

Floristic diversity of steppe vegetation in the region of Djelfa, North-West Algeria

Nouredine Habib^{1,2}, Zineb Regagba^{1,2}, Mohamed Djamel Miara^{1,3}, Mohammed Ait Hammou^{1,3}, Julie Snorek⁴

¹ Faculty of Nature and the Life sciences, Ibn Khaldoun University, Tiaret, BP. 78 Zaâroura, Tiaret, 14000 Algeria.

² Laboratory of Geomatic and Sustainable development, LGeo2D, University of Ibn Khaldoun, Tiaret, Algeria.

³ Laboratory of Agrobiotechnology and Nutrition in arid and semi-arid areas, University of Ibn Khaldoun, Tiaret, Algeria.

⁴ Department of Environmental Studies, Dartmouth College, Hanover, NH, USA.

Correspondencia

Mohamed Djamel Miara

e-mail: miara14130@yahoo.fr

Recibido: 24 febrero 2020

Aceptado: 24 abril 2020

Publicado on-line: 15 mayo 2020

Editado por: Marta Recio Criado

Abstract

This study is a floristic investigation of the steppe region of Djelfa located in northern Algeria, with the aim of characterizing and analysing the wild flora of this region. Four stations were chosen according to a stratified sampling method and phyto-ecological surveys were carried out in 32 plots of 100m² each. This allowed us to identify 127 taxa of plants belonging to 33 families dominated by *Asteraceae* (29%) and *Poaceae* (12%). The analysis of biological types has shown the dominance of annual Therophytes (56%) in this flora, which indicates the presence of the phenomenon of Therophytization in these regions. This phenomenon was also measured by calculating the perturbation index. The analysis of chorological types has shown the dominance of the Mediterranean element (48%), with an interesting number of endemic taxa. However, all the endemic taxa cited in the literature for this region have not been found, which reinforces our fears about the state of conservation of these taxa of biological and heritage value.

Key words: Chorology, Djelfa, Endemic Flora, Steppe, Stratified method

Résumé

Analyse floristique de la végétation steppique dans la région de Djelfa, Nord-Ouest algérien

Cette étude est une investigation floristique de la région steppique de Djelfa située au nord de l'Algérie, et cela dans le but de caractériser et d'analyser la flore sauvage de cette région. 4 stations ont été choisies selon une méthode d'échantillonnage stratifié et des relevés phytoécologiques ont été réalisés sur 32 parcelles de 100m². Cela nous a permis d'identifier 127 taxons de plantes appartenant à 33 familles dominées par les *Asteraceae* (29%) et les *Poaceae* (12%). L'analyse des types biologiques a montré la dominance des Thérophytes annuels (56%) dans cette flore, ce qui indique la présence du phénomène de Thérophytisation dans ces régions. Ce phénomène a également été mesuré en calculant l'indice de perturbation. L'analyse des types chorologiques a montré la dominance de l'élément méditerranéen (48%), avec un nombre intéressant de taxons endémiques. Cependant, tous les taxons endémiques cités dans la littérature pour cette région n'ont pas été retrouvés, ce qui renforce nos inquiétudes quant au statut de conservation de ces taxons de valeur biologique et patrimoniale.

Mots clés : Chorologie, Djelfa, Flore endémique, Steppe, Méthode stratifiée

Introduction

The Mediterranean region is characterized by an exceptional biological diversity as well as considerable biological richness estimated at 25,000 species of vascular plants, which corresponds to 9.2% of the total diversity of species in a territory representing only 1.5% of the terrestrial surface (Médail & Quézel, 1997; Myers, 1988, 1990;

Mittermeier *et al.*, 2004). Algeria, due to its geographical position, presents a great diversity of habitats occupied by an important floristic richness (Médail & Quézel, 1997; Véla & Benhouhou, 2007 in Miara *et al.*, 2018a).

According to Quézel & Santa (1962-63 in Véla & Benhouhou, 2007), the Algerian flora comprises

3,139 species consisting of 3,744 taxa including 464 endemic and 1,818 more or less rare species. This inventory is now evaluated at 4,449 taxa including 3,951 native taxa and 498 introduced to Algeria (Dobignard & Chatelain, 2010-13). The flora of this country is mainly dominated by 3 botanical families with more than 150 species each: *Asteraceae*, *Poaceae* and *Brassicaceae* (433, 289 and 171 species, respectively), while 7 genera present between 30 and 58 species: *Helianthemum*, *Linaria*, *Centaurea*, *Ononis*, *Trifolium*, *Astragalus*, *Silene* (Abdelguerfi & Ramdane, 2003).

The Algerian steppes constitute a geographical unit whose limits are defined by a bioclimatic criterion. With an estimated area of about 20 million hectares, the Algerian steppes are located between the 400-mm rainfall isohyet to the North and 100 mm-rainfall isohyet to the South, forming a 1000-km-long ribbon over a width of 300 km in the west and in the center, reduced to less than 150 km in the East (Halem, 1997 in Miara *et al.*, 2018b). According to Nedjraoui & Bedrani (2008), the steppe regions constitute a buffer between coastal Algeria and Saharian Algeria, of which they limit the negative climatic influences on the former.

Several studies (Le Houerou, 1969; Djebaili, 1978; Aiduod, 1983) confirm that in the Algerian steppe, the reduction in floristic diversity is not only occurring as a result of climatic factors (dryness and heightened aridity), but it is also strongly impacted by anthropic factors (primarily fires and grazing), which are prompted by irrational land exploitation such as overgrazing and land clearing.

To this, the effect of the phenomenon of therophytization is also to be considered. According to Quézel & Médail (2003). Therophytization can be defined as the generalized invasion by annual and often ruderal species, which are mainly disseminated by herds. According to Daget (1980), this is a characteristic of arid zones, expressed as a strategy of adaptation to unfavorable conditions and a form of resistance to harsh climatic conditions.

The region of Djelfa is located in the south of the Algerian Tell Atlas in contact with the Saharian Atlas.

This region is a typical example of the North African steppe which is highly threatened and weakened by ecological and anthropic factors including desertification (Nedjraoui & Bedrani, 2008).

So, in order to contribute to better conservation of these very sensitive natural spaces, a deeper knowledge of the biodiversity of these areas is essential. Unfortunately, and despite several floristic studies published recently for the region of Djelfa (Korichi, 2016; Maamri, 2016; Rahmoune, 2018; Benalia *et al.*, 2018; Bekai *et al.*, 2019), the floristic knowledge on this area is still insufficient, while several endemic and rare taxa cited in this region since the colonial period there has not been observed, namely: *Erodium hymenodes* L'Her., *Echium suffruticosum* Baratte., *Celsia battandieri* Murb., *Bellium rotundifolium* (Desf.) DC., *Atractylis polycephala* Coss. and *A. phaeolepis* Pomel.

This research aims to highlight the floristic diversity of the wild steppe areas of the Djelfa region in the Northwest Algeria, by seeking the aforementioned taxa. Specifically, we will assess the floristic biodiversity of this region to analyze some aspects related to the local flora such as life traits (biological types) and chorology (chorological types).

Materials and methods

Study area

The province of Djelfa is located in the central part of Algeria beyond the southern boundary of the Tellian Atlas; our study area is located between 2° and 5° of longitude East and 33° and 35° of North latitude (Figure 1). Three quarters of the territory of the province of Djelfa is made up of steppe ecosystems. In addition, a significant forest heritage exists in this region and consists mainly of Aleppo pine (215,182 ha), representing only 6.67% of the total area of the province (Cherfaoui, 2017).

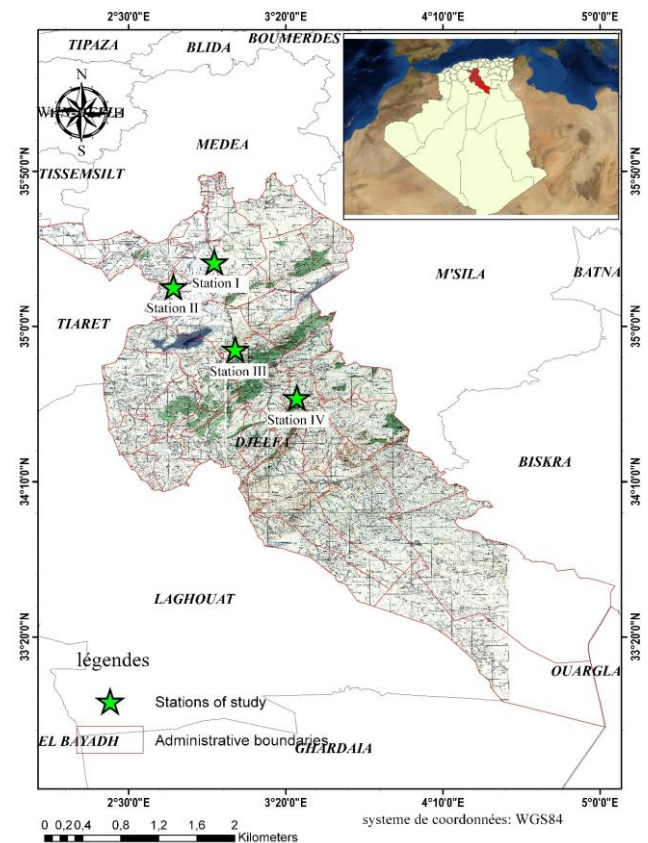


Figure 1. Geographical location of the study area.

Figure 1. Localisation géographique de la zone d'étude.

Field sampling

We carried out a total of 32 phytocological surveys at 4 stations (Table 1) which were chosen according to a stratified sampling method (Gounot, 1969).

The station I is located in Ain Oussera at approximately 90 km northwest of the province of Djelfa. It is characterized by some diversified steppe formations with *Stipa tenacissima* L. and *Artemisia herba-alba* Asso.

The station II is located in Guernini at approximately 80 km northwest of the province of Djelfa. It contains some degraded rangelands with vegetation dominated by *Stipa tenacissima* L. and *Lygeum spartum* L.

The station III is located in Zaafrane, 60 km northwest of the province of Djelfa. It is characterized by sand dunes with vegetation dominated by *Tamarix gallica* L. In this area, there are also some artificial plantations of *Atriplex canescens* Sieb is located in the region of Ain Maabed at 30 km from the province of Djelfa.

The station IV is located in the city of Moudjbara at approximately 18 km southeast of the province of Djelfa. It is characterized by pre-forest formations dominated by *Pinus halepensis* Mill., *Stipa tenacissima* L. and *Artemisia herba-alba* Asso.

Data collection and plant identification

The location of the 32 phytosociological surveys was chosen in a random way in zones that were clearly homogeneous and representative. Surveys were carried out according to the method of Braun-Blanquet (1951). For each surveys, we noted the floristic, geographical and environmental data.

Table 1: GPS coordinates and altitudes of the 4 stations of Djelfa province.

Tableau 1: Coordonnées GPS et altitudes des 4 stations de la province de Djelfa.

Stations	Longitude	Latitude	Altitude
Station I (Ain Ouessara)	2,95	35,34	728
Station II (Guernini)	2,73	35,21	814
Station III (Ain Maabed)	3,06	34,89	881
Station IV (Moudjbara)	3,40	34,57	1320

In each station, we took eight floristic samples from an area measuring 100 m². According to Djebaili (1984), this surface is the minimum area required to be a representative sample of the characteristic flora of the Algerian steppe regions. These floristic surveys were carried out during the optimal periods (spring) of 2016 and 2017. The botanical identification of the collected taxa was made using the flora of Quézel & Santa (1962-63) and that of Ozenda (1977). The species chorology was defined according to Dobignard & Chatelain (2010-13). Chorological types have been grouped according to Benabadi *et al.* (2007) which comprises the following groupings: 1) Mediterranean species (West-Mediterranean, East-Mediterranean, Ibero-Mauritanian, Center-Mediterranean, Sub-Mediterranean), 2) Nordic

species (European, Eurasians, Paleo-temperate, Boreals-circum and Paleo sub-tropical), 3) widely distributed species (Euro-Mediterranean, Atlantic-Mediterranean, Eurasian-Mediterranean, Irano-Touranian, Cosmopolitan), 4) Saharan species and 5) endemic species. The nomenclature of the identified taxa was updated using the synonymic index of North Africa (Dobignard & Chatelain, 2010-13). The specimens of plants harvested in the field were coded and deposited in the herbarium of the Botanical laboratory of the University of Tiaret, Algeria.

The perturbation index (PI) is used to quantify the therophytisation. It is calculated according to Loisel & Gamila (1993) as the ratio of the sum of chamaephytes and therophytes on the full number of the species.

Results and discussion

Floristic analyses

In total, we recorded 127 taxa at the four sites (Table 2). This number seems very interesting compared to that obtained by some authors who worked in the same region including Zehraoui (2016) with 107 species, Korichi (2016) with 66 species, Maamri (2016) with 129 species, Rahmoune (2018) with 126 species, Benalia *et al.* (2018) with 84 species and Bekai *et al.* (2019) with 106 species.

Our taxa belong to 33 botanical families. The most represented families are: *Asteraceae* (37 taxa, 29%), *Poaceae* (15 taxa, 12%), *Brassicaceae* and *Fabaceae* with a total of 11 taxa (9%) per family (fig.2). Other families like *Amaranthaceae*, *Lamiaceae* and *Caryophyllaceae* are moderately represented with 6, 5 and 4 taxa respectively. The rest of the families are poorly represented and accounted less than 4 taxa. According to Ozenda (1977), *Asteraceae*, *Poaceae* and *Brassicaceae* characterize the arid and semi-arid areas in the Mediterranean regions.

In Algeria, some studies (Benabadi *et al.*, 2007; Kazi-Tani *et al.*, 2010) highlighted the dominance of *Asteraceae*, *Poaceae* and *Fabaceae* in the steppe regions. This was also reported in Morocco by Fennane *et al.* (2012).

In the region of Djelfa, the study of Djaballah & Chehma (2008) about the floristic and nutritional characteristics of the steppe rangelands mention the dominance of the same families in the most stations. It is also the case in the studies published by Korichi (2016), Maamri (2016), Rahmoune (2018), Benalia *et al.* (2018) and Bekai *et al.* (2019) in the same region.

The biological types

The abundance of the various species related to their biological type according to Raunkiaer (1934) is as follows: therophytes > hemicryptophytes > chamaephytes > geophytes > phanerophytes, with a clear predominance of therophytes (71 taxa, 56%) and hemicryptophytes (fig. 3).

Table 2. List of the inventoried taxa.**Tableau 2.** List des taxons inventoriés.

Taxa (Dobignard & Chatelain, 2010-13)	Biological types	Chorological types	Locality
Aizoaceae			
<i>Aizoanthes hispanicum</i> (L.) Klak	Th	Med	SI
Amaranthaceae			
<i>Atriplex canescens</i> (Pursh) Nutt.	Ch	Wd	SIII
<i>Blitum exsuccum</i> C. Loscos	Th	Wd	SI,SII
<i>Caroxylon vermiculatum</i> (L.) Akhani & Roalson	Ch	Wd	SI,SII
<i>Hammada schmittiana</i> (Pomel) Botsch.	Ch	Sah	SI,SII
<i>Hammada scoparia</i> (Pomel) Iljin	Ch	Sah	SI
<i>Noaea mucronata</i> (Forssk.) Asch. & Schweinf.	Ch	Wd	SI,SII,SIII
Anacardiaceae			
<i>Pistacia atlantica</i> Desf.	Ph	End (North Africa)	SI
Apiaceae			
<i>Eryngium ilicifolium</i> Lam.	Th	Med	SII
<i>Stoibrax pomelianum</i> (Maire) B. L. Burt	Th	End (Algeria-Morocco)	SIV
<i>Thapsia garganica</i> L.	Hc	Med	SI,SII
Apocinaceae			
<i>Nerium oleander</i> L.	Ph	Med	SIII
Asparagaceae			
<i>Muscari comosum</i> (L.) Mill.	Ge	Med	SI,SII
Asteraceae			
<i>Anacyclus clavatus</i> (Desf.)	Th	Wd	SI,SII,SIII,SIV
<i>Anacyclus monanthos</i> subsp. <i>cyrtolepidioides</i> (Pomel) Humphries	Th	End (North Africa)	SI,SIII
<i>Andryala integrifolia</i> L.	Th	Med	SIV
<i>Artemisia campestris</i> L.	Ch	Nor	SI,SII,SIII,SIV
<i>Artemisia herba-alba</i> Asso	Ch	Med	SI,SII,SIII
<i>Atractylis caespitosa</i> Desf.	Hc	Med	SI,SII
<i>Atractylis cancellata</i> L.	Th	Med	SI
<i>Atractylis serratuloides</i> Sieber ex Cass.	Ch	Sah	SI,SII,SIII
<i>Bombycilaena discolor</i> (Pers.) M. Láz	Th	Wd	SI,SII
<i>Calendula arvensis</i> (Vaill.) L.	Th	Med	SI,SII,SIII,SIV
<i>Carduus spachianus</i> Durieu	Th	Med	SI,SII
<i>Carthamus eriocephalus</i> (Boiss.) Greuter	Th	Sah	SI
<i>Carthamus lanatus</i> L.	Th	Wd	SI,SII,SIII,SIV
<i>Carthamus rhapsodicoides</i> (Pomel) Greuter	Th	End (Algeria-Morocco)	SIV
<i>Centaurea furfuracea</i> Coss. & Durieu	Th	Med	SI
<i>Centaurea maroccana</i> Ball	Th	Med	SI,SII,SIII
<i>Centaurea oranensis</i> Greuter & M. V. Agab.	Hc	End (Algeria-Morocco)	SI,SII,SIII,SIV
<i>Centaurea sicula</i> L.	Th	Med	SI,SII, SIV
<i>Echinops spinosissimus</i> Turra	Hc	Sah	SI,SII
<i>Erigeron trilobus</i> (Decne.) Boiss.	Th	Med	SIII
<i>Filago crocidion</i> (Pomel) Chrtek & Holub	Th	End (Algeria-Morocco)	SI,SII,SIII
<i>Koelpinia linearis</i> Pallas.	Th	Wd	SI,SII,SIII,SIV
<i>Launaea fragilis</i> (Asso) Pau	Th	Wd	SI,SII
<i>Launaea mucronata</i> (Forssk.) Muschl. subsp. <i>mucronata</i>	Th	Sah	SI,SII
<i>Launaea nudicaulis</i> (L.) Hook. f.	Th	Wd	SII
<i>Onopordum acaulon</i> L.	Hc	Med	SI,SII,SIII

<i>Onopordum espiniae</i> Coss. ex Bonnet	Hc	Med	SI
<i>Pallenis hierichuntica</i> (Michon) Greuter	Th	Sah	SI,SII,SIII
<i>Pallenis spinosa</i> (L.) Cass.	Ch	Wd	SI
<i>Picris asplenioides</i> subsp. <i>saharae</i> (Coss. & Kralik) Dobignard	Th	End (North Africa)	SI,SII,SIII
<i>Reichardia tingitana</i> (L.) Roth	Th	Med	SI,SII,SIII
<i>Scolymus hispanicus</i> L.	Hc	Med	SI,SII,SIII
<i>Scorzonera undulata</i> Vahl	Ge	Med	SI,SII,SIII
<i>Senecio gallicus</i> Vill.	Th	Med	SIII
<i>Xeranthemum inapertum</i> (L.) Mill	Th	Wd	SI,SII,SIII
Boraginaceae			
<i>Echium humile</i> subsp. <i>pyncanthum</i> (Pomel) Greuter & Burdet	Th	Sah	SI,SII,SIII
<i>Lappula patula</i> (Lehm.) Gürke	Hc	Wd	SI,SII
Brassicaceae			
<i>Brassica fruticulosa</i> Cirillo	Hc	Med	SIV
<i>Clypeola cyclodontea</i> Delile	Th	Med	SIV
<i>Clypeola jonthlaspi</i> subsp. <i>microcarpa</i> (Moris) Arcang.	Th	Wd	SII
<i>Diploxixis harra</i> (Forssk.) Boiss.	Th	Wd	SI,SII
<i>Enarthrocarpus clavatus</i> Delile ex Godr.	Th	End (North Africa)	SI,SII
<i>Eruca vesicaria</i> (L.) Cav.	Th	Med	SI,SII,SIII,SIV
<i>Maresia nana</i> (DC.) Batt.	Th	Wd	SI,SII,SIII
<i>Matthiola fruticulosa</i> (Loefl. ex L.) Maire	Ch	Med	SIV
<i>Matthiola longipetala</i> (Vent.) DC.	Th	Wd	SI,SII
<i>Muricaria prostrata</i> (Desf.) Desv.	Th	End (North Africa)	SI,SII,SIII
<i>Pseuderucaria clavata</i> (Boiss. & Reut.) O. E. Schulz	Th	Sah	SIII
Caprifoliaceae			
<i>Lomelosia crenata</i> (Cirillo) Greuter & Burdet	Th	Sah	SI,SII,SIII,SIV
Caryophyllaceae			
<i>Herniaria cinerea</i> DC.	Th	Nor	SI,SII,SIII,SIV
<i>Paronychia argentea</i> Lam.	Hc	Med	SI,SII,SIII,SIV
<i>Silene secundiflora</i> Otth	Th	Med	SIII
<i>Telephium imperati</i> L. subsp. <i>imperati</i>	Hc	Med	SI,SII,SIII
Cistaceae			
<i>Helianthemum cinereum</i> (Cav.) Pers.	Ch	Wd	SIV
<i>Helianthemum helianthemoides</i> (Desf.) Grosser	Ch	End (North Africa)	SI,SII
<i>Helianthemum ruficomum</i> (Viv.) Spreng.	Ch	Med	SIV
Cucurbitaceae			
<i>Citrullus colocynthis</i> (L.) Schrad.	Hc	Wd	SIII
Euphorbiaceae			
<i>Euphorbia falcata</i> L.	Th	Wd	SI,SIII
Fabaceae			
<i>Argyrolobium uniflorum</i> (Decne.) Jaub. & Spach	Hc	Sah	SII
<i>Astragalus crenatus</i> Schult.	Th	Sah	SI,SII
<i>Astragalus gombo</i> Bunge	Hc	Sah	SIII
<i>Astragalus reinii</i> Ball.	Hc	End (Algeria-Morocco)	SI,SII,SIII,SIV
<i>Coronilla scorpioides</i> (L.) W.D.J. Koch	Th	Med	SI,SII,SIII
<i>Hippocrepis multisiliquosa</i> L.	Th	Med	SI
<i>Lathyrus clymenum</i> L.	Th	Med	SI
<i>Lotus ornithopodioides</i> L.	Th	Med	SI,SII
<i>Medicago littoralis</i> Loisel.	Th	Med	SI,SII
<i>Medicago minima</i> (L.) L.	Th	Wd	SI,SII,SIII

<i>Onobrychis alba</i> (Waldst. & Kit.) Desv.	Hc	Nor	SIV
<i>Ononis serrata</i> Forssk.	Hc	Med	SIII
<i>Retama raetam</i> (Forssk.) Webb	Ph	Wd	SIII
Geraniaceae			
<i>Erodium crassifolium</i> (Forssk.) L'Hér.	Th	Med	SI,SII
Hyacinthaceae			
<i>Dipcadi serotinum</i> (L.) Medik.	Ge	Wd	SII,SIV
Iridaceae			
<i>Moraea sisyrinchium</i> (L.) Ker Gawl.	Ge	Nor	SI,SII,SIII
<i>Ajuga iva</i> (L.) Schreb.	Th	Med	SI,SII,SIII,SIV
<i>Maropsis deserti</i> (de Noé) Pomel	Hc	Sah	SIII
<i>Salvia verbenaca</i> L.	Hc	Wd	SI,SII
<i>Teucrium polium</i> L.	Hc	Wd	SI,SII,SIII
<i>Thymus algeriensis</i> Boiss. & Reut.	Ch	End (North Africa)	SIV
Malvaceae			
<i>Malva aegyptia</i> L.	Th	Wd	SI,SII,SIII
<i>Malva parviflora</i> L.	Th	Wd	SI,SII,SIII
Nitrariaceae			
<i>Peganum harmala</i> L.	Ch	Wd	SI,SII,SIII,SIV
Orobanchaceae			
<i>Cistanche lutea</i> (Desf.) Hoffmanns. & Link	Ge	End (North Africa)	SIII
Papaveraceae			
<i>Glaucium corniculatum</i> (L.) Rudolph	Th	Med	SI,SIV
<i>Papaver hybridum</i> L.	Th	Med	SIV
Pinaceae			
<i>Pinus halepensis</i> Mill.	Ph	Med	SIV
Plantaginaceae			
<i>Kickxia aegyptiaca</i> (L.) Nábelek	Th	Sah	SI
<i>Plantago albicans</i> L.	Hc	Med	SI,SII,SIII,SIV
<i>Plantago ciliata</i> Desf.	Th	Wd	SI,SII,SIII
<i>Plantago ovata</i> Forssk.	Th	Med	SI,SII,SIII
Poaceae			
<i>Aegilops peregrina</i> (Hack.) Eig	Th	Med	SII
<i>Anisantha rubens</i> (L.) Nevski	Th	Nor	SII,SIII,SIV
<i>Centropodia forsskalii</i> (Vahl) Cope	Th	Sah	SI
<i>Cynodon dactylon</i> (L.) Pers.	Ge	Wd	SI,SII,SIII,SIV
<i>Echinaria capitata</i> (L.) Desf.	Th	Wd	SI,SII,SIII
<i>Hordeum murinum</i> L.	Th	Nor	SI,SII,SIII,SIV
<i>Lygeum spartum</i> L.	Ge	Med	SI,SII,SIII
<i>Macrochloa tenacissima</i> (L.) Kunth	Hc	Med	SI,SIII
<i>Poa bulbosa</i> L. subsp. <i>bulbosa</i>	Th	Nor	SIV
<i>Rostraria cristata</i> (L.) Tzvelev	Th	Wd	SI,SII
<i>Schismus barbatus</i> (Loefl. ex L.) Thell.	Th	Wd	SI,SII
<i>Stipa parviflora</i> Desf.	Hc	Med	SI,SII,SIII
<i>Stipagrostis obtusa</i> (Delile) Nees	Hc	Wd	SIII
<i>Stipagrostis plumosa</i> (L.) Munro ex T. Anderson	Hc	Wd	SI
<i>Stipagrostis pungens</i> (Desf.) De Winter subsp. <i>pungens</i>	Hc	Wd	SIII
Ranunculaceae			
<i>Adonis aestivalis</i> L.	Th	Nor	SI,SII,SIII,SIV
Resedaceae			

<i>Reseda alba L. subsp. alba</i>	Th	Nor	SI,SIV
<i>Reseda decursiva Forssk.</i>	Hc	Med	SI,SII,SIII
<i>Reseda lutea L. subsp. lutea</i>	Th	Nor	SI,SII
Rhamnaceae			
<i>Ziziphus lotus (L.) Lam.</i>	Ph	Med	SI,SII,SIII
Scrophulariaceae			
<i>Scrophularia canina L.</i>	Th	Med	SIII
Tamaricaceae			
<i>Tamarix gallica L.</i>	Ph	Wd	SIII
Thymelaceae			
<i>Thymelaea microphylla Coss. & Durieu ex Meisn.</i>	Ch	End (North Africa)	SI
Zygophyllaceae			
<i>Tribulus terrestris L.</i>	Th	Wd	SI

Wd: wide distributed; End: endemic; Sah: Saharian; Nor: Nordic; Med: Mediterranean; Th: therophytes; Ch: chamaephytes; Ph: phanerophytes; Ge: geophytes; Hc: hemicryptophytes.

Wd: large distribution; End: endémique; Sah: saharienne; Nor: nordique; Med: Méditerranéen; Th: thérophytes; Ch: chaméhytes; Ph: phanérophytes; Ge: géophytes; Hc: hemicryptophytes.

Indeed, the dominance of therophytes characterizes the arid and semi-arid regions (Aidoud, 1984; Miara *et al.*, 2016). Several authors (Daget, 1980; Barbero *et al.*, 1990; Aidoud, 1984) underline the relationship between the high rate of therophytes and the increasing gradient of aridity in the Algerian steppe areas. The phenomenon of therophytisation observed in the present study is probably related to

vegetation like in the Mediterranean region (Miara *et al.*, 2016).

Hemicryptophytes are classified in second position of contribution with 27 taxa (21%). The prevalence of hemicryptophytes can be explained by the degradation of the ecological conditions generally related to the climate and the anthropic action (Ozenda, 1977).

The other chorological types (chamaephytes, geophytes, phanerophytes) are moderately or weakly represented with 16, 7 and 6 species respectively. Indeed, Kadi-Hanifi (2003) reported that the number of the phanerophytes, hémicryptophytes and geophytes declined with the aridity and openness of the environment.

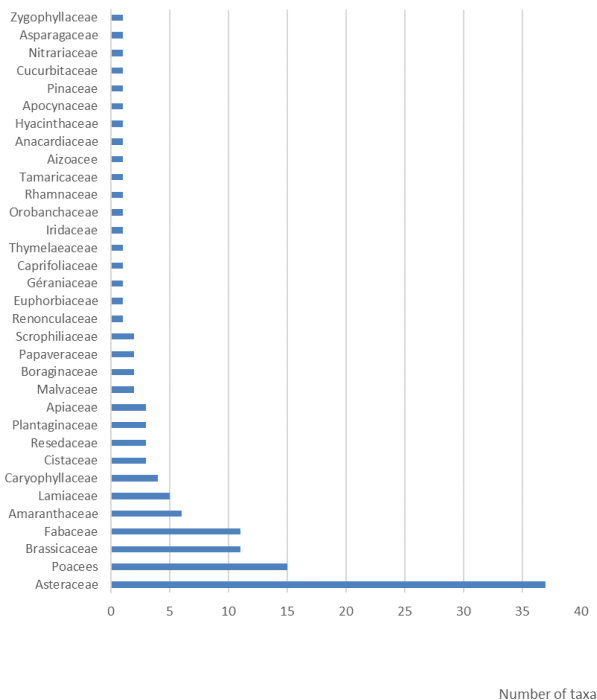


Figure 2. The most represented families (number of taxa).

Figure 2. Les familles les plus représentées (nombre de taxons).

the arduous climatic conditions but also to the anthropogenic actions (Benabadji & Bouazza, 2002; Benaradji *et al.*, 2009; Hachemi *et al.*, 2012). The high number of therophytes taxa represented in our list indicate some undergoing degradation of the local

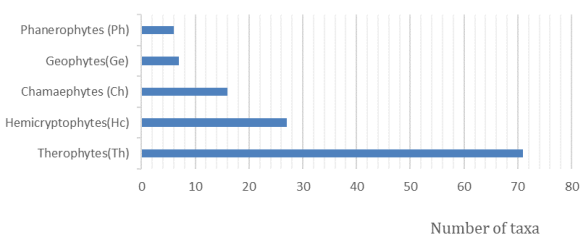


Figure 3. Biological types (number of taxa).

Figure 3. Types biologiques (nombre de taxons).

The rates of the perturbation index (PI) in the four stations of study vary between 59% and 81%. This confirms the presence of the phenomenon of Therophytization in these regions by the dominance of Therophytes annual species more or less needing water resources, trophic and the opening areas (Regagba, 2012). This also indicate the adaptation of these species to the effect of the anthropic actions (Grime, 1977; Barbero *et al.*, 1989a, 1989b). The Therophytisation is the ultimate stage of degradation of the ecosystems with the dominance of the sub-

nitrophiles species related to the overgrazing (Hachemi *et al.*, 2002).

Chorological types

The chorological spectrum of our studied areas is generally marked by the prevalence of the Mediterranean element (48 taxa, 35%). This reflects the global and logical affinity of our flora to the Mediterranean region that is generally appropriate to the climate which characterizes this area (Le Houerou, 1995; Quézel, 1983).

The wide distribution taxa come in second position with 38 taxa (28%). The abundance of these species is generally related to the phenomenon of Therophytization of the Mediterranean flora induced by the action of several ecological and anthropogenic factors (Miara *et al.*, 2016). The Nordic taxa occupies the third position with a total number of 19 taxa (14%). This number can also be explained by the remote geographical location of northern Europe.

The Saharian element comes in fourth position with 17 taxa (13%). The presence of a significant number of these taxa in these environments is explained by the geographic situation of the steppe areas bordering the desert (Aidoud, 1983).

Finally, the endemic type is represented with 14 taxa (10%). These taxa belongs to Algerian-Moroccan (5 taxa) and North African elements (9 taxa). The number of endemic species reported in this study is quite low compared to the endemic taxon richness of these regions (Bekai *et al.*, 2019). Indeed, an important reduction of the rates of endemic taxa in the steppe area was observed by the previous studies (Kadi-Hanifi, 2003; Abdelmoumen & Zoheir, 2015; Nacère *et al.*, 2016). In the Mediterranean region, these endemic taxa, even when they occur as Therophytes, are very fragile and vulnerable to anthropogenic disturbances (Quézel and Médail, 2003).

Thus, all the endemic species cited for the region in the flora of Quézel and Santa (1962-63) were not found in particular: *Erodium hymenodes*, *Echium suffruticosum*, *Celsia battandieri*, *Bellium rotundifolium*, *Atractylis polycephala*, *A. phaeolepis*. This may indicate local extinctions which are the result of a trivialization of the local flora by annual therophyte sub- nitrophiles taxa with greater ecological valence.

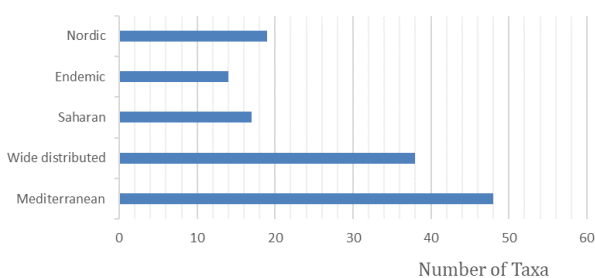


Figure 4. Chorological types (number of taxa).

Figure 4. Types chorologiques (nombre de taxons).

Conclusion

The results obtained show an interesting richness of the local flora (127 taxa, which is mainly dominated by therophyte taxa of low ecological and heritage value. It also turns out that the phenomenon of therophytization observed in this region has contributed to a certain "trivialization" of the regional flora which normally is quite specific and rich with strict endemic taxa. This is confirmed by the chorological analysis showing the absence of all endemic plants (including strict endemics) reported in this region in the past. In addition, the presence of a good number of other endemics of North Africa relatively preserves the floristic originality of this region. Finally, we insist on the necessity and the urgency to protect these natural spaces containing a rich and original biodiversity.

Conflicts of interest

The authors declare no conflict of interest throughout this research and writing process.

References

- Abdelguerfi, A. & Ramdane, M.S.A. (2003). *Evaluation des besoins en matière de renforcement des capacités nécessaires à la conservation et l'utilisation durable de la biodiversité importante pour l'agriculture*. Projet ALG/97/G31. Plan d'Action et Stratégie Nationale sur la Biodiversité. Tome XI, 230 p.
- Abdelmoumen, S. & Zoheir, M. (2015). Evaluation of Plant Diversity in the Steppes of White Wormwood of the Region of Saida (Western Algeria). *Open Journal of Ecology*, 5 (10): 491-500.
[https://DOI: 10.4236/oje.2015.510040](https://doi.org/10.4236/oje.2015.510040).
- Aidoud, A. (1983). *Contribution à L'étude des écosystèmes steppiques du Sud Oranais*. U.S.T.H.B, Alger, 232p.
- Aidoud, F. (1984). *Contribution à la connaissance des groupements à sparte (Lygeum spartum L.) des hauts plateaux sud-oranais. Etude phytoécologique et syntaxonomique*. Thèse doct 3ème cycle, univ, Sci. Technol. H boumediène, Alger, 256 p.+ ann.
- Barbero, M., Bonin, G., Loisel, R. & Quezel, P. (1989a). Sclerophyllous *Quercus* forests of the Mediterranean area: Ecological and ethological significance. *Bielefelder. Okol. Beitr*, 4:1-23.
<http://www.herbmedit.org/boccone/13-011.pdf>.
- Barbero, M., Quezel, P., Loisel, R. (1989b). Disturbances and fires in the Mediterranean region. *Int. Estud. Pyrenaiscos. Jaca*, 12: 194-215.
- Barbero, M., Quezel, P. & Loisel, R. (1990). Les apports de la phytoécologie dans l'interprétation des changements et perturbations induits par l'homme sur les écosystèmes forestiers méditerranéens. *Forêt méditerranéenne*, XII (3): 194-215.
http://www.foretmediterranee.org/upload/biblio/FORET_MED_1990_3_194.pdf.

- Bekai, F., Kadik, L. & Nedjimi, B. (2019). Effects of deferring grazing on the floristic diversity of *Stipa tenacissima* L. rangelands in central Algerian steppe. *Afr. J. Ecol.*, 00:1–8. <https://doi.org/10.1111/aje.12614>
- Benabadji, N., Benmansour, D. & Bouazza, M. (2007). La flore des monts d'Ain Fezza dans l'ouest Algérien, biodiversité et dynamique. *Sciences & Technologie. C. Biotechnologies*, 26: 47-59.
- Benabadji, N. & Bouazza M. (2002). Contribution à l'étude du cortège floristique de la steppe au sud d'El Aricha (Oranie, Algérie). *Sciences & Technologie. C. Biotechnologies*, 1: 11-19. <http://revue.umc.edu.dz/index.php/c/article/view/1849/1969>.
- Benalia, Y., Mostefa, T., Benzian, A., Elhadi, B., Mounir, G., Saoussane, K. & Brahim., G. (2018). Therapeutic use of spontaneous medicinal flora from an extreme environment (dune cordon) in Djelfa region, Algeria. *Journal of Pharmacy & Pharmacognosy Research*, 6 (5), 358-373.
- Benaradj, A. (2009). *Mise en défens et remontée biologique des parcours steppiques dans la région de Naâma: dissémination et multiplication de quelques espèces steppiques*. Magistère thesis, Fac. Sci. Nat. et de la Vie, Univ. Mascara, 229p.
- Braun-Banquet, J. (1951). *Pflanzen soziologie. Grund zuge der Vegetation Kunde*. Ed. 2. Springer, Vienne, Autriche. 227p. DOI https://doi.org/10.1007/978-3-7091-8110-2_1.
- Cherfaoui, T. (2017). *Etude de la Croissance et de l'accroissement du pin d'Alep dans la forêt Senalba Gharbi (Djelfa)*. Cas de la Série 13. Magister thesis. University of Tlemcen, 58p.
- Daget, P. (1980). Sur les types biologiques botaniques en tant que stratégie adaptative (cas des thérophytes). In: Barbault, R., Blandin, P. & Meyer, J. A. (eds), *Recherches d'écologie théorique, les stratégies adaptatives*. Maloine, Paris: 89-114.
- Djaballah, F. & Chehma, A. (2008). *Effet de deux méthodes d'aménagement « mise en défens et plantation » sur les caractéristiques floristiques et nutritives des parcours steppiques de la région de Djelfa*. Magistère thesis, University of Ouargla, 98p. <http://hdl.handle.net/123456789/463>
- Djebaili, S. (1978). *Recherches phytosociologiques et phytoécologiques sur la végétation des hautes plaines Steppiques et de l'Atlas Saharien*. Doctorate thesis. University of Montpellier, 229 p.
- Djebaili, S. (1984). *Algerian steppe, phytosociology and ecology*. O.P.U. Algiers. 171p.
- Dobignard, A. & Chatelain, C. (2010-2013). *Index synonymique de la Flore d'Afrique du Nord*, V: 1-5. Genève.
- Fennane, M. & Ibn Tattou, M. (2012). Statistiques et commentaires sur l'inventaire actuel de la flore vasculaire du Maroc. *Bulletin de l'Institut Scientifique*, Rabat, section Sciences de la Vie, 2012, n°34 (1): 1-9.
- Gounot, M. (1969). *Méthode d'étude quantitative de la végétation*. Masson, Paris, 308p.
- Grime, J.P. (1977). Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. *The American Naturalist*, 111 (982): 1169-1194. <https://doi.org/10.1086/283244>.
- Hachemi, N., Hasnaoui, O., Benmehdi, I., Medjati, N. & Bouazza, M. (2012). Contribution à l'étude de la thérophytisation des matorrals des versants sud des monts de Tlemcen (Algérie occidentale). *Mediterranea*, 23: 158-180. DOI: 10.14198/MDTRRA2012.23.06
- Halem, M. (1997). *La steppe Algérienne: causes de la désertification et propositions pour un développement durable*. MSc dissertation, University Sidi Bel Abes, Algeria.
- Kadi-Hanifi, H. (2003). Diversité biologique et phytogéographique des formations à *Stipa tenacissima* L. de l'Algérie. *Science et changements planétaires/Sécheresse*, 14 (3): 169-179.
- Kazi-Tani, C., Le Bourgeois, T. & Munoz, F. (2010). *Contribution à l'étude des communautés d'adventices des cultures du secteur phytogéographique Oranais (nord-ouest algérien): aspects botanique, agronomique et phyto-écologique*. AFPP.
- Korichi, A. (2016). *Etude floristique et ethnobotanique de Chouchet Tobdji (forêt de Sénalba Chergui) - Région de Djelfa*. Magister thesis. Univ Djelfa, 78p.
- Le Houerou, H. N. (1969). La Végétation de la Tunisie steppique : structure, écologie, sociologie, répartition, évolution, utilisation, biomasse (productivité, avec références aux végétations analogues d'Algérie, de Libye et du Maroc). *Annales de l'Institut National de la Recherche Agronomique de Tunisie*, 42 (5): 1- 643 + Annexes.
- Le Houerou, H.N. (1995). Bioclimatologie et biogéographie des steppes arides du nord de l'Afrique. Diversité biologique, développement durable et désertification. *Option méditerranéenne*. Ser. B: recherches et études, 369 p.
- Loisel, R. & Gamila, H. (1993). Traduction des effets de débroussaillage sur les écosystèmes forestiers et pré-forestiers par indice de perturbation. *Ann. Soc. Sci. Nat. Arch. Toulon*: 123-132.
- Maamri, F. (2016). *Les espèces pastorales et fourragères originaires de la steppe Algérienne : distribution, diversité et voie d'utilisation*. ENSA Alger, 220p.
- Médail, F. & Quézel, P. (1997). Hot-spots analysis for conservation of plant biodiversity in the Mediterranean basin. *Ann. Missouri Bot. Gard*, 84: 112-127
- Miara, MD., Ait Hammou M, Hadjadj Aoul S, DahmaniW, Negadi M, Rebbas K, Bounar R. & Smaili T. (2016). Note sur les thérophytes dans les monts de Tiaret (massif de Guezoul- Algérie occidentale). *Revue Ecologie – Environnement*, 12: 17-24.

- Miara, MD., Ait Hammou, M., Dahmani, W., Negadi, M. & Djellaoui A. (2018a). Nouvelles données sur la flore endémique du sous-secteur de l'Atlas tellien Oranais "O3" (Algérie occidentale). *Acta Botanica Malacitana*, 43: 63-69. <https://doi.org/10.24310/abm.v43i0.4453>
- Miara, MD., Bendif, H., Ait Hammou, M. & Teixidor-Toneu, I. (2018b). Ethnobotanical survey of medicinal plants used by nomadic peoples in the Algerian steppe. *Journal of Ethnopharmacology*, 219: 248-256. <https://doi.org/10.1016/j.jep.2018.03.011>
- Mittermeier, R.A., Robles Gil P., Hoffmann M., Pilgrim J., Brooks T., Mittermeier C.G., Lamoreux J., Da Fonseca, G.A.B. (2004). *Hotspots revisited: Earth's biologically richest and most endangered terrestrial ecoregions*, Preface by Peter A. Seligmann, Foreword by Harrison Ford. Cemex, Conservation International, Agrupacion Sierra Madre, Monterrey, Mexico, p. 392.
- Myers, N. (1988). Threatened biotas: Hotspots in tropical forests. *Environmentalist*, 8, 178-208.
- Myers, N. (1990). The biodiversity challenge: Expanded hotspots analysis. *Environmentalist*, 10: 243-256.
- Nedjraoui, D. & Bédrani, S. (2008). La désertification dans les steppes algériennes: causes, impacts et actions de lutte. *Vertigo*, V: 8, n° 1. <http://vertigo.revues.org/index448.html>.
- Ozenda, P. (1977). *Flore du Sahara* (Deuxième édition revue et complétée). CNRS, Paris, 622p.
- Quézel, P. & Santa, S. (1962,1963). *Nouvelle flore d'Algérie et des régions désertiques méridionales*. Tomes I et II, 1170 p.
- Quézel, P. (1983). Flore et végétation actuelles de l'Afrique du nord, leur signification en fonction de l'origine, de l'involution et des migrations des flores et structures de végétation passées. *Bothalia*, 14 (3/4) : 411-416. DOI: 10.4102/abc.v14i3/4.1186.
- Quézel, P. & Médail, F. (2003). *Ecologie et biogéographie des forêts du bassin méditerranéen*. Elsevier, Paris. 571 p.
- Rahmoune, A. (2018). *Ecologie et analyse floristique de la végétation et de la flore de la forêt de Sahary Guebli (réserve de chasse) Wilaya de Djelfa*. Master thesis. University of Batna, 135p.
- Regagba, Z. (2012). *Dynamique des populations végétales halophytes dans la région sud-est de Tlemcen. Aspects phytoécologiques et cartographiques*. Doctorate thesis. University of Tlemcen, 179p.
- Vela, E & Benhouhou, S. (2007). Evaluation d'un nouveau point chaud de biodiversité végétale dans le bassin méditerranéen (Afrique du nord). *C.R. Biologies*, 330: 589-605.
- Zehraoui, R. & Kadik, L. (2016). Résultats préliminaires de l'étude de l'impact des reboisements du barrage vert sur la biodiversité floristique cas de la région de Djelfa (Algérie). Séminaire International «Biodiversité et Changements Globaux» Djelfa, 11p. https://www.researchgate.net/scientificcontributions/2132032359_Zehraoui_Rabia