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Analysis of rare and endemic flora in northeastern Algeria: the case of the wilaya of Souk Ahras

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Abstract

Scarcity and endemism are considered the most important concepts of a region's biodiversity and conservation. Nevertheless, our understanding of the models of scarcity and endemism is limited to high biodiversity regions as, for example, the wilaya of Souk Ahras, northeastern Algeria. In this study, we have compiled a list of all heritage species, their taxonomic composition, and geographic distribution. A total of 119 species was documented, and their distribution was as analyzed in the biological environments of two distinct phytogeographic sectors — C1 and H2. The rate of scarcity and endemism increased alongside the organic matter richness and, as a result, the forest and pre-forest area supported an over-representation of these species. The preservation of this biodiversity, exceptional and threatened, urgently requires appropriate scientific studies and environmental protection as short term measures.

Keywords: biogeography, conservation, endemism, rarity, Souk Ahras, threat.

1. Introduction

The distribution and abundance of species are key in ecology and biogeography (Huang *et al.*, 2016). The concept of endemism states that a taxon is limited in its distribution to a distinct area, which is the heart of biogeography (Anderson, 1994), and an important criterion for the conservation of biodiversity on a global, national, and local scales (Myers *et al.*, 2000; Riemann & Ezcurra, 2005). Rare plants have great conservation value, either for their heritage or their risk of extinction (Gaston, 1991; Pimm *et al.*, 1998).

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The identification of the vital areas for preserving biodiversity, with high concentration of closely related species (Myers *et al.*, 2000; Médail and Diadema, 2006), becomes a fundamental task for the biogeography conservation (Cañadas *et al.*, 2014; Morrone, 2018). With a richness of 25000 vascular plant species, half of which are endemic and are well adapted to dry periods (Quézel, 1995; Véla and Benhouhou, 2007), among the 34 hotspots in plant diversity on the planet (Myers, 2003), the Mediterranean basin is ranked as the third richest hotspot (Mittermeier *et al.*, 2004), with additional complex geological, biological and cultural character (Blondel *et al.*, 2010).

Algeria, due to its geographical position, is part of this hotspot with 4449 taxa, 6.5 % of which are endemic (Dobignard and Chatelain, 2010-2013), with a high rarity index. More than three quarters (77.9 %) of the strict endemic taxa of Algeria are rare plants, representing less than a quarter of the total number of plants (Véla and Benhouhou, 2007). Despite being classified as a biodiversity hotspot, several regions of this country are yet to be explored (Benhouhou *et al.*, 2018).

In order to safeguard the plant biodiversity of these threatened regions, it is imperative to establish benchmarks that describes their biodiversity (Primack *et al.*, 2012), by updating the taxonomic nomenclature of the Algerian flora (Amirouche and Misset, 2009). This can be carried out with collaboration between scientists and amateurs, active field work, and taxonomic problem solving (Domina *et al.*, 2015).

Work on rare and endemic flora in Algeria has been excessively confined to its geography (Hamel *et al.*, 2013; Zedam, 2015; Miara *et al.*, 2017, 2018; Mansouri *et al.*, 2018; Djebbouri and Terras, 2019; Gordo and Hadjadj-Aoul, 2019). Furthermore, the touchstone study on endemic and/or rare plants in Algeria by Véla and Benhouhou (2007) was based on old data from the flora of Quézel and Santa (1962–1963).

It is in this context that the current work is rooted, proposing an inventory and an update on the rare and endemic flora present in the wilaya (or department) of Souk Ahras. Thereby, here we suggest a starting point for new conservation projects and research on local flora.

2. Materials and Methods

2.1 Study area

The wilaya of Souk Ahras, located in the extreme northeast of Algeria, is limited in the north and west by the wilayas of El Tarf and Guelma, southwest by the wilaya of Oum el Bouaghi,

southeast by the wilaya of Tebessa, and in the east by Tunisia (Figure. 1). This region is part of the 11th regional biodiversity hotspot in the Mediterranean, called "Kabylias–Numidia–Kroumiria" (Véla and Benhouhou, 2007), and covers the Important Plant Area (IPA) called "El Kala 2" (Yahi *et al.*, 2012; Benhouhou *et al.*, 2018).

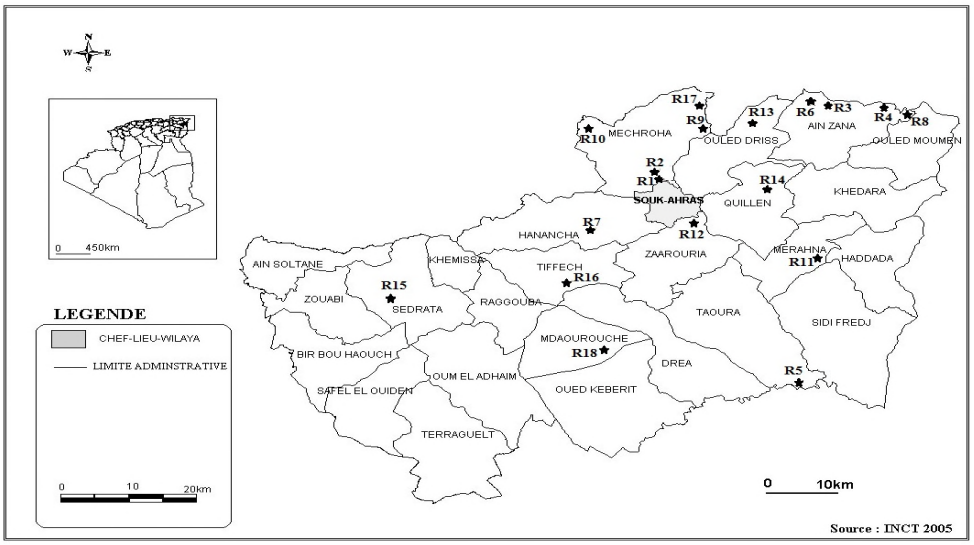

Figure 1: Geographical location of the study sites

Two heterogeneous sets determined the geomorphological configuration of this wilaya: the north (C1) was represented by mountains and forests and made up of 12 municipalities, with a total area of 1880 km^2, characterized by a humid and subhumid bioclimates, with an average rainfall of 730 mm/year; the south (H2) made up of high plains and pastures encompassing 14 municipalities, covering an area of 2480 km^2, and characterized by a semi-arid bioclimate, with an average rainfall of 350 mm/year (Hamaidia and Berchi, 2018).

The average daily temperature varied according to the seasons (from 10 °C in January to 47 °C in August). Average monthly temperatures were 15 °C in January and 35 °C in July (CONM, 1990-2020). In this wilaya, the wooded area amounted to 82,375 ha. It comprised of two definite parts separated by the Medjerda wadi: to the north the cork oak (*Quercus suber* L.) and zeen oak (*Quercus canariensis* Willd.), and to the south the *Pinus halepensis* Mill. (Boudy, 1955). The ecosystems were similar as those of the rest of Numidia (forests, maquis, humid environments, and lawns), except for the coast and the dune compounds (see de Bélair *et al.*, 2005).

2.2 Methodology

2.2.1 *Floristic study*

The list of rare and endemic species was established according to a systematic sampling, from 2017 to 2020, from floristic surveys. This data collection was carried out at the level of forests of zeen oak (*Quercus canariensis* Willd.), cork oak (*Quercus suber* L.), matorrals of *Pistacia lentiscus* L., *Olea europaea* L., rocky areas, water bodies, neighboring lawns, and steppes (*Macrochloa tenacissima* (L.) Kunth and *Artemisia herba-alba* Asso), according to the phytosociological method of Braun-Blanquet *et al.* (1952).
At the level of each site, ecological parameters were studied, namely the specific richness of rare and endemic species, altitude, and precipitation (see Table 1).

Table 1: The coordinates of the sampled stations

Code	Sites	GPS coordinates	Biogeographic sector (Quézel and Santa) (1962-1963)	Type of vegetation	Precipitation (mm/year) (CONM, 1990-2020)	Altitude (m)	Bioclimate (CONM, 1990-2020)
R1	Ain senour	36°19'25"N ; 7°52'30"E	C1	Lawn	945	843	Humid
R2	Ain Talhi	36°20'22"N ; 7°51'40"E	C1	Matorral	945	853	Humid
R3	Ain Trab	36°21'53"N ; 8° 7'59"E	C1	Humid environment	884	902	Humid
R4	Ain Zena	36°24'02"N ; 8°11'28"E	C1	Matorral	842	1155	Humid
R5	Ben Attia	36°01’31"N ; 8°06’38"E	H2	Steppe	266	517	Semi-arid
R6	Djebel Mcid	36°23'56"N ; 8°3'28" E	C1	Matorral	972	1383	Humid
R7	Hannecha	36°13′1″N ; 7°49′60″ E	C1	Matorral	712	847	Sub-humid
R8	Pool of Ain Zena	36°24′2″N ; 8°11′28″E	C1	Humid environment	837	839	Humid
R9	Mazeraa	36°23'7"N ; 7°53'13"E	C1	Zeen oak forest	1124	925	Humid
R10	Machroha	36°21′26″N ; 7°50′8″ E	C1	Cork oak forest	935	733	Humid
R11	Merahna	36°12'8"N ; 8°9'31" E	H2	Steppe	280	551	Semi-arid
R12	Oued Medjarda	37°07′12"N ; 10°3′27"E	H2	Humid environment	730	570	Sub-humid
R13	Ouled Bechih	36°20'21"N ; 7°52'19"E	C1	Cork oak forest	955	822	Humid
R14	Tarja	36°17'25"N ; 8°03'01"E	H2	Matorral	782	1150	Sub-humid
R15	Sedrata	36°7'51"N ; 7°31'57"E	H2	Steppe	370	797	Semi-arid
R16	Tiffech	36°11'30"N ; 7°47'10"E	H2	Lawn	416	972	Sub-humid
R17	Majen Matlag	36°25'40"N ; 7°55'45"E	C1	Humid environment	701	692	Humid
R18	M'daourouche	36°04'29"N ; 7°49'11"E	H2	Steppe	330	753	Semi-arid

The taxa were identified according to the flora of Battandier (1888–1890), Battandier and Trabut (1895), Maire (1952–1987), Quézel and Santa (1962–1963), Pignatti (1982), and ; Blanca *et al.* (2009). The nomenclature has been updated according to the synonymic index of North Africa (Dobignard and Chatelain, 2010–2013) and the African Plant Database (APD, 2020). The rarity of taxa was in referrence to the flora of Quézel and Santa (1962–1963) and according to our observations in the field, namely the following statuses: rare (R) and very rare (RR) for non-endemic taxa. For endemic taxa, the classification was as follows: common (C), fairly common (FC), and fairly rare (FR).

The biological types (Raunkiaer, 1934) of the different taxa has been assigned based on Pignatti (1982), Blanca *et al.* (2009) and, for some endemics, according to Quézel and Santa (1962–1963).

Chorological characterization was carried out based in the flora of Andalusia (Blanca *et al.*, 2009), whereas the eight endemic sub-elements followed the flora of Italia (Pignatti, 1982) and the synonymic index of Dobignard and Chatelain (2010–2013).

Threats and protection status

The characterization of the on-site threatened species was carried out based on the criteria of rarity by Quézel & Santa (1962-1963), criteria of vulnerability on a global scale by the International Union for the Conservation of Nature in 1997 (Walter & Gillett, 1998), and according to the current red list available (IUCN, 2021). The red list makes it possible to highlight the taxa at the highest risk of extinction and defines the priorities in policies to safeguard and conserve the plant biodiversity. We also considered species with heritage interest protected by Decree No. 03–12 / 12–28, in addition to the non-cultivated plant species protected in Algeria (JORA, 2012) and the synonymic index of North Africa (Dobignard and Chatelain, 2010–2013).

3.1 Scarcity

Of the 119 species recorded in the study region, nine taxa were quite rare, 55 taxa were rare, 13 taxa were very rare (Table 2), and 14 taxa were rather rare endemics. Indeed, the species observed in the study region seldom had the same heritage value. Additionally, 33 taxa were both endemic and rare (e.g. *Bunium crassifolium, Convolvulus durandoi, Dactylorhiza elata, Ophrys subfusca* subsp. *battandieri*). Such relationship between scarcity and endemism was noticeable in our studied flora. Our list includes 28 taxa widely distributed in the national territory (e.g., *Anarrhinum pedatum, Stachys duriaei, Bellevalia mauritanica, Rupicapnos*

numidica), 40 rare to very rare Mediterranean taxa (*sensu lato*), three rare paleotemperate taxa, and one rare Eurasian taxon.

Taxa	Family	Biological types	Chorological types	Locality	Habitat	Scarcity
Achillea ligustica All.	Asteraceae	Hem	Mediterranean	Mazeraa	Zeen oak forest	VR
Allium porrum subsp. *polyanthum* (Schult. & Schult. f.) Jauzein & J.-M. Tison	Amaryllidaceae	Geo	Eury-Mediterranean	Ben Attia, Tiffech	Steppe, lawn	R*
Althaea hirsuta L.	Malvaceae	Th	Eury-Mediterranean	Ain senour	lawn	R
Ambrosina bassii L.	Araceae	Geo	Subend. Tyrrhenian	Mazeraa, Ouled Bechih	Zeen oak forest, cork oak forest	C
Anacamptis pyramidalis (L.) Rich.	Orchidaceae	Geo	Mediterranean	Ain Talhi	Matorral	R*
Anarrhinum pedatum Desf.	Plantaginaceae	Hem	End. Alg-Tun-Mor	Ain Zena	Cliff	C
Antirrhinum tortuosum Bo ex Vent.	Plantaginaceae	Ch	Mediterranean	Ain Zena, Hannecha	Cliff, matorral	R
Arabis pubescens (Desf.) Poir. subsp. *pubescens*	Brassicaceae	Hem	End Alg-Tun-Mor	Ain Zena	Zeen oak forest	FC
Arenaria cerastioides Poir.	Caryophyllaceae	Th	End Alg-Tun-Mor	Ain Zena	Zeen oak forest	FC
Argyrolobium saharae Pomel	Fabaceae	Ch	End Alg-Mor-Egy	Ben Attia	Steppe	R
Aristolochia paucinervis Pomel	Aristolochiaceae	Geo	Subend. Tyrrhenian	Ain Trab	Humid environment	R
Armeria choulettiana Pomel	Plumbaginaceae	Hem	End Alg-Tun-Mor	Ain Talhi	Matorral	FR
Barnardia numidica (Poir.) Speta	Asparagaceae	Geo	End Alg-Tun-Lib	Mazeraa, Ouled Bechih, Ain Zena	Zeen oak forest, cork oak forest, cliff	C
Bellevalia mauritanica Pomel	Asparagaceae	Geo	End Alg-Tun-Mor-Lib-Egy	Tarja	Matorral	FC
Biscutella raphanifolia Poir.	Brassicaceae	Hem	End Alg-Tun-Itl	Ain Talhi, Tiffech	Matorral, lawn	FR
Brassica procumbens (Poir.) O.E. Schulz	Brassicaceae	Th	End Alg-Tun	Ain Talhi, Ain Zena, Ben Attia, Ouled Bechih, Mazeraa	Matorral, cliff, steppe, cork oak forest, zeen oak forest	C
Bunium crassifolium (Batt.) Batt.	Apiaceae	Geo	End Alg-Tun	Machrouha, Ain Zena	Cork oak forest, cliff	R
Cachrys libanotis L.	Apiaceae	Hem	Mediterranean	Hannecha	Matorral	R
Calamintha menthifolia Host.	Lamiaceae	Hem	Mediterranean	Mazeraa	Humid environment	R
Calendula suffruticosa subsp. *boissieri* Lanza	Asteraceae	Hem	End Alg-Tun-Mor	Hannecha, Ain Zena	Matorral, cliff	R
Cardopatium amethystinum Spach	Asteraceae	Hem	End Alg-Tun	Merahna	Steppe	FR
Castanea sativa Mill.	Fagaceae	Ph	Mediterranean	Mazeraa	Zeen oak forest	VR
Cedrus atlantica (Endl.) Carrière	Pinaceae	Ph	End Alg-Mor	Djebel Mcid	Matorral	FC
Centaurea involucrata Desf.	Asteraceae	Th	End Alg-Mor	Ben Attia	Steppe	FR*
Centaurea solstitialis subsp. *schouwii* (DC.) Gugler	Asteraceae	Hem	End Alg-Tun-Itl	Tiffech	Lawn	VR
Chaerophyllum temulum L.	Apiaceae	Hem	Eurasian	Majen Matlag	Humid environment	R
Convolvulus durandoi Pomel	Convolvulaceae	Geo	End Alg-Tun	Ain Talhi, Ain zena	Matorral, cliff	R
Cosentinia vellea (Aiton) Tod. subsp. *vellea*	Sinopteridaceae	Hem	Eury-Mediterranean	Ain Zena	Cliff	R*
Cyclamen africanum Boiss. & Reut.	Primulaceae	Geo	End Alg-Tun-Mor	Mazeraa, Mechrouha, Ouled Bechih, Ain Zena	Zeen oak forest, cork oak forest, cliff	C

Cynosurus polybracteatus Poir.	Poaceae	Th	End Alg-Tun	Mazeraa	Zeen oak forest	C
Dactylorhiza elata (Poir.) Soó	Orchidaceae	Geo	End Alg-Tun	Ain Trab	Humid environment	R
Daucus gracilis Steinh.	Apiaceae	Th	End Alg-Tun-Mor	Mechrouha, Ain Zena	Cork oak forest, cliff	FR
Daucus virgatus (Poir.) Maire	Apiaceae	Hem	End Alg-Tun	Ain senour, Ain Zena	Matorral, cliff	R
Deverra scoparia Coss. & Durieu subsp. *scoparia*	Apiaceae	Hem	End Alg-Tun-Mor-Lib-Mau	Ben Attia, Merahna	Steppe	C
Diatelia tuberaria (L.) Demoly	Cistaceae	Ch	Mediterranean	Mechrouha	Cork oak forest	R
Drimia anthericoides (Poir.) Véla & De Bélair	Asparagaceae	Geo	End Alg	Ain Talhi	Matorral	R*
Drimia numidica (Jord. & Fourr.) J.C. Manning & Goldblatt	Asparagaceae	Geo	End Alg-Tun-Spa	Ain Talhi, Ain senour, Mechroha, Mazeraa, Mare Ain Zena, Ain Zena, Tarja, Djebel Mcid, Ouled Bechih, Ain Trab, Majen Matlag	Matorral, lawn, Zeen oak forest, cliff, humid environment, cork oak forest	C
Ebenus pinnata Aiton	Fabaceae	Hem	End-Alg-Tun-Mor-Lib	Tarja, Tiffech, Ben Attia, Sedrata, M'daourouche	Matorral, steppe	C
Echinops bovei Boiss.	Asteraceae	Hem	End Alg-Tun-Mor	Ain Talhi, Ain Zena, Tiffech	Matorral, cliff, lawn	C
Eryngium pusillum L.	Apiaceae	Hem	Mediterranean	Mare Ain Zena, Majen Matlag	Humid environment	R
Euphorbia cuneifolia Guss.	Euphorbiaceae	Th	End Alg-Tun-Itl	Majen Matlag	Humid environment	FR
Galactites mutabilis Durieu	Asteraceae	Th	End Alg-Tun	Ain senour, Ain Talhi, Mechroha, Ain zena, Tarja, Ouled Bechih, Tiffech	Matorral, lawn, cliff, cork oak forest, Zeen oak forest	FR
Genista ferox (Poir.) Dum. Cours. subsp. *ferox*	Fabaceae	Ph	End Alg-Tun-Itl	Ain Talhi, Mechroha, Tarja, Ain Zena, Ouled Bechih, Mazeraa	Matorral, cork oak forest, cliff, Zeen oak forest	C
Genista tricuspidata Desf. subsp. *tricuspidata*	Fabaceae	Ph	End Alg-Tun-Mor	Mechrouha	Cork oak forest	C
Genista ulicina Spach	Fabaceae	Ph	End Alg-Tun	Ain Talhi, Mechrouha, Ouled Bechih, Ain Zena, Djebel Mcid	Matorral, cork oak forest, cliff	FR
Geranium atlanticum Boiss.	Geraniaceae	Hem	End Alg-Tun-Mor	Djebel Mcid	Matorral	C
Geranium columbinum L.	Geraniaceae	Th	Paleotemperate	Majen Matlag	Humid environment	R
Geranium dissectum L.	Geraniaceae	Th	Paleotemperate	Majen Matlag, Ain Trab	Humid environment	R
Hedera algeriensis Hibberd	Araliaceae	Ph	End Alg-Tun	Mazeraa	Zeen oak forest	C
Helosciadium crassipes W.J. Koch	Apiaceae	Hydr	Mediterranean	Mare Ain Zena, Ain Trab, Majen Matlag	Humid environment	VR
Hertia cheirifolia (L.) Kuntze	Asteraceae	Ph	End Alg-Tun	Ben Attia, Merahna, Sedrata, M'daourouche	Steppe	C
Hippocrepis atlantica Ball	Fabaceae	Hem	End Alg-Tun-Mor	Ain Zena	Cliff	C
Hyacinthoides lingulata (Poir.) Rothm.	Asparagaceae	Geo	End Alg-Tun-Mor	Mechrouha, Mazeraa	Cork oak forest, Zeen oak forest	C
Hypericum androsaemum L.	Hypericaceae	Ch	Paleotemperate	Mazeraa, Ouled Bechih	Zeen oak forest, cork oak forest	R
Hypericum montanum L.	Hypericaceae	Hem	Eury-Mediterranean	Djebel Mcid, Ouled Bechih	Matorral, cork oak forest	R
Illecebrum verticillatum L.	Caryophyllaceae	Th	Mediterranean	Mare Ain Zena	Humid environment	VR

Iris unguicularis Poir.	Iridaceae	Geo	End Alg-Tun	Mechrouha, Mazeraa	Cork oak forest, zeen oak forest	C
Jonopsidium albiflorum Durieu	Brassicaceae	Th	End Alg-Tun-Itl	Djebel Mcid, Tarja	Matorral	R
Juncus heterophyllus Dufour	Juncaceae	Hydr	Mediterranean	Mare Ain Zena, Majen Matlag	Humid environment	R
Lathyrus latifolius subsp. *algericus* (Ginzb.) Dobignard	Fabaceae	Hem	End Alg-Tun-Mor	Ain Talhi	Matorral	R*
Lepidium rigidum Pomel	Brassicaceae	Hem	End Alg-Tun	Ain senour	Lawn	FC
Linaria virgata subsp. *algeriensis* Murb.	Plantaginaceae	Ch	End Alg-Tun	Sedrata	Steppe	C
Linum corymbiferum Desf. subsp. *corymbiferum*	Linaceae	Hem	End Alg-Tun	Mechrouha	Cork oak forest	C
Linum tenue Desf. subsp. *tenue*	Linaceae	Th	End. Alg-Mar-Spa	Mechrouha	Cork oak forest	R
Lithospermum tenuiflorum L. f.	Boraginaceae	Ch	Mediterranean	Tarja	Matorral	R
Lonchophora capiomontana Durieu	Brassicaceae	Th	End Alg-Tun-Lib	Sedrata	Steppe	FC
Mandragora officinarum L.	Solanaceae	Hem	Mediterranean	Ben Attia	Steppe	R
Moricandia suffruticosa (Desf.) Coss. & Durieu	Brassicaceae	Hem	End Alg-Tun-Mor	Ben Attia	Steppe	C
Myriophyllum alterniflorum DC.	Haloragaceae	Hydr	Mediterranean-Atlantic	Majen Matlag	Humid environment	R
Neotinea maculata (Desf.) Stearn	Orchidaceae	Geo	Mediterranean - Atlantic	Mechrouha	Cork oak forest	R
Oenanthe virgata Poir.	Apiaceae	Hem	End Alg-Tun-Mor	Mare Ain Zena, Oued Medjarda, Majen Matlag	Humid environment	C
Ononis angustissima subsp. *polyclada* Murb.	Fabaceae	Ch	End Alg-Tun-Mar	Ben Attia	Steppe	FC
Ononis aragonensis Asso	Fabaceae	Ph	Ibero-maghrebian	Sedrata	Steppe	VR
Ophioglossum lusitanicum L.	Ophioglossaceae	Geo	Mediterranean	Mechrouha, Djebel Mcid	Cork oak forest, matorral	R
Ophrys ×joannae Maire	Orchidaceae	Geo	End Alg-Tun	Ain Talhi	Matorral	VR*
Ophrys atlantica Munby subsp. *atlantica*	Orchidaceae	Geo	Ibero-maghrebian	Sedrata	Steppe	FR
Ophrys atlantica subsp. *hayekii* (H. Fleischm. ex Soó) Soó	Orchidaceae	Geo	Mediterranean	Sedrata	Steppe	R
Ophrys iricolor Desf. subsp. *iricolor*	Orchidaceae	Geo	Mediterranean	Ain Talhi, Mechrouha	Matorral, cork oak forest	R*
Ophrys marmorata subsp. *caesiella* (P. Delforge) Véla	Orchidaceae	Geo	Mediterranean	Hannecha, Mechrouha	Matorral, cork oak forest	R*
Ophrys numida Devillers-Tersch. & Devillers	Orchidaceae	Geo	End Alg-Tun	Ain Talhi, Hannecha, Ain senour	Matorral, lawn	R*
Ophrys subfusca subsp. *battandieri* (E.G. Camus) Kreutz	Orchidaceae	Geo	End Alg-Tun-Mor	Hannecha, Ain senour	Lawn, matorral	R
Orchis anthropophora (L.) All.	Orchidaceae	Geo	Mediterranean-Atlantic	Tarja	Matorral	R*
Orchis laeta Steinh.	Orchidaceae	Geo	End Alg-Tun	Ain Talhi	Matorral	VR*
Orchis patens Desf. subsp. *patens*	Orchidaceae	Geo	End Alg-Tun-Itl	Ain Talhi	Matorral	VR*
Origanum vulgare subsp. *glandulosum* (Desf.) Ietsw.	Lamiaceae	Ch	End Alg-Tun	Djebel Mcid, Hannecha, Ain Zena	Matorral, cliff	C
Orobanche rapum-genistae Thuill.	Orobanchaceae	Geo	Eury-Mediterranean	Mazeraa	Zeen oak forest	VR
Phlomis bovei de Noé	Lamiaceae	Hem	End Alg-Tun-Mar	Hannecha	Matorral	R
Phlomis herba-venti subsp. *pungens* (Willd.) Maire ex De Filipps	Lamiaceae	Hem	Mediterranean	Hannecha, Ain Zena	Matorral, cliff	R
Pilularia minuta Durieu	Marsileaceae	Hydr	Mediterranean	Majen Matlag	Humid environment	VR
Pistacia atlantica Desf.	Anacardiaceae	Ph	End Alg-Tun-Mor	Ben Attia, Sedrata	Steppe	FC
Plagius grandis (L.) Alavi & Heywood	Asteraceae	Ch	End Alg-Tun	Ain senour, Tiffech, Ain Zena	Lawn, cliff	C

Plagius maghrebinus Vogt & Greuter	Asteraceae	Ch	End Alg-Tun-Mor	Mazeraa, Mechrouha, Oued Medjarda, Majen Matlag	Zeen oak forest, cork oak forest, humid environment	C
Psychine stylosa Desf.	Brassicaceae	Th	End Alg-Tun-Mor	Ben Attia, Sedrata	Steppe	FC
Ranunculus bulbosus subsp. *aleae* (Willk.) Rouy & Foucaud	Ranunculaceae	Th	Mediterranean	Majen Matlag	Humid environment	R
Reichardia tingitana subsp. *discolor* (Pomel) Jahand. & Maire	Asteraceae	Th	Mediterranean	Ben Attia	Steppe	R
Rhaponticum acaule (L.) DC.	Asteraceae	Hem	Subend. Tyrrhenian	Ain senour, Tiffech	Lawn	C
Romulea ligustica Parl.	Iridaceae	Geo	Mediterranean	Ain Talhi, Mare Ain Zena, Ain Zena, Ouled Bechih, Djebel Mcid	Matorral, humid environment, cliff, cork oak forest	R
Rosmarinus eriocalyx Jord. & Fourr. subsp. *eriocalyx*	Lamiaceae	Ch	End Alg-Tun	Hannecha	Matorral	R
Rupicapnos numidica (Coss. & Durieu) Pomel	Papaveraceae	Hem	End Alg-Tun	Ain Zena	Cliff	FC
Sambucus ebulus L.	Adoxaceae	Hem	Eury-Mediterranean	Ain Trab, Oued Medjarda	Humid environment	R
Sambucus nigra L.	Adoxaceae	Ph	Eury-Mediterranean	Oued Medjarda	Humid environment	R
Santolina africana Jord. & Fourr.	Asteraceae	Ch	End Alg-Tun-Mor	Ben Attia, Merahna, M'daourouche	Steppe	FC
Scrophularia tenuipes Coss. & Durieu ex Coss.	Scrophulariaceae	Hem	End Alg-Tun	Mazeraa	Zeen oak forest	R
Scutellaria columnae All. subsp. *columnae*	Lamiaceae	Hem	Mediterranean	Mazeraa	Zeen oak forest	R
Sedum cepaea L.	Crassulaceae	Th	Mediterranean-Atlantic	Mazeraa, Ouled Bechih	Zeen oak forest, cork oak forest	R
Sedum pubescens Vahl	Crassulaceae	Th	End Alg-Tun	Tarja	Matorral	FC
Serapias lingua L. subsp. *lingua*	Orchidaceae	Geo	Mediterranean	Ain Talhi, Mare Ain Zena	Humid environment	R*
Serapias stenopetala Maire & T. Stephenson	Orchidaceae	Geo	End Alg-Tun	Mare Ain Zena	Humid environment	VR*
Sideritis incana L. subsp. *incana*	Lamiaceae	Ch	Mediterranean	Ben Attia, M'daourouche	Steppe	R*
Sinapis pubescens subsp. *indurata* (Coss.) Batt.	Brassicaceae	Hem	End Alg	Ain Zena, Hannecha, Djebel Mcid	Cliff, matorral	R
Smyrnium perfoliatum L.	Apiaceae	Hem	Eury-Mediterranean	Mazeraa	Zeen oak forest	R
Stachys duriaei de Noé	Lamiaceae	Th	End Alg-Tun	Hannecha, Ain Zena	Matorral, cliff	FC
Teucrium atratum Pomel	Lamiaceae	Ch	End Alg-Tun	Mechrouha	Cork oak forest	R
Thymus algeriensis Boiss. & Reut.	Lamiaceae	Ch	End Alg-Tun-Mor	Hannecha, Ain Zena, Ben Attia, Djebel Mcid, M'daourouche, Ain senour, Tiffech	Matorral, cliff, lawn, steppe	C
Thymus munbyanus subsp. *coloratus* (Boiss. & Reut.) Greuter & Burdet	Lamiaceae	Ch	End Alg-Tun-Mor	Mecherouha, Ouled Bechih, Ain Zena	Cork oak forest, cliff	C
Veronica montana L.	Plantaginaceae	Hem	European	Pool of Ain Zena	Humid environment	VR
Vinca major L.	Apocynaceae	Ch	Mediterranean	Mechrouha	Cork oak forest	R*
Viola munbyana Boiss. & Reut.	Violaceae	Hem	End Alg-Tun-Mor	Djebel Mcid	Matorral	FC
Viola riviniana Reich.	Violaceae	Hem	Mediterranean	Mezeraa, Mechrouha	Zeen oak forest, cork oak forest	R

End: Endemic, Subend: Subendemic Alg: Algeria; Tun: Tunisia; Mor: Morocco; Lib: Libya; Egy: Egypt; Maur: Mauritania; Itl: Italy; Spa: Spain; Bio. T: biological type; Th: Therophyte; Hem: Hemicryptophyte; Ch: Chamaephyte; Geo: Geophyte; Ph: Phanerophyte; Hydr: Hydrophyte; C: common; F: fairly; R: rare; VR: very rare; (*) modified rarity.

Of all the taxa studied, ten were threatened or near-threatened as registered on the IUCN Red List (IUCN, 2021), while 13 species were protected by Executive Decree No. 12-03 in Algeria (J.O.R.A, 2012) (see Table 3).

Table 3: List of species protected according to Executive Decree n° 12-03 (JORA, 2012) and/ or evaluated according to IUCN (2021)

Taxa	JORA (2012)	IUCN (2021)
Argyrolobium saharae Pomel	P	
Bunium crassifolium (Batt.) Batt.	P	
Cedrus atlantica (Endl.) Carrière ex Manetti	P	EN
Convolvulus durandoi Pomel	P	NT
Cyclamen africanum Boiss. & Reut.	P	
Dactylorhiza elata (Poir.) Soó		NT
Drimia anthericoides (Poir.) Véla & de Bélair		EN
Illecebrum verticillatum L.	P	
Juncus heterophyllus Dufour		NT
Mandragora officinarum L.	P	
Ononis aragonensis Asso	P	
Orchis laeta Steinh.		NT
Orchis patens Desf. subsp. *patens*	P	
Phlomis bovei de Noé	P	
Pilularia minuta Durieu		EN
Pistacia atlantica Desf.	P	NT
Scrophularia tenuipes Coss. & Durieu ex Coss.	P	NT
Serapias stenopetala Maire & T. Stephenson		CR
Teucrium atratum Pomel	P	

P: protected, NT: near-threatened, EN: endangered, CR: critically endangered.

3.2 Biogeographic distribution

We have identified three biogeographic sets in the studied flora:

3.2.1 *The Mediterranean set*

This set included 39 species (32.77 %) of the flora listed, 27 for the Mediterranean element (*sensu stricto*), eight for the Eury-Mediterranean connecting element, and four for the Atlantic-Mediterranean connecting element. In this set, the richest families were the *Orchidaceae* family, with seven taxa, and the *Apiaceae* and *Lamiaceae,* with four taxa for each.

3.2.2 *Nordic set*

This set was represented by three paleotemperate taxa (*Hypericum androsaemum, Geranium dissectum* and *Geranium columbinum*), one Eurasian taxon (*Chaerophyllum temulum*) and one Europaen taxon (*Veronica montana* L.).

3.2.3 *Endemic set*

This set was the most important group of the studied flora, with 75 (63.02 %) species. The existent 26 families were of endemic taxa, including the *Asteraceae* (11 endemics), followed by the *Fabaceae* and *Brassicaceae* (nine endemics each). The genus *Ophrys* was the most diverse with four taxa, followed by the genus *Genista* with three taxa.

These species belonged to eight sub-elements of endemism:

- Endemic to Algeria: Two taxa strictly endemic to Algeria were identified in our list (*Drimia anthericoides* and *Sinapis pubescens* subsp. *indurata*);
- Algerian–Tunisian endemics: The number of Algerian–Tunisian endemic taxa was the highest among all the groups, with 27 species or 36 % of the endemic flora of the region. This number was noteworthy for a region situated at the Tunisian borders;
- Algerian–Moroccan endemics: This element was composed of two taxa (*Cedrus atlantica* and *Centaurea involucrata*);
- Endemic to Algeria, Tunisia and Italy: Six endemic taxa were noted in Algeria–Tunisia and extending to Italy (*Biscutella raphanifolia, Jonopsidium albiflorum, Orchis patens* subsp.

patens, Euphorbia cuneifolia, Centaurea solstitialis subsp. *schouwii,* and *Genista ferox* subsp. *ferox*);

- Ibero–Maghrebian: This group had two species (*Ononis aragonensis* and *Ophrys atlantica* subsp. *atlantica*);
- Endemic to North Africa: The number of taxa in this group was appreciable, with 31 species or 41.33% of the endemic flora of the region. These taxa were often found in at least three countries of North Africa (Algeria, Tunisia, Morocco, and Libya) and sometimes extended to Egypt and Mauritania;
- Tyrrhenian sub-endemics: Here, three taxa were shared between Numidia, Kroumiria, and the Corso-Sardinian block and/or the Tyrrhenian island group;
- Betico-Maghrebian endemics (Algeria, Tunisia and Spain or Algeria, Morocco and Spain) were represented by a single taxon.

3.3 Biological distribution

According to the global list of recorded species, the composition of the biological spectrum showed that the hemicryptophytes, with their 38 taxa (31.93 %), were predominant over other life forms. Geophytes were fairly well represented with 30 species (25.21 %), followed by therophytes, chamaephytes and phanerophytes, with 20 (16.8 %), 17 (14.28 %) and 10 (8.40 %) species respectively. Hydrophytes were poorly represented with only four species (3.36 %).

The even biological distribution between species was also observed in the identified biogeographic elements, except for the four hydrophytic taxa which were typically Mediterranean.

3.4 Distribution of rare and endemic species according to habitat types

Matorrals, humid environments, and cork oak forests were the richest in rare species (more than 15 species each), while lawns were the poorest with only seven species.

Matorral showed most frequent endemism, including 31 taxa, followed closely by cliff ecosystems with 22 taxa. Zeen oak forests, steppes, and cork–oak forests were in an intermediate situation (respectively 14, 17, and 18 species). While, lawns and wetlands were the poorest in endemics (11 and seven species respectively).

From a bioclimatic point of view, rare and endemic taxa were found in the three bioclimatic stages of the study region, from humid to semi-arid.

3.5 The influence of environmental and edaphic variables on the richness of rare and endemic plants

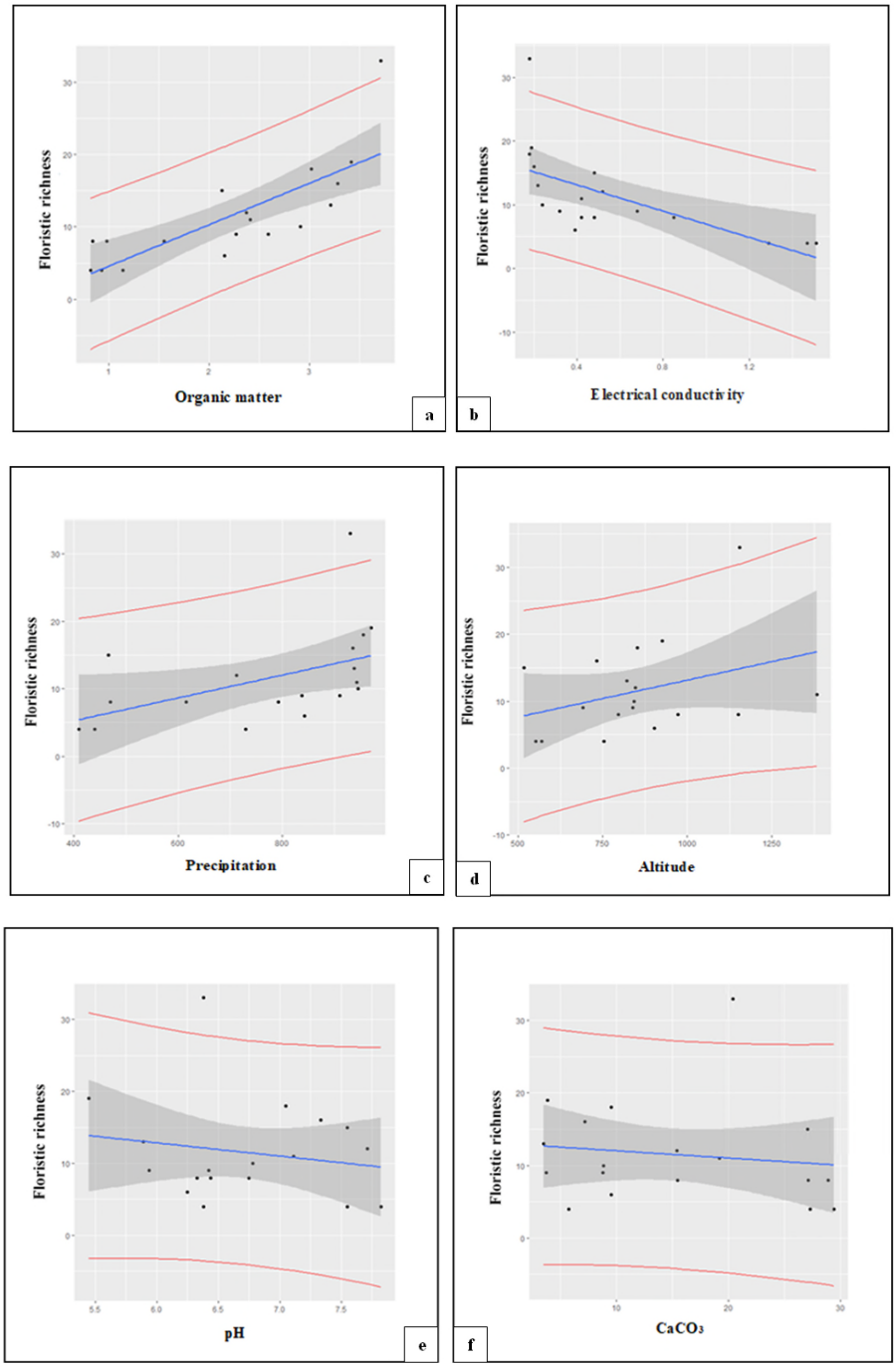

Figure 2: Correlations between the richness in rare and endemic species of the studied localities (black dots), (a) organic matter; (b) electrical conductivity; (c) precipitation; (d) altitude; (e) pH; (f) total limestone

Among all the studied sites, no significant regressions were observed between specific richness and topographic (altitude), climatic (precipitation), and edaphic variables (pH, electrical conductivity, total limestone, and organic matter). Two variables were significant, namely organic matter ($R^2 = 0.6101$; $p = 0.0001$) and the electrical conductivity ($R^2 = 0.4103$; $p = 0.0041$) (Fig. 2 a & b). Other variables do not seem to influence the floristic composition hence the distribution of rare and endemic plants (Fig. 2 c, d, e & f).

4. Discussion

4.1 Characterization of the flora

The rare and very rare flora of the study area had 119 taxa, i.e. 16.03 % of the flora of the Souk Ahras region, based on 742 species according to the current state of our research (Hamel, Véla & de Bélair, unpublished).

This first inventory of rare and endemic plants in the region of Souk Ahras highlighted the main aspects of this flora (changes in nomenclature, distribution, and type of endemism). Local researchers sometimes tend to neglect these aspects, however they should be considered as a priority in scientific research (Rao, 2004), towards the conservation of the local flora (Véla and Benhouhou, 2007). We observed some introduced individuals of *Cedrus atlantica*, heighting between 10 to 15 m and particularly present in the humid belt (the summit of Djebel Mcid, altitude 1380 m), and its natural regeneration was ensured by the presence of small plants. The palynological work of Benslama *et al.* (2010) in the El Kala region (northeast of Algeria) hypothesizes the existence of cedar regional refugium in a relatively mild climate during the last glaciation, collateral to the hypotheses formulated by Terrab *et al.* (2006). Its presence would have benefited the glacial refugia, further east of its current range in Algeria and Tunisia, from which it disappeared following the contraction during the Holocene (Ben Tiba and Reille, 1982).

The large number of rare and endemic species recorded in the study region have been particularly identified in forest and pre-forest formations (matorrals, cork oak, and zeen oak forests). This richness in taxa accounts for the variability of biogeographical and ecological situations in connection with anthropogenic actions (Barbéro *et al.*, 2001; Yahi *et al.*, 2008).

Quézel (2000) confirmed the richness in endemic species or taxa, which grew on cliffs and rocks, with its disjunct area. Our observations, at an ecological level, concerning the site conditions involving rare and endemic species, were overall in agreement with Quézel and Santa (1962–1963).

The observed plants were very unevenly distributed in the two biogeographical sectors (Quézel and Santa, 1962) of the study region. The Constantine sector (C1) had the highest number of rare and endemic plants (99 species), while the subsector of the highlands of Constantine (H2) was home to 27 high–value taxa. In fact, fluctuations in ecological conditions and the heterogeneity of habitats are determining factors of flora richness of these biogeographical zones (Touati *et al.*, 2020).

Some species of C1 and H2 were not reported previously in "The flora of Algeria", e.g., *Antirrhinum tortuosum, Argyrolobium saharae, Aristolochia paucinervis, Bunium crassifolium, Calamintha menthifolia, Castanea sativa, Chaerophyllum temulum, Daucus virgatus, Galactites mutabilis, Genista ulicina, Heliosciadium crassipes, Mandragora officinarum, Ononis angustissima* subsp. *polyclada, Ophrys atlantica* subsp. *hayekii, Orchis laeta, Orchis patens* subsp. *patens, Phlomis bovei, Pilularia minuta, Reichardia tingitana* subsp. *discolor, Scrophularia tenuipes, Smyrnium perfoliatum, Teucrium atratum, Veronica montana* and *Viola riviniana*. All these new observations in the two biogeographical sectors of the region encouraged us to carry out a meticulous search for taxa, which might have escaped in previous investigations, as in the case of the 16 taxa illustrated by Edough Peninsula of Boulemtafes *et al.* (2018) and the study of *Pteris vittata* L. in February 2016 in Western Numidia (Hamel *et al.*, 2020a). In a more global context, the presence of these plants in other biogeographical sectors suggested the requirement of a revision of the Algerian flora (cf. eflora Maghreb).

Other rare and endemic taxa, such as *Euphorbia helioscopia* subsp. *helioscopioides* (Loscos & C. Pardo) Nyman and *Odontites discolor* Pomel, were found in our region. They seem to have previously disappeared or declined in the same habitat (Battandier and Trabut, 1890; Maire, 1928; Quézel and Santa, 1963). In some cases, natural environments have been so disrupted by other elements, such as fires, overgrazing, and urban development, that some sites were destroyed Considering the established uncertainity, additional surveys could be carried out in the future.

Mandragora officinarum, defined as rare and endangered in Quézel and Santa (1962), has been exclusive to the Kabylias-Numidia sector (K) and the Algerian coastal sub-sector (A1) (site not found until now) (see Hanifi *et al.*, 2007). We have observed it on the steppes of Ben Attia, which seems very rare and new for the subsector H2 of the Constantine highlands (Touati *et al.*, 2020).

We have noticed that endemism status of some taxa had been changing, such as for *Genista ferox* subsp. *ferox,* previously mentioned as strictly endemic to the Maghreb by Quézel and

Santa (1962) and recently retained as endemic in Algeria, Tunisia, Morocco, and Sardinia by CJB (2020). This is the case of *Aristolochia paucinervis*, previously mentioned in the flora of Quézel and Santa (1962-1963) as Mediterranean, while APD (2020) considers this as a Tyrrhenian subendemic. The changes in the chorological type of these species can be explained by the increased botanical investigations, either in the Mediterranean or in North Africa. Such investigations aim at listing biodiversity and monitor its evolution, either expanding the floristic lists by adding taxa or narrowing them by removing others (Gordo and Hadjadj-Aoul, 2019).

4.2 Taxonomic, biological and biogeographic diversity

A total of 119 remarkable taxa (endemic, rare, threatened, or protected) of angiosperms and pteridophytes were reported in our study sites. All these listed species are factors of a great conservation value, either for heritage reasons or for their risk of extinction (Pimm *et al.*, 1988; Gaston *et al.*, 1998).

The highest degree of endemicity corresponds to *Asteraceae* (11 taxa)*, Brassicaceae* (nine taxa), *Fabaceae* (nine taxa), *Orchidaceae* (eight taxa) and *Lamiaceae* (seven taxa). These results corroborate the conclusions by Le Houérou (1995), who stated that the *Asteraceae, Fabaceae,* and *Lamiaceae* are the richest families in endemics in North Africa, and by Quézel (1978) regarding the *Lamiaceae* family. The richness of the local flora in Orchids in the study area confirmed the observations made by Boukehili *et al.* (2018). This resemblance is the result of their common history from which resulted a very homogeneous biogeographical unit (Quézel, 1964).

The relative number of endemic taxa *sensu lato* presented in this work was 63.05%. However, it is comparably very high to that stated by Hamel *et al.* (2013) for the Edough peninsula (47%), Djebbouri and Terras (2019) for the forest formations of Saïda (North-West Algeria) (08.81%), Medjahdi *et al.* (2009) for the Traras mountains (19.71%) and Miara *et al.* (2017) for the Tiaret region (38%). This richness was the result of climate diversity, exposures, substrates, and orography with a mountain range, which culminates at 1405 m (Djebel Mcid), 1230m (Saïda),1008m (Edough) and875m (Tarras). As stated by Verlaque *et al.* (1997), the Mediterranean endemism is mainly concentrated in mountain ranges and islands.

We have identified two restricted endemic species (endemic to Algeria). These taxa were both rare and endemic “taxa classified as of high heritage value”, *Drimia anthericoides* was on the red list of the IUCN (Véla and de Bélair, 2017), as “endangered”. These are:

- *Drimia anthericoides:* endemic to northeastern Algeria seemed to be a new species rank to the national flora (Véla *et al.*, 2016). It is a critical taxon considered as a variety of *Urginea maritima* (L.) Baker (Maire, 1958; Quézel and Santa, 1962). Nevertheless, it differs from other aggregate species/varieties of *Charybdis maritima* (L.) Speta [= *Urginea maritima*] in terms of characters of flowers, fruits, bulbs, leaves, and by ploidy level (Véla *et al.*, 2016). A review of the sites on the Tunisian side would still be beneficial in order to verify any past confusion. However, the observation site is on private land, thus potentially threatened by agriculture and/or grazing.
- *Sinapis pubescens* subsp. *indurata*: the diversity of the genus *Sinapis* in Algeria is remarkable with eight species and subspecies, of which two are endemics *(S. pubescens* subsp. *aristidis* and subsp. *indurata*) (Dobignard and Chatelain, 2011). This taxon has been previously reported in Souk Ahras in three different localities: Mont Mahrouf by H. de Perraudière (without specifying a date?) and by Reboud (without date?) in Sgao and Djebel Mcid (Maire, 1965). We have consulted all the plates of APD (2020) labeled "*Sinapis pubescens* subsp. *indurata*" of which three plates "MPU009015, MPU009016 and S-G-9038" collected by H. de Perraudière (7/16/1861) related to our species.

The Algerian–Tunisian endemism represented the majority of endemic taxa recorded with 27 species. However, these border endemics correspond less to specialized areas with highly endemic species, than to the vast biogeographical zones, where endemic species are locally less rare and even abundant (Véla and Benhouhou, 2007; Hamel *et al.*, 2013).

Our study area had 26 endemic species from Northwest Africa, with at least three countries (Algeria, Morocco, Tunisia and/or Libya).
The presence of Tyrrhenian endemics in the flora studied (three taxa) could explain the past terrestrial connections of the Algerian Tellian and Tunisian coast with Tyrrhenia (Quézel, 1964; Hamel and Boulemtafes, 2017; Hamel *et al.*, 2020b). The importance of the Mediterranean (*sensu lato*) element of the rare flora in the study area (40 species, or 31.61 %) was in agreement with Quézel (1983), who found a greater number of Mediterranean-type species (40.13 %) in the North African flora.
Two plants were classified as flagship species in the Algerian (IPA), called "El Kala 2": *Scrophularia tenuipes* and *Scutellaria columnae.* These two plants, along with *Convolvulus durandoi*, *Orchis laeta, Phlomis bovei,* and *Drimia anthericoides,* are found in a restricted area (occurrence between 100 and 5,000 km²). Additionally, *Dactylorhiza elata* and *Serapias*

stenopetala, two restricted endemic species were found in less than 100 km² (Yahi *et al.*, 2012).

Some plants, including the strict endemic *Sinapis pubescens* subsp. *indurata,* which are rare nationally but locally common, exist in the study area. In general, this rarity is due to the limited extent of the subhumid climate in Algeria.

The studied flora was dominated by hemicryptophytes (31.09 %), which prefer fairly stable environments and soil rich in organic matter (Kazi Tani *et al.*, 2010). This suggested that the rainfall, the weakness of the light, and the pastures of the undergrowth favored the development of hemicryptophytes. Barbéro *et al.* (2001) reported that their abundance in Maghreb countries is due to the presence of organic matter and moisture. In addition, the dominance of hemicryptophytes has also been confirmed in the rare and endemic flora of the Edough Peninsula (Hamel *et al.*, 2013). Geophytes were also well represented with 30 species. Their rate is relatively higher in a forest environment than in lawns and steppe areas where they tend to fade (Barbéro *et al.*, 1981). Chamaephytes were represented by 20 species or 16.8 % of the studied flora. They would be well adapted to the phenomenon of soil aridification as they can develop variants to drought (Floret *et al.*, 1990). On the other hand, in certain regions, the encrusted soils are thin and the continuous calcareous crust which covers them does not allow any plant rooting (Boudjadja *et al.*, 2010). Gamoun *et al.* (2011) claim that sandy soil is more productive due to increased water impermeability than limestone soil, which reduces water penetration.

4.3. Threats and conservation measures

Due to insufficient documentation and studies, 109 of the rare and endemic plants in our study area and elsewhere in Algeria have not been yet assessed, according to the criteria established by IUCN (2021). Protection is urgent to a total of 106 rare and endemic species. Without it, they are threatened with extinction, especially since they are not placed on the list of protected plant species in Algeria (JORA, 2012).

The rare and endemic flora of the Souk Ahras region is undergoing an alarming degradation. Additionally, anthropogenic activities, especially fires, overgrazing, and uncontrolled exploitation of species known for their therapeutic virtues (e.g. *Origanum vulgare* subsp. *glandulosum, Thymus algeriensis, Rosmarinus eriocalyx* subsp. *eriocalyx, Mandragora officinarum, Thymus munbyanus* subsp. *coloratus, Deverra scoparia* subsp. *scoparia,* and *Santolina africana*) stand as threats to this flora. Other taxa are heavily consumed (*Allium*

porrum subsp. *polyanthum, Bunium crassifolium, Echinops bovei, Rhaponticum acaule,* and *Romulea ligustica*) or used as ornamentals (e.g. *Hedera algeriensis, Sambucus nigra, Iris inguicularis,* and *Cyclamen africanum*) (see Sakhraoui, 2021).

Based on our study we propose the main short-term conservation solutions below:

- Habitat protection, including populations of threatened species where conservation problems are most critical (*Cedrus atlantica, Drimia anthericoides, Pilularia minuta,* and *Serapias stenopetala*) by creating "micro-reserves", thus providing sustainable conservation and leading to a representative natural habitat (Laguna *et al.*, 2004).
- Modeling the distribution of each species for its reintroduction into its natural habitat or into new suitable areas, according to the species distribution models.
- Revise and update the list of protected plant species in Algeria according to the criteria of endemism, rarity, and threats, as both rare and endemic species have high conservation value.

5. Conclusion

Our analysis based on the current knowledge of the rare and endemic flora of the wilaya of Souk Ahras revealed a significant specific richness (119 species), characterized by 75 endemic species and 77 rare species. This regional endemic flora is hardly known as a large area of the study region and remains very poorly explored. The entire area located at the Algerian–Tunisian border, the steppes of *Macrochloa tenacissima* (L.) Kunth, and *Artemisia herba-alba* Asso, located in the south of the region, deserve to be thoroughly explored. Likewise, the relationship between scarcity and endemism was remarkable. Half endemic taxa in a broad sense were rare and listed on the protected plant species in Algeria, while the majority (more than a hundred) are not protected. Hence, it is necessary to protect these species in accordance to endemicity and rarity.

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Declaration of Competing Interest

No potential conflict of interest was reported by the authors.

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Appendix A.

Some rare and endemic species from the wilaya of Souk Ahras
(All the photos: Hamel T., except the photo A.5: de Bélair G.).

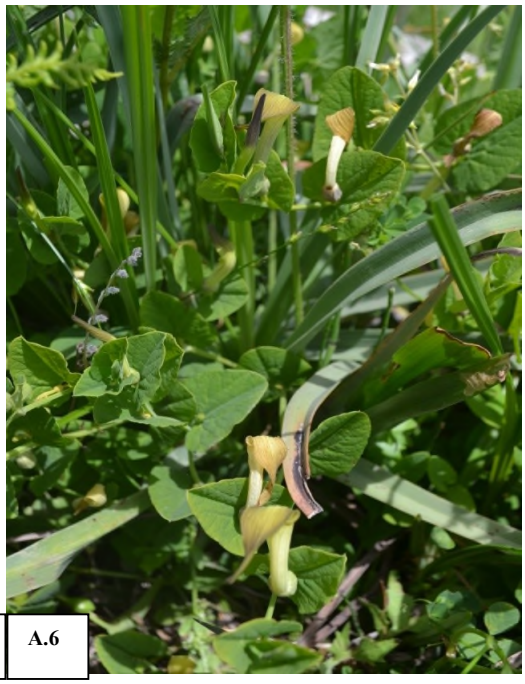
A.1

A.2

A.3

A.4

A.5

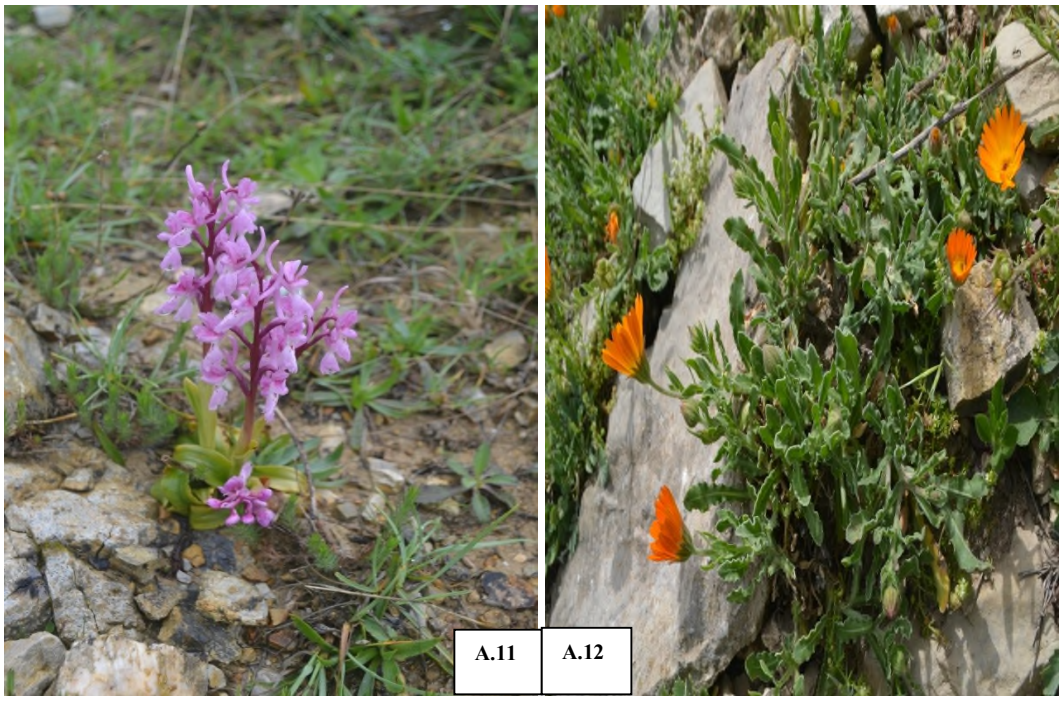


A.6

A.7

A.8

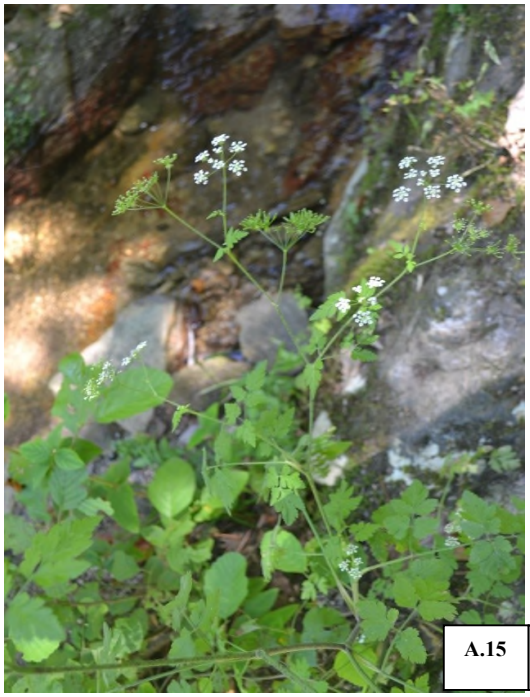
A.9 **A.10**



A.11 **A.12**

A.13

A.14



A.15

A.16

A.1. *Serapias stenopetala* Maire & T. Stephenson	**A.9.** *Sideritis incana* L. subsp. *incana*
A.2. *Dactylorhiza elata* (Poir.) Soo	**A.10.** *Argyrolobium saharae* Pomel
A.3. *Mandragora officinarum* L.	**A.11.** *Orchis laeta* Steinh
A.4. *Sinapis pubescens* L. subsp. *indurata* (Coss.) Batt	**A.12.** *Calendula suffruticosa* subsp. *boissieri* Lanza
A.5. *Drimia anthericoides* (Poir.) Véla & De Bélair	**A.13.** *Scutellaria columnae* All. subsp. *columnae*
A.6. *Aristolochia paucinervis* Pomel.	**A.14.** *Convolvulus durandoi* Pome
A.7. *Santolina africana* Jord. & Fourr.	**A.15.** *Chaerophyllum temulum* L.
A.8. *Ononis angustissima* subsp. *polyclada* Murb.	**A.16.** *Orobanche rapum-genistae* Thuill.