonia cretica L.	*Fagonia cretica*	Zygophyllacées	Th	H.A	Méd.
Frankenia corymbosa Desf.	*Frankenia corymbosa*	Frankeniacées	Ge	H.V	Méd.
Frankenia laevis L.	*Frankenia laevis*	Frankeniacées	Ge	H.V	Paléo-temp.
Frankenia thymifolia Desf.	*Frankenia thymifolia*	Frankeniacées	Ch	L.V	End. N.A.
Fumana thymifolia (L.) Webb	*Fumana thymefolia*	Cistacées	Ch	H.V	Euras. Af. Sept.
Galactites elegans (All.) Soldano	*Galactites tomentosa*	Composées	He	H.V	Circumméd.
Globularia alypum L.	*Globularia alypum*	Globulariacées	Ch	L.V	Méd.
Glyceria fluitans (L.) R.Br.	*Glyceria fluitans*	Graminées	Ge	H.V	Sub-cosm.
Halogeton sativus (L.) Moq.	*Halogeton sativus*	Chénopodiacées	Th	H.A	W. Méd.
Hordeum leporinum	*Hordeum murinum subsp leporinum*	Graminées	Th	H.A	Circumbor.
Limonium pruinosum (L.) Chaz.	*Limonium pruinosum*	Plumbaginacées	Th	H.A	Sah.
Lygeum spartum L.	*Lygeum spartum*	Graminées	Ge	H.V	W. Méd.
Malva aegyptia L.	*Malva aegyptiaca*	Malvacées	Th	H.A	Sah-Sind. Méd.

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Malva sylvestris L.	*Malva sylvestris*	Malvacées	Th	H.A	Euras
Marrubium vulgare L.	*Marrubium vulgare*	Labiées	Ch	L.V	Cosmop.
Medicago minima (L.) L.	*Medicago minima*	Papilionacées	Th	H.A	Eur. Méd.
Medicago rugosa Desr.	*Medicago rugosa*	Papilionacées	Th	H.A	E. Méd.
Muricaria prostrata (Desf.) Desv.	*Muricaria prostrata*	Crucifères	Th	H.A	End. N.A.
Olea europaea subsp. europaea	*Olea europea*	Oléacées	Ph	L.V	Méd.
Pallenis spinosa (L.) Cass.	*Pallenis spinosa*	Composées	He	H.V	Euro-Méd.
Papaver rhoeas L. naturalised	*Papaver rhoeas*	Papavéracées	Th	H.A	Paléo-Temp.
Peganum harmala L.	*Peganum harmala*	Zygophyllacées	Ch	H.V	Iran-Tour-Eur.
Phalaris aquatica L.	*Phalaris bulbosa*	Graminées	Th	H.A	Macar. Méd.
Plantago albicans L.	*Plantago albicans*	Plantaginacées	Ge	H.V	Méd.
Plantago lagopus L.	*Plantago lagopus*	Plantaginacées	Th	H.A	Méd.
Plantago lanceolata L.	*Plantago lanceolata*	Plantaginacées	Ge	H.V	Euras.
Plantago ovata Forssk.	*Plantago ovata*	Plantaginacées	He	H.V	Méd.
Reseda alba L.	*Reseda alba*	Résédacées	He	H.V	Euras.
Salsola flavescens Cav.	*Salsola foetida*	Chénopodiacées	Ch	L.V	Sah-Sind.
Salsola kali L.	*Salsola kali*	Chénopodiacées	Th	H.A	Paléo-Temp.
Salsola glomerata (Maire) Brullo	*Salsola sieberi*	Chénopodiacées	Ch	L.V	Sah-Sind.
Salsola tetrandra Forssk.	*Salsola tetragona*	Chénopodiacées	Ch	L.V	Sah.
Salsola vermiculata L.	*Salsola vermiculata*	Chénopodiacées	Ch	L.V	Sah-Méd.
Salvia verbenaca L.	*Salvia verbenaca*	Labiées	He	H.A	Méd.-Atl.
Sanguisorba minor Scop.	*Sanguisorba minor*	Rosacées	Th	H.A	Euras.
Lomeliosia stellata (L.) Raf.	*Scabiosa stellata*	Dipsacacées	Th	H.A	W. Méd.
Scolymus hispanicus L.	*Scolymus hispanicus*	Composées	He	H.V	Méd.
Scorzonera laciniata L.	*Scorzonera laciniata*	Composées	Ge	H.V	Sub-méd-Sib.
Scorzonera undulata Vahl	*Scorzonera undulata*	Composées	Ge	H.V	Sud-méd.
Sinapis arvensis L. naturalised	*Sinapis arvensis*	Crucifères	Th	H.A	Paléo-temp.
Spergularia munbyana Pomel	*Spergularia munbyana*	Caryophyllacées	Ge	H.V	End.
Stipa tenacissima L.	*Stipa tenacissima*	Graminées	Ge	H.V	Iber-Maur.
Suaeda fruticosa (L.) Forssk.	*Suaeda fruticosa*	Chénopodiacées	Ch	L.V	Cosmop.
Tamarix gallica L.	*Tamarix gallica*	Tamaricacées	Ph	L.V	N. Trop.
Thapsia garganica L.	*Thapsia garganica*	Ombellifères	Ch	H.V	Méd.
Thymus munbyanus subsp. coloratus (Boiss. & Reut.) Greuter & Burdet	*Thymus ciliatus* subsp *coloratus*	Labiées	Ch	H.V	End. N.A.
Trifolium angustifolium L.	*Trifolium angustifolium*	Papilionacées	Th	H.A	Méd.
Ziziphus lotus (L.) Lam.	*Ziziphus lotus*	Rhamnacées	Ph	L.V	Méd.

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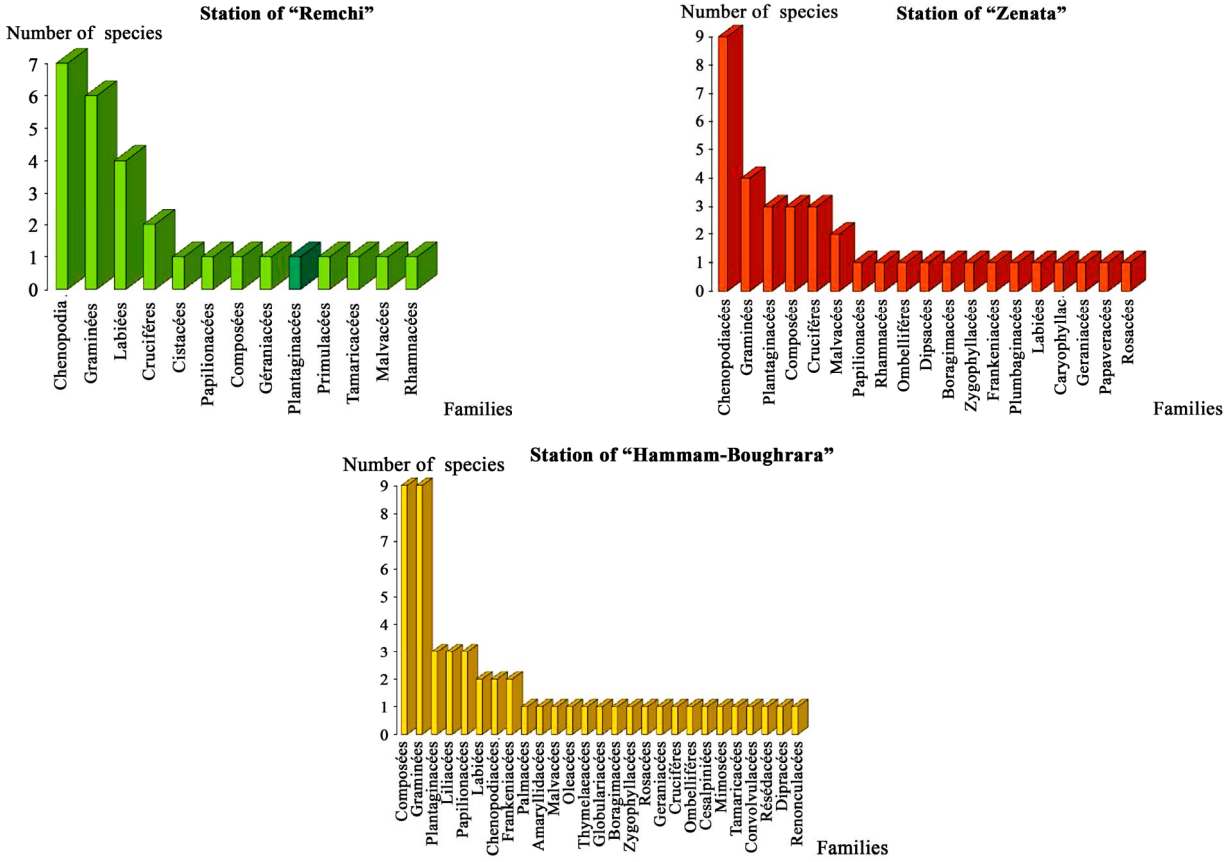

Figure 2. Distribution of species by families.

Table 3. Distribution of species' number by biological types.

	"Remchi" Station		"Zenata" Station		"Hammam-Boughrara" Station	
Biological types	Number of species	%	Number of species	%	Number of species	%
Therophytes (Th)	13	46	19	51	17	33
Chamaephytes (Ch)	10	36	9	24	10	19
Hemicryptophytes (He)	2	7	4	11	7	13
Geophytes (Ge)	1	4	4	11	13	25
Phanerophytes (Ph)	2	7	1	3	5	10

As for therophytes, we found *Atriplex dimorphostegia*, *Avena sterilis*, *Aegilops triuncialis*, *Papaver rhoeas* and *Hordeum murinum*.

The phanerophytes (**Ph**) are limited to *Tamarix gallica*. In Hammam Boughrara station, the number of geophytes (**Ge**) should not be overlooked. During favorable years, the regressive evolution of vegetation appears by extension of geophytes like *Stipa tenacissima*, *Sanguisorba minor*, *Frankenia corymbosa* and *Frankenia laevis*) and the gradual appearance of hemicryptophytes with rosettes (**He**) (*Pallenis spinosa*, *Echinops spinosus*, *Galactites tomentosa*, *Echium vulgare* and *Reseda alba*).

Finally, the distribution of biological types follows this pattern for the three studied sta tions: Th > Ch > He > Ge > Ph.

- **Biogeographic types**

The distribution of species sampled by phy togeographic element was very heterogeneous in the three stations, although retained a net balance of Mediterranean species (**Figure 3**). In the Remchi and Zenata stations, Saharo-Sindian species succeeded the Mediterranean species; it shows climatic worsening related to desert vegetation. For the Hammam Boughrara station, the West-Mediterranean species rejoin the Mediterranean to strengthen the

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group. The strictly endemic species of North African stock were relatively few in number [34].

- **Morphological types**

Our study stations' vegetal cover is dominated by perennials and annuals herbaceous with an average percentage of 75% (**Table 4**). Among the morphological types, we can name the following optional or obligatory halophytes: *Frankenia corymbosa*, *Frankenia laevis*, *Frankenia thymifolia*, *Lygeum spartum* and *Halogeton sativus*.

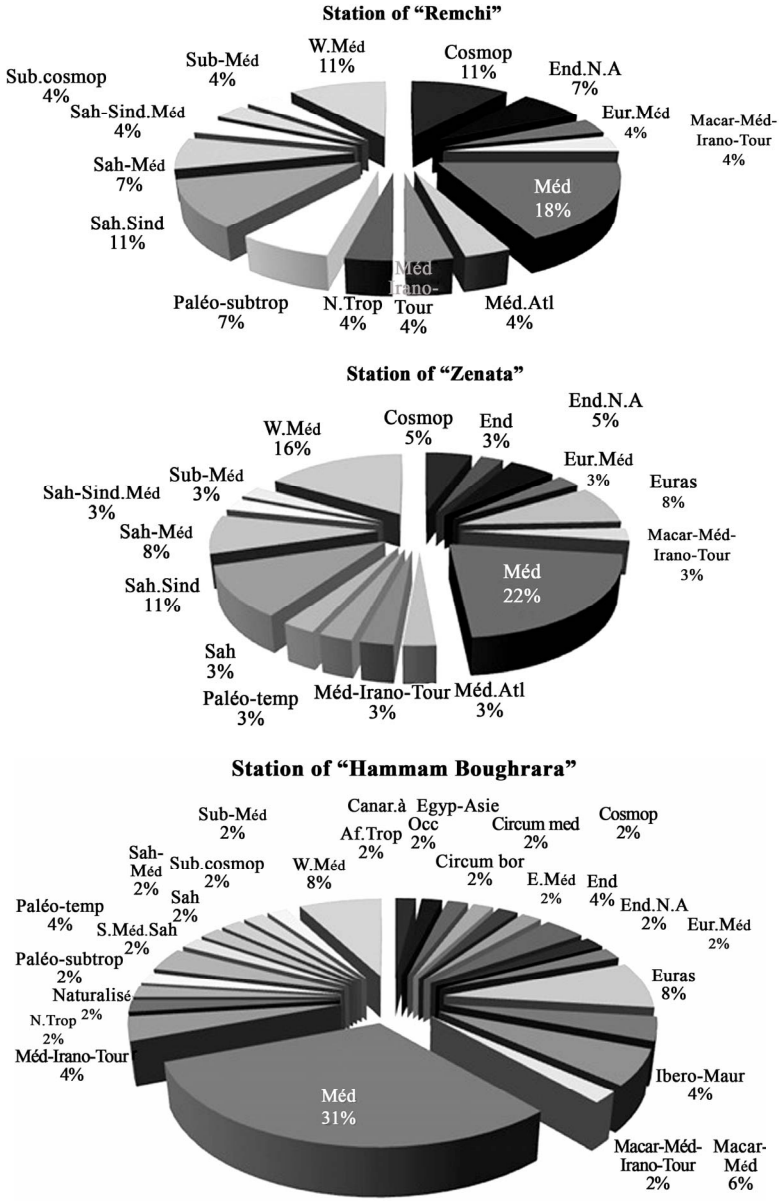

Figure 3. Distribution of species according to the biogeographic types.

Table 4. Distribution of species' number by morphological types.

Morphological types	"Remchi" Station		"Zenata" Station		"Hammam-Boughrara" Station	
	Number of species	%	Number of species	%	Number of species	%
Perennials woody (P.W)	7	25	8	22	14	27
Perennials herbaceous (P.H)	7	25	9	24	21	40
Annuals herbaceous (A.H)	14	50	20	54	17	33

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Woody perennials are then in the minority with an average of 25%. They are represented, among other species, by the following optional or obligatory halophytes: *Tamarix gallica*, *Atriplex halimus*, *Salsola vermiculata* and *Suaeda fruticosa*.

Despite the misleading presence of shrubs, it is no longer a pre-forest scrubland, but a degraded scrubland. Note that this scrubland underlines the ultimate degradation of woody vegetation.

5. CONCLUSIONS

The study area was installed, according to Emberger climagramme, in the lower semi-arid and higher arid bioclimatic level with cool or temperate winter.

The soils of these halophilic populations have a silty-sandy to sandy texture; the organic matter content (up to 2.21%) and limestone (up to 27%) are relatively low, the pH is alkaline (above 7.7).

The vegetation analysis helped to clarify the distribution of species and to identify the botanical components. Sustainability between different stations of the region is reflected by the dominance of three families: Chenopodiaceae, Asteraceae and Poaceae.

Flora study shows a clear therophytic and chamæphytic dominance: 33% and 19% respectively.

Marked by crop expansion (food crops in green houses), the region suffers from overgrazing. Climatic constraints and lack of rational management of pasture courses contributed to a sharp deterioration in *Atriplex halimus* and Salsolaceae populations (*Salsola vermiculata*) and to the disappearance of some taxa.

The settlement of this region shows significant changes in transition groups (mixing, mosaics). Flora is, however, very varied. In addition to the species strictly related to edaphic substrate (gypsum, salt), a large number of species is indifferent to it. Most of the latter belongs to dry and warm habitats, similar to steppes vegetation. One considers if they have morphological characteristics which respond to the adverse effects of atmospheric and soil drought, and to the relatively high levels of gypsum or salts in these soils. This region is also subject to the amplification phenomena of surrounding land salinity, often responsible for spatial variations of the native plant communities.

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APPENDIX

Tables 1, 2 and 3: Floristic inventories of the 3 study sites.

"Zenata" Site

Place : Zenata																	
Altitude (m)	+……..180……+……..…….105…….+……..……200……+																
Slope (%)	+……..5……..……..+……..10……+……...5…..……+																
Geom. substrate	+……Ca……+……Heterometric deposits……..……+																
Recovery level (%)	+…....20……..…..+……15……+……10……+…….30…..+																
Number of inventories		56	57	58	59	60	61	62	63	64	65	66	67	68	69	78	79
Species	Pres.																
Caracteristics of Nitratophiles: *Stellarietea-mediae*																	
Erodium moschatum	14	2.2	2.2	2.1	2.1	+	+	1.1	1.1	.	1.1	2.1	2.1	2.1	2.1	1.1	.
Papaver rhoeas	8	1.1	1.1	1.1	.	.	1.1	1.1	1.1	1.1	1.1	.	.	.	.	.	.
Sanguisorba minor	8	2.1	2.1	1.2	.	.	1.1	+	1.1	1.1	1.1	.	.	.	.	.	.
Avena alba	7	.	1.1	1.1	.	.	1.1	+	1.1	1.1	1.1	.	.	.	.	.	.
Calendula arvensis	2	2.1	2.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Caracteristics of *Atriplico halimi-Suaedetum fruticosae*																	
Atriplex halimus	11	1.1	1.1	1.1	.	1.1	1.1	+	+	+	+	1.1	.	1.1	.	.	.
Salsola vermiculata	8	.	.	.	.	2.1	1.1	.	1.1	1.1	1.1	1.1	1.1	1.1	.	.	.
Salsola foetida	7	+	1.1	+	1.1	.	.	.	.	+	.	+	.	.	1.1	.	.
Salsola sieberi	6	1.1	1.1	.	1.1	1.1	.	1.1	.	.	1.1	.	.	.	.	.	.
Halogeton sativus	5	.	1.1	.	1.1	.	.	1.1	.	+	.	+	.	.	.	.	.
Plantago ovata	4	.	.	.	.	.	.	.	1.1	1.1	.	.	.	.	.	.	.
Aeluropus littoralis	1	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.
Suaeda fruticosa	12	1.1	1.1	1.1	2.2	1.1	+	2.1	.	2.1	.	2.1	2.1	1.1	.	1.1	.
Erucaria uncata	8	.	1.1	.	1.1	.	.	1.1	.	1.1	1.1	.	1.1	1.1	.	.	1.1
Echium vulgare	6	1.1	1.1	1.1	1.1	2.1	+	.	.	.	.	.	.	.	.	.	.
Caracteristics of *Salsolo-peganion*																	
Atriplex dimorphostegia	10	1.1	1.1	.	+	+	+	+	1.1	+	+	1.1	.	.	.	.	.
Arthrophytum scoparium	10	.	.	.	.	+	1.1	1.1	.	+	2.1	2.1	1.1	1.1	.	1.1	1.1
Peganum harmala	10	.	.	.	.	1.1	1.1	.	+	.	1.1	1.1	2.1	2.1	2.1	2.1	1.1
Plantago albicans	2	.	.	.	.	.	.	.	.	.	.	.	.	.	2.1	1.1	.
Atriplex glauca	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.
Frankenia thymifolia	1	.	.	.	.	.	.	.	.	.	.	.	.	2.1	.	.	.
Limonium pruinosum	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.1	.
Lygeum spartum	11	.	.	1.1	.	.	+	1.1	+	+	1.1	1.1	2.1	2.1	1.1	1.1	.
Muricaria prostrata	9	.	.	.	1.1	.	1.1	.	1.1	.	1.1	1.1	+	+	1.1	1.1	.
Salvia verbenaca	4	.	.	.	.	.	.	.	.	.	.	.	+	+	1.1	1.1	.
Spergularia munbyana	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.1
Species "compagnes"																	
Malva aegyptiaca	7	1.1	2.1	1.1	+	.	+	1.1	+	.	.	.	.	.	.	.	.
Astragalus pentaglottis	5	.	1.1	.	1.1	.	.	2.1	2.1	.	.	.	2.1	.	.	.	.
Ziziphus lotus	3	.	.	.	.	.	.	.	.	.	.	.	2.1	.	2.1	+	.
Ammoides verticillata	2	.	.	.	.	.	.	.	.	.	.	.	2.2	.	2.1	.	.
Malva sylvestris	2	.	.	.	.	.	.	.	.	.	.	.	.	2.1	2.1	.	.
Bellis annua	2	.	.	.	.	.	2.2	.	.	.	.	.	.	2.1	.	.	.
Scabiosa stellata	8	.	.	.	.	.	+	+	+	+	1.1	.	1.1	1.1	.	1.1	.
Plantago lagopus	8	.	.	.	.	1.1	1.1	1.1	+	+	+	.	1.1	1.1	.	.	.
Avena sterilis	5	.	+	+	+	+	.	.	.	.	.	1.1	.	.	.	.	.
Pallenis spinosa	2	.	.	.	.	.	.	.	.	.	.	1.1	.	1.1	.	.	.
Brassica nigra	1	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.

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"Remchi" site

Place: Remchi																			
Altitude (m)	+……200……..+……..200……..+…….1050……+																		
Slope (%)	+……..…5……..…..+……..10……..…+																		
Geom. substrate	+……Deposit's soil……..……+…..…Heterometric deposits……..…+																		
Recovering level (%)	+……..…20……+……..…..35……...+……..10……+…….25……..…+																		
Number of inventories		116	117	118	119	32	33	34	35	36	37	83	84	85	86	42	43	44	45
Species	Pres.																		
Caracteristics of *Ononido-Rosmarinetea*																			
Teucrium polium	5	.	.	1.1	1.1	.	.	.	.	.	.	1.1	.	1.2	.	+	.	.	.
Ampelodesma mauritanicum	3	.	1.1	+	2.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cistus albidus	2	.	.	.	.	1.1	.	.	.	1.1	.	.	.	.	.	.	.	.	.
	2	.	.	.	.	.	.	.	.	+	1.1	.	.	.	.	.	.	.	.
Caracteristics of Nitratophiles: *Stellarietea mediae*																			
Astragalus pentaglottis	6	.	1.1	1.1	.	.	2.1	.	2.1	.	2.1	.	1.1	.	.	.	.	.	.
Muricaria prostrata	6	.	.	.	2.1	2.1	.	1.1	1.1	.	1.1	.	1.1	.	.	.	.	.	.
Salvia verbenaca	4	.	1.1	1.1	.	.	+	.	.	.	.	1.1	.	.	.	.	.	.	.
Calendula arvensis	4	.	.	2.1	.	2.1	.	.	.	1.1	.	1.1	.	.	.	.	.	.	.
Marrubium vulgare	2	.	.	.	.	.	.	.	.	.	1.1	.	1.1	.	.	.	.	.	.
Erodium moschatum	2	.	.	1.1	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.
Caracteristics of *Thero-Brachypodietea*																			
Plantago ovata	16	2.1	2.1	1.1	1.1	+	1.1	+	.	+	1.1	1.1	1.1	+	+	+	+	+	.
Aegilops triuncialis	14	1.1	.	.	1.1	+	2.1	2.1	1.1	+	1.1	1.1	1.1	+	1.1	.	1.1	1.1	.
Brachypodium distachyum	3	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	1.1	.	+	.
Anagalis arvensis	2	.	.	.	.	.	.	.	.	.	1.1	.	1.1	.	.	.	.	.	.
Bromus rubens	2	.	.	.	.	.	.	.	.	.	.	.	.	1.1	1.1	.	.	.	.
Avena sterilis	1	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.
Caracteristics of *Salsolatum vermiculatea*																			
Erucaria uncata	7	.	1.1	1.1	.	.	.	.	.	1.1	1.1	1.1	1.1	.	1.1	.	.	.	.
Tamarix gallica	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	1.1
Salsola foetida	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.
Caracteristics of "différentielles": *Atriplico halimi-Suaedetum fruticosae*.																			
Atriplex halimus	7	.	.	.	.	.	.	.	.	.	.	1.1	1.1	1 .1	+	.	1.1	1.1	1.1
Suaeda fruticosa	1	.	.	.	.	.	.	.	.	.	.	.	.	2.1	.	.	.	.	.
Arthrophytum scoparium	2	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	1.1	.	.
Caracteristics of *Salsolo-peganion*																			
Lygeum spartum	6	.	.	.	.	.	.	.	.	.	.	1.1	.	1.1	.	1.1	1.1	+	1.1
Halogeton sativus	2	.	.	.	.	.	.	.	.	.	.	2.1	.	2.1	.	.	.	.	.
Atriplex dimorphostegia	2	.	1.1	.	2.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salsola vermiculata	5	.	.	.	.	.	.	.	.	.	1.1	.	+	.	.	1.1	1.1	2.1	.
Species "compagnes"																			
Malva aegyptiaca	6	.	.	.	.	.	2.1	1.1	.	1.1	2.1	.	1.1	.	1.1	.	.	.	.
Ziziphus lotus	4	.	.	.	.	.	.	.	1.1	.	1.1	.	2.1	.	2.1	.	.	.	.

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"Hammam Boughrara" Site

Place : Hammam Boughrara																										
Altitude (m)		400					+				400					+				400						+
Slope (%)		5					+				10	+				+				5						+
Geom. substrate		Thin deposits																								+
Recovering level (%)		75					+				75									60						+
Number of inventories		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Species	Pres.																									
Caracteristics of *Oleo-ceratonion*																										
Olea europea	3	+.+	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.
Ceratonia silica	3	.	+.+	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+.+
Caracteristics of *Rosmarinea officinalis*																										
Agave americana	13	1.1	+.+	2.1	+.+	.	.	+.+	.	1.1	+.+	.	.	+.+	.	.	+.+	.	.	1.1	.	+.+	.	.	+.+	+.+
Asparagus stipularis	5	+.+	.	+.+	.	+.+	.	.	.	+.+	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.
Asparagus acutifolius	8	+.+	.	+.+	.	.	+.+	.	.	+.+	.	.	.	+.+	.	.	.	.	+.+	.	.	+.+	.	.	+.+	.
Artemisia herba-alba	8	.	+.+	.	+.+	.	+.+	.	.	.	.	.	.	.	.	.	.	.	.	+.+	+.+	.	+.+	.	+.+	+.+
Calycotome spinosa	8	.	+.+	.	+.+	+.+	.	.	.	.	.	+.+	.	.	.	.	.	.	+.+	+.+	.	.	+.+	.	1.1	.
Asparagus albus	5	+.+	.	.	+.+	.	.	.	.	+.+	.	.	.	.	+.+	.	.	.	.	.	.	+.+	.	.	.	.
Chamaerops humilis subsp argentea	3	.	+.+	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	.	+.+	.	.	.
Daphne gnidium	4	+.+	.	.	.	+.+	.	+.+	.	.	.	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.
Globularia alypum	4	.	.	+.+	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	+.+	.	.	.	.	+.+	.
Thymus ciliatus	3	.	.	+.+	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	+.+	.	.	.	.
Stipa tenacissima	5	1.1	.	+.+	.	+.+	.	.	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	+.+
Caracteristics of *Thero-Brachypodietea*																										
Plantago lagopus	2	.	+.+	.	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago albicans	4	.	+.+	+.+	.	.	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	.	+.+
Plantago lanceolata	4	.	+.+	+.+	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	.	.	+.+	.
Avena alba	11	+.+	.	.	+.+	.	1.1	+.+	.	+.+	2.1	+.+	.	.	.	.	.	1.1	.	.	.	.	.	1.1	+.+	+.+
Avena sterilis	7	+.+	.	.	.	.	1.1	.	.	+.+	1.1	.	+.+	.	.	.	.	.	.	.	.	.	.	+.+	.	+.+
Hordeum murinum	8	+.+	.	.	1.1	.	2.2	.	.	.	+.+	.	.	+.+	.	.	+.+	.	.	+.+	.	.	+.+	.	.	.
Ballota hirsuta	5	.	+.+	.	.	.	.	+.+	.	.	.	.	.	.	+.+	.	.	.	.	+.+	.	.	.	+.+	.	.
Echinops spinosus	4	.	+.+	+.+	.	.	+.+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thapsia garganica	6	+.+	.	.	1.1	.	.	.	.	1.1	+.+	.	.	.	.	.	+.+	.	.	.	.	+.+	.	.	.	.
Agropyrum lolium	4	.	+.+	.	.	.	+.+	.	.	.	.	+.+	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.
Pallenis spinosa	4	+.+	.	.	.	+.+	.	.	+.+	.	.	.	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.
Atractylis carduus	5	.	+.+	.	+.+	.	.	.	.	.	1.1	.	.	.	.	.	.	+.+	.	.	.	+.+	.	.	.	.
Chrysanthemum grandiflorum	12	+.+	.	+.+	1.1	.	+.+	+.+	.	+.+	.	.	+.+	.	.	.	.	.	+.+	.	+.+	.	.	+.+	+.+	+.+
Galactites tomentosa	8	+.+	.	+.+	+.+	.	.	.	+.+	.	.	+.+	.	.	.	.	.	.	.	+.+	.	.	+.+	.	.	+.+
Glyceria fluitans	5	+.+	.	.	.	.	+.+	.	.	.	.	.	+.+	+.+	+.+	.	.	.	.	.	.	.	.	.	.	.
Calendula arvensis	8	+.+	.	.	.	+.+	.	.	.	+.+	.	+.+	.	.	+.+	.	.	+.+	.	.	.	.	+.+	.	.	+.+
Malva sylvestris	3	.	+.+	.	.	.	+.+	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	.	.	.	.
Scorzonera undulata	4	.	.	+.+	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.	+.+
Convolvulus althaeoides	7	1.1	.	.	+.+	.	.	+.+	.	.	+.+	.	.	+.+	+.+	+.+	.	.	.	.	.	.	.	.	.	.
Bromus rubens	3	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	+.+	.	+.+	.	.	.	.	.	.	.	.
Phalaris bulbosa	4	.	+.+	.	.	.	.	.	.	+.+	.	+.+	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.
Echium vulgare	6	+.+	.	.	+.+	.	.	.	+.+	.	.	+.+	.	.	.	.	.	1.1	.	.	+.+	.	.	.	.	.
Scolymus hispanicus	6	.	+.+	.	+.+	.	.	+.+	+.+	.	.	.	.	.	.	.	.	+.+	.	.	.	.	+.+	.	.	.
Fagonia cretica	3	.	.	.	.	+.+	.	.	.	.	.	.	.	+.+	+.+	.	.	.	.	.	.	.	.	.	.	.
Sanguisorba minor	5	.	.	.	.	+.+	.	.	.	.	.	+.+	+.+	+.+	.	.	.	+.+	.	.	.	.	.	.	.	.
Reseda alba	4	.	+.+	+.+	+.+	.	+.+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aegilops triuncialis	11	+.+	.	.	1.1	.	+.+	.	.	+.+	+.+	.	.	+.+	.	+.+	+.+	.	.	+.+	.	.	.	.	+.+	+.+
Erodium moschatum	7	+.+	+.+	.	+.+	.	.	.	.	.	.	+.+	.	+.+	.	+.+	.	.	.	.	.	.	+.+	.	.	.
Delphinium peregrinum	4	.	+.+	.	.	.	+.+	.	+.+	+.+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Caracteristics of *Stellarietea-mediae*																										
Scabiosa stellata	6	+.+	.	+.+	+.+	.	+.+	.	+.+	.	+.+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sinapis arvensis	8	.	+.+	+.+	.	.	+.+	.	.	.	.	.	.	+.+	+.+	+.+	.	.	.	+.+	.	.	.	.	.	.
Medicago rugosa	2	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	.	.	+.+	.	.	.	.	.
Trifolium angustifolium		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Caracteristics of *Salsolatum vermiculatea*																										
Atriplex halimus	11	1.1	+.+	1.1	+.+	.	.	+.+	2.1	.	+.+	.	.	.	+.+	.	.	.	.	+.+	.	.	+.+	.	.	+.+
Salsola vermiculata	5	+.+	.	+.+	.	.	.	.	+.+	.	.	.	.	.	.	.	.	+.+	.	.	.	.	+.+	.	.	.
Tamarix gallica	8	+.+	.	+.+	.	.	.	+.+	+.+	.	.	.	.	.	+.+	+.+	.	.	.	+.+	.	.	.	.	.	+.+
Frankenia corymbosa	4	.	.	+.+	.	+.+	.	.	.	.	.	.	.	.	.	+.+	.	.	.	+.+	.	.	.	.	.	.
Frankenia laevis	4	.	.	+.+	.	.	.	+.+	.	.	.	.	.	.	+.+	.	+.+	.	.	.	.	.	.	.	.	.
Species "compagnes"																										
Acacia albida	4	.	+.+	.	.	.	.	.	+.+	.	.	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.	+.+

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