New analysis of the endemic vascular plants of Algeria, their diversity, distribution pattern and conservation status

Authors: Meddour, Rachid, Sahar, Ouahiba, and Jury, Stephen

Source: Willdenowia, 53(1-2) : 25-43

Published By: Botanic Garden and Botanical Museum Berlin (BGBM)

URL: https://doi.org/10.3372/wi.53.53102

Willdenowia
Annals of the Botanic Garden and Botanical Museum Berlin

Botanischer Garten Berlin

New analysis of the endemic vascular plants of Algeria, their diversity, distribution pattern and conservation status

Rachid Meddour[1*], Ouahiba Sahar[1] & Stephen Jury[2]

Version of record first published online on 21 March 2023 ahead of inclusion in April 2023 issue.

Abstract: In this study, we provide a new analysis on strict-endemic vascular plant taxa of Algeria and discuss their taxonomic diversity, geographical distribution and conservation status, based on a large literature review and our own field observations. Overall, 248 taxa (species, subspecies and varieties) are currently considered as Algerian endemics, from 41 families and 128 genera. They constitute about 6.3% of the total known flora of Algeria. The northern floristic regions are richer in endemic species: K1, K2, AS3, C1+C2 and O1 are by far the richest floristic regions for strict-endemic taxa, highlighting the importance of their mountain ranges. Most (59%) of the endemic plants have a narrow geographical distribution range (range-restricted). An overview of the IUCN conservation status of the Algerian endemics indicates that only 16 taxa (6.4%) are evaluated, out of which 5.6% of the taxa are threatened. Overall, 44% of the Algerian endemics are legally protected and 43% are included in the protected areas network. Finally, we focus on the shortfalls of knowledge that could orient further research on endemism data in Algeria. They concern taxonomic, chorological or conservation figures and above all the actual presence of the endemic species. It is, therefore, urgent to carry out targeted field expeditions in order to find and re-collect these species, most of which are strictly localized and have probably never been searched or found for 60 years to over a century.

Keywords: Algeria, endemism, IUCN, Mediterranean flora, North Africa, phytogeography, range-restricted, taxonomy, threatened plants, vascular plants

Article history: Received 23 October 2022; peer-review completed 17 January 2023; received in revised form 25 January 2023; accepted for publication 7 February 2023.

Citation: Meddour R., Sahar O. & Jury S. 2023: New analysis of the endemic vascular plants of Algeria, their diversity, distribution pattern and conservation status. – Willdenowia 53: 25–43. https://doi.org/10.3372/wi.53.53102

Introduction

The concept of endemism most used at present is referred to the restriction of the distribution of certain taxa to a distinct area (Laffan & Crisp 2003). Plant species are considered endemic to a country if they occur solely within its political borders (Gallagher & al. 2020). It is obvious that the endemics constitute the foremost group in terms of biodiversity and conservation of the flora (Millaku & al. 2016). Therefore, the number of endemic taxa in a country is one of the fundamental features of biodiversity (Hobohm 2014) and a first step for assessing the flora of that country (Treurnicht & al. 2017). A list of endemics to a country is of great relevance for conservation policy at both the national and local scales (Fois & al. 2022).

Algeria, which is an integral part of the biodiversity hotspot of the Mediterranean region (Médail & Quézel 1997), is recognized as an important centre of plant species diversity and endemism (Véla & Benhouhou 2007), facing a high level of human-induced threat (Quézel 2002). The vascular flora of Algeria is very diverse and offers an exceptional setting for the study of endemism and the distribution of its species.

The first attempt to describe the endemic vascular flora of Algeria was done by Quézel (1964). This author stated that the number of species endemic to N Algeria was estimated at 247, a rate of 8.6% of the N Algerian flora. According to Greuter (1991), Enríquez-Barroso & Gómez-Campo (1991) and Véla & Benhouhou (2007), Algeria has 320, 256 or 224 endemic taxa, respectively. According to the most recent data (Dobignard & Chatelain 2010–2013), the Algerian vascular flora includes 3951 native taxa (species and subspecies), with 290 Algerian endemic species (6.5%).

Accounts on diversity of endemics in Algeria seem to be numerous, but there are some discrepancies about the exact number of endemic species. Comparing numbers with information from previous literature is always difficult, because some references are based on the number

1 Mouloud Mammeri University, Department of Agronomic Sciences, Hasnaoua 2, BP 17 RP, 15000, Tizi Ouzou, Algeria; o.sahar@yahoo.fr

2 3 Grove Road, Leighton Buzzard, LU7 1SF, United Kingdom; stephenljury21@btinternet.com

Author for correspondence: Rachid Meddour, rachid_meddour@yahoo.fr

of species only, while others also consider infraspecific taxa and include endemic and subendemic species or only strict-endemics (Dobignard & Chatelain 2010–2013). Otherwise, many subendemic taxa were formerly considered as strict-endemics to Algeria (Quézel & Santa 1962–1963), until their chorological status was changed according to new findings in neighbouring countries, specifically Morocco and Tunisia. The observed differences in these accounts are furthermore justified by the new contributions of knowledge on the Algerian flora and the consideration of taxa formerly overlooked or cryptic following taxonomic revisions (see, e.g., Romo & Boratyński 2010; Véla & al. 2013, 2016; Vicente & al. 2016, 2020). Statistics of this nature are complicated by ongoing taxonomic studies (Helme & Trinder-Smith 2006). After many recent findings regarding nomenclatural changes, mostly recombinations but also new taxa (Dobignard & Chatelain 2010–2013), and geographical distribution changes, Algeria does not have an accurate and complete inventory relating to the endemic vascular plant taxa. Therefore, an updated checklist of Algerian endemics, including how many and which taxa are endemic and where they are found, is currently needed.

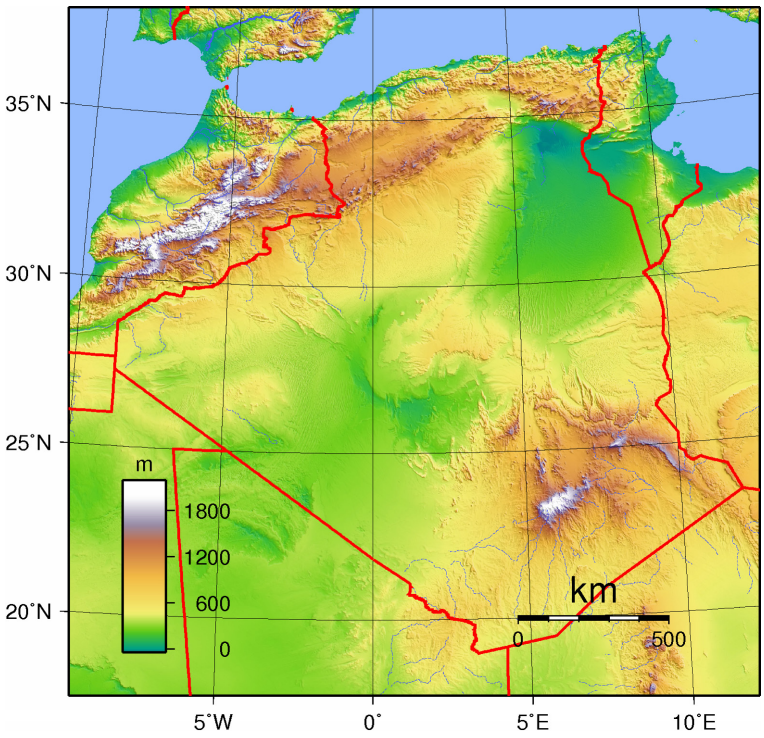

Fig. 1. Topographic map of Algeria and neighbouring countries (source: https://fr.wikipedia.org/wiki/Algérie#/media/Fichier:Algeria_Topography.png).

The aims of this study are hence to provide a new analysis of the strict-endemic vascular taxa of Algeria, to analyse their diversity, to interpret their distribution patterns and phytogeography within the Algerian floristic regions and to summarize their currently known conservation status.

Material and methods

Study area

Algeria is the largest country in Africa, with a total land area of 2,381,741 km². It is also the largest country bordering the Mediterranean Sea, with a coastline stretching along a length of 1355 km (Fig. 1). The Algerian territory is clearly divided into three geographical entities, the north or "Tell", restricted to the coastal plains and adjacent Tellian Atlas mountains, the "Steppe" considered in the widest sense and encompassing the High plateaus and the Saharan Atlas (both belonging to the Mediterranean region), and the south or "Sahara" (part of the Saharo-Arabian region). Therefore, its flora belongs to the Holarctic floristic kingdom (Quézel 1978).

Algeria is one of the most biodiverse countries in North Africa because of its unique biogeography with a transition between tropical and temperate climates (Véla & Benhouhou 2007), given its geographical position at the edge of the Mediterranean Sea. The interaction of the Mediterranean climate with the relief of the Atlas results in a strong environmental gradient, creating a north-south decrease in rainfall and an increase in dry season length, which determines huge changes in the structure and floristic composition of various types of vegetation linked to different ecological and bioclimatic zones (Meddour 2012). Therefore, considerable habitat diversity occurs throughout Algeria, explaining its high level of endemism and high plant diversity, with the presence of two major regional biodiversity hotspots, the "Kabylias-Numidia-Kroumiria" and the "Baetic-Rifean complex" (Véla & Benhouhou 2007).

Algeria has an important protected areas framework, encompassing ten national parks, two cultural parks and two natural reserves, oriented toward the conservation of habitats and their biodiversity (Benhouhou & al. 2018).

Data collection and analysis

In this work, we examined all available literature on the vascular flora of Algeria, and the main taxonomic web sources, to compile an updated checklist of strict-endemics to Algeria (or Algerian endemics) that occur only within the political borders of the country. The bibliographic research started with the *Index synonymique de la flore d'Afrique du Nord* (Dobignard & Chatelain 2010–2013), where the Algerian endemics are labelled Alg*, which served as a priority source to select them. We matched these endemic plants with data available in the key da-

tabases, such as the African Plant Database (APD 2022) and the online eflora du Maghreb (eflora Maghreb 2022), which specify the endemic status of all plants present in Algeria. We cross-checked the information with data from the Euro+Med PlantBase (Euro+Med 2022) and the Plants of the Word Online database (POWO 2022), which allow confirmation of endemism, in particular the exclusive presence in Algeria of the taxa selected. We have only retained the taxa (species, subspecies and varieties) considered by all the sources mentioned above as strict-endemics. Plants no longer considered as endemic to Algeria, for taxonomic or chorological reasons (Algerian-Tunisian, Algerian-Moroccan endemics or other subendemics), were therefore excluded (Table 1). Likewise, hybrid species exclusive to Algeria are not recorded in the present analysis. A refined dataset was created at the end of this sorting.

The taxonomic nomenclature of taxa (with their authorities) was revised, and accepted names of species and infraspecific taxa follows the African Plant Database (APD 2022), except in the case of *Cyclamen repandum* var. *baborense* Batt. ex Debussche & Quézel, where the name has been updated according to POWO (2022). For angiosperms, plant family circumscription follows APG IV (2016).

The distribution of endemic taxa in the phytogeographical subsectors (hereafter "floristic regions") of Algeria was mainly documented according to the existing literature (Battandier & Trabut 1888–1890, 1895, 1905; Maire 1952–1987; Quézel & Santa 1962–1963; Ozenda 2004), herbarium specimen label data (cf. eflora Maghreb 2022) and our own field surveys. In Algeria, 20 floristic regions were defined based on the distribution of the endemic plants in relation to the local climates, geology and geomorphology, and according to different vegetation types (Quézel & Santa 1962–1963; Meddour 2012). Among these floristic regions, 15 northern ones are under Mediterranean influence, while five others are entirely Saharan (Fig. 2).

We made the deliberate choice not to use the rarity index as established by Quézel & Santa (1962–1963), because it is very outdated and far from any modern significance. One of the three attributes defining rarity is the size of the species range (large vs small) (Rabinowitz 1981). In this sense, the distribution analysis of endemic flora will allow us to identify the "range-restricted" taxa, i.e. present in only one floristic region within Algeria. In the same way, Fennane & Ibn Tattou (1999) considered the taxa present in one (or two) phytogeographic divisions of Morocco as "rare".

With regard to the conservation status of the Algerian endemics, there is yet no national Red List established in line with the IUCN criteria. The data derived from IUCN database (IUCN 2022) are used to determine what proportion of the endemic plant species have an assessment of their extinction risk, although this status has not been assessed for all taxa, nor specifically for Algeria. The assessed endemic plants have been classified at global geographical scope either into a threat category, according to the new categories (IUCN 2012), as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU), or into the other categories as Near Threatened (NT), Data Deficient (DD) or Least Concern (LC).

Algerian endemic taxa protected by the national legislation in Algeria are compiled according to the *List of non-cultivated plant species protected throughout Algeria*, set by Executive Decree no. 12-03 of 4 January 2012 (JORA 2012), after carefully checking the nomenclatural synonymy issues.

Otherwise, we highlight endemic taxa that are already benefitting from protected area status in Algeria, such as national parks (NP), natural reserves (NR) and cultural parks (CP), formerly classified as national parks until 2011. Algerian Cultural Parks (CPs) are recognized as "Other Effective Area-Based Conservation Measures" (OECMs), which offer an excellent opportunity to acknowledge effective long-term biodiversity conservation that takes place outside currently designated protected areas (IUCN 2020).

Results

Diversity and taxonomic analysis

The Algerian endemic vascular flora includes 248 taxa (distributed among 174 species, 72 subspecies and 2 varieties) (see Appendix 1), representing almost 6.3% of the native flora of Algeria. They belong to a large number of 128 genera and 41 families.

The distribution of endemic species in Algeria is uneven according to the 41 families (Fig. 3). Twenty families, containing three or more endemic taxa each, collectively contribute 90% of the endemic taxa in Algeria: *Asteraceae* (20% of endemics), *Fabaceae* (10%), *Caryophyllaceae* (9%) and *Lamiaceae* (8%) are the best-represented families, followed by *Brassicaceae* (7%), *Papaveraceae* (7%) and *Poaceae* (6%). Then, four families include two taxa each, and the remaining 17 families are represented by only one endemic taxon each. Otherwise, there is a weak correspondence between species-rich plant families and endemism. Some larger families contribute more endemic species to the flora of Algeria, while others contribute few endemics, relative to their dominance in the flora. The case of the *Poaceae*, which is the second most species-rich plant family, illustrates this fact; it occupies only the seventh position in terms of number of endemics. Besides, certain families are significantly over-represented, such as *Papaveraceae*, contributing a high proportion of endemics relative to their contribution to the overall flora (Fig. 3).

Endemism appears to be particularly dispersed within the genera present in Algeria (Table 2). Indeed, out of 128 genera containing endemic taxa in Algeria, only 15 of them have four or more taxa each, 11 gen-

Table 1. List of taxa previously considered as Algerian endemics (Dobignard & Chatelain 2010–2013) but now no longer considered as Algerian endemics, with reasons for their exclusion.

Excluded endemic taxa	**Reasons for exclusion**
Armeria mauritanica Wallr.	Reported from Morocco (APD 2022)
Brassica fruticulosa subsp. *radicata* (Desf.) Batt.	Reported from Morocco (APD 2022; Euro+Med 2022)
Bufonia duvaljouvei Batt. & Trab. subsp. *duvaljouvei*	Reported from Morocco (Euro+Med 2022)
Cenchrus rogeri (Stapf & C. E. Hubb.) F. Verloove	Synonym of *Cenchrus violaceus* (Lam.) Morrone widely present from Sahara to Sahel (POWO 2022)
Crotalaria vialattei Batt.	Reported from Morocco (APD 2022)
Dianthus cintranus subsp. *mauritanicus* (Pomel) Greuter & Burdet	Reported from Morocco (APD 2022)
Fedia graciliflora subsp. *diana* Mathez & Xena (syn. *Valeriana graciliflora* (Fisch. & C. A. Mey.) Byng & Christenh.)	Subspecies previously distinguished no longer recognized and species widely present in W Mediterranean region (POWO 2022)
Fumaria munbyi Boiss. & Reut.	Reported from Morocco (APD 2022)
Gagea mauritanica Durieu	Reported from Balearic Islands (Euro+Med 2022)
Lathyrus allardii Batt.	Battandier (1895) already considered it a weed in Algeria; perhaps only a form of *Lathyrus gorgoni* Parl., native farther east and occasionally introduced (Domina & al. 2015; POWO 2022)
Limonium ramosissimum (Poir.) Maire	Widely distributed in W Mediterranean region (Euro+Med 2022)
Linaria tristis subsp. *marginata* (Desf.) Maire	Reported from Morocco (APD 2022)
Myrtus nivellei Batt. & Trab. subsp. *nivellei*	Reported from Chad and presence questionable in Libya (APD 2022)
Odontites lapiei Batt.	Reported from Morocco (APD 2022)
Odontites purpureus (Desf.) G. Don subsp. *purpureus* (syn. *Odontites purpureus* (Desf.) G. Don)	Reported from Morocco (APD 2022) and Morocco, Tunisia and Spain (Euro+Med 2022); autonym not used (APD 2022)
Odontites rigidifolius (Biv. ex Spreng.) Benth.	Reported from Sicily (Euro+Med 2022)
Odontites triboutii Gren. & Paill.	Reported from Tunisia (APD 2022)
Odontites violaceus Pomel	Reported from Morocco (Euro+Med 2022)
Olea europaea subsp. *laperrinei* (Batt. & Trab.) Cif.	Reported from Niger, Chad and South Sudan (APD 2022)
Ophrys pectus Mutel (syn. *O. pallida* Raf.)	Reported from Sicily (APD 2022)
Ophrys sphegodes subsp. *moesziana* Soó	Synonym of *Ophrys fusca* Link subsp. *fusca* widely distributed in Mediterranean region (Euro+Med 2022)
Opophytum gaussenii (Leredde) Greuter & Burdet	Synonym of *Mesembryanthemum cryptanthum* Hook. f. reported from several countries (Namibia, Morocco, Canary Islands, Libya, Egypt and Palestine) (APD 2022)
Orobanche ducellieri Maire	Synonym of *Phelipanche mutelii* (F. W. Schultz) Pomel widely distributed in Mediterranean region (APD 2022; Euro+Med 2022)
Pentzia monodiana Maire	Reported from Chad (APD 2022)
Potamogeton hoggarensis Dandy	Reported from Chad (APD 2022)
Pulicaria volkonskyana Maire	Reported from Niger (Carvalho & Gillet 1960) and Chad (POWO 2022)
Roegneria marginata subsp. *kabylica* (Maire & Weiller) Dobignard (syn. *Pseudoroegneria marginata* (H. Lindb.) V. Lucía & al.)	Subspecies previously distinguished no longer recognized and species also reported from Morocco (APD 2022)

Excluded endemic taxa	Reasons for exclusion
Romulea battandieri Bég.	Synonym of *Romulea columnae* Sebast. & Mauri subsp. *columnae* widely present in W Europe and Mediterranean region (Euro+Med 2022)
Salicornia deserticola A. Chev.	Synonym of *Sarcocornia fruticosa* (L.) A. J. Scott distributed in circum-Mediterranean region (Euro+Med 2022)
Saxifraga trabutiana Engl. & Irmsch.	Reported from Morocco (APD 2022) and Spain (Euro+Med 2022)
Scorzoneroides muelleri subsp. *reboudiana* (Pomel) Greuter	Reported from Morocco and Tunisia (APD 2022)
Senecio perralderianus Coss. & Durieu subsp. *perralderianus* (syn. *S. perralderianus* Coss. & Durieu)	Subspecies previously distinguished under *S. perralderianus* no longer recognized and species also reported from Morocco (APD 2022)
Senecio squalidus subsp. *aurasiacus* (Batt. & Trab.) C. Alexander	Reported from Sicily (APD 2022; Euro+Med 2022)
Sideritis incana subsp. *atlantica* (Pomel) Dobignard	Reported from Morocco and Tunisia (APD 2022)
Stipagrostis pungens subsp. *pubescens* (Henrard) H. Scholz (syn. S. *pungens* (Desf.) De Winter)	Subspecies previously distinguished under *S. pungens* no longer recognized and species widely distributed from Sahara to Afghanistan (POWO 2022)
Stipagrostis pungens subsp. *transiens* (Maire) H. Scholz (syn. S. *pungens* (Desf.) De Winter)	Subspecies previously distinguished under *S. pungens* no longer recognized and species widely distributed from Sahara to Afghanistan (POWO 2022)
Thymus dreatensis Batt.	Reported from Morocco (Euro+Med 2022)

era (*Anthemis* L., *Centaurea* L., *Crepis* L., *Festuca* L., *Fumaria* L., *Genista* L., *Ononis* L., *Rupicapnos* Pomel, *Salsola* L., *Silene* L. and *Teucrium* L.) have five endemic taxa or more and only two of these genera have more than ten (*Rupicapnos* and *Silene*). The genus *Silene* is by far the richest in the Algerian endemic flora, with 12 strict-endemic species. Algeria is therefore identified as a centre of endemism for these two genera. The greater part of the genera (103 genera, 81%) are represented by only one or two endemic taxa each. In addition, generic endemism is shown in Algeria by the presence of two exclusively Algerian genera, namely *Agropyropsis* (Batt. & Trab.) A. Camus (*Poaceae*) and *Otocarpus* Durieu (*Brassicaceae*).

Location of endemic species according to the floristic regions

There is considerable variation in the number of endemics within the floristic regions (from zero to 63 taxa) (Fig. 4). Out of the 20 floristic regions in Algeria, ten regions harbour at least 20 endemic taxa and five regions (K2, K1, AS3, C1+C2, O1) include more than 30 endemics each. The highest endemism richness (number of endemic taxa per floristic region) is recorded in the Small Kabylia (K2), with 63 endemic taxa (25% of all endemics), followed by Great Kabylia (K1), with 49 endemic taxa (20%), E Saharan Atlas, including the Aurès massif (AS3: 42 taxa, 17%), the Hills of Constantine and Bibans-Hodna-Belezma mountains (C1+C2: 40 endemic taxa, 16%) and the Oran coast (O1: 39 taxa, 16%). The outstanding richness of these floristic regions can be explained by the presence of the highest peaks among mountain ranges in the country (K1: Djurdjura, 2308 m; K2: Babors, 2004 m; AS3: Aurès, 2328 m; C1+C2: Belezma, 2178 m) in direct contact with the influence of the Mediterranean Sea. In addition, the C Sahara (SC) is worth mentioning for its endemic richness: this mountainous area in the Algerian Sahara (Ahaggar, 2918 m; Tassili n'Ajjer) hosts 18 strict-endemics (7%).

Altogether, a high number of Algerian endemics (147 or 59%) are range-restricted, i.e. narrowly localized and known from only one floristic region. These endemics are observed especially on the hills of Oran (O1: 24 taxa), the forests of Small Kabylia (K2: 20), the summits of the C Sahara (SC: 15), the Aurès massif (AS3: 12) and the mountains of the W Tell (O3: 11). In all these floristic regions, a large portion of the endemic flora is constituted of these range-restricted taxa, which greatly individualize them phytogeographically.

Conservation status and protection of endemics in Algeria

Concerning their conservation status, 90 Algerian endemic taxa were previously included in the 1997 IUCN Red List of threatened species and classified as follows: 24 taxa Endangered (E), 16 Vulnerable (V), 45 Rare (R) and 5 Indeterminate (I), according to the pre-2001 IUCN categories (cf. Walter & Gillett 1998).

Since the 2001 categories and criteria version, the IUCN Red List has made very few new evaluations for

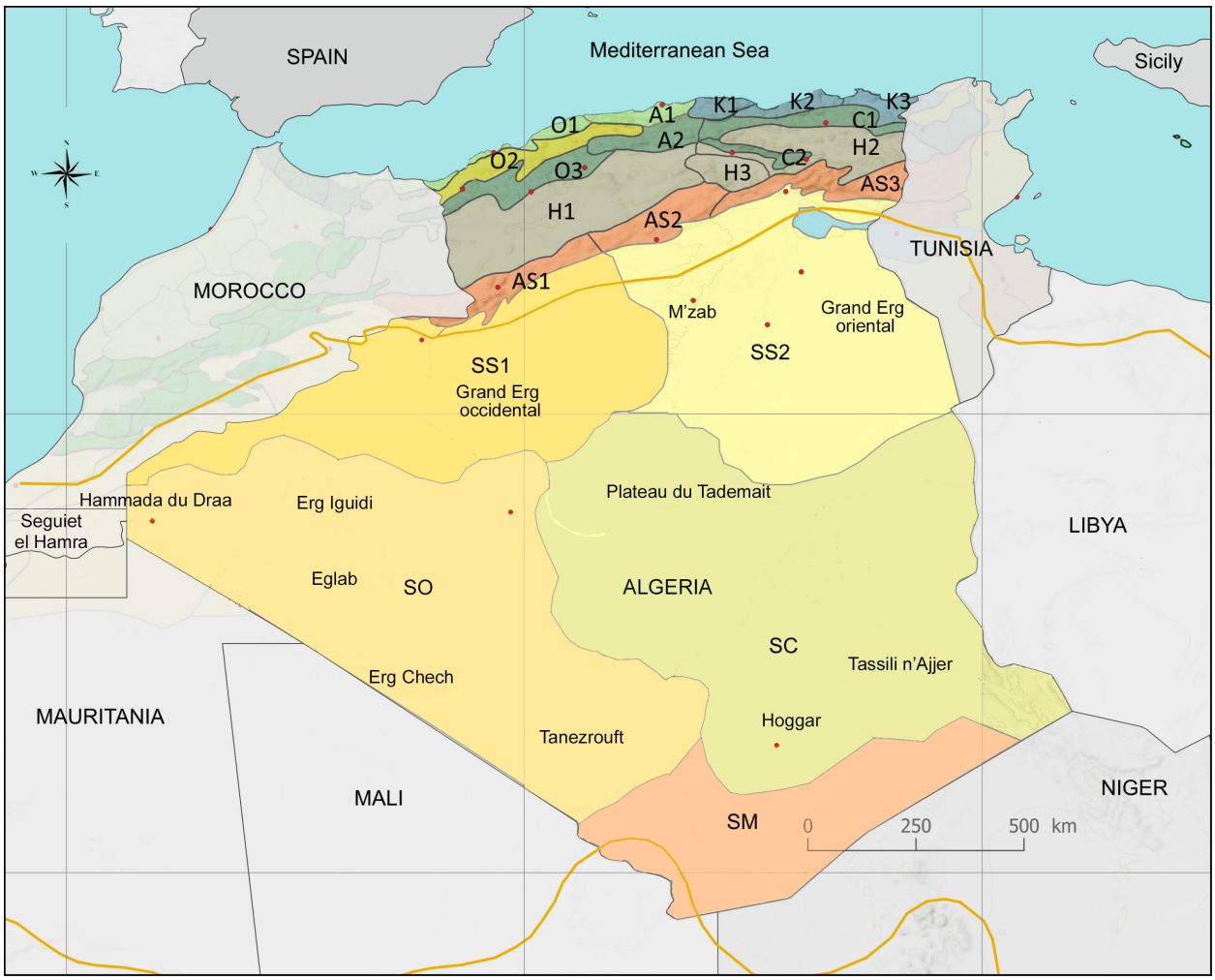

Fig. 2. Floristic regions of Algeria (Quézel & Santa 1962–1963, modified by Chatelain & Meddour in Meddour & al. 2021). Brown lines delineate the Saharan area. Floristic regions are encoded as follows. – **Littoral and mountains of Tell:** O1: hills of Oran coast; O2: plains of Oran hinterland including La Macta; O3: mountains of Tlemcen and other mountains of Oran Tell; A1: hills and coast near Algiers including Mitidja; A2: mountains of Algiers Tell; K1: Great Kabylia including Djurdjura; K2: Small Kabylia including Babors; K3: Numidia; C1: hills of Constantine Tell; C2: mountains of Bibans/Hodna/Belezma axis. – **High plateaus:** H1: W high plains (from S Oran to S Algiers); H2: E high plains (S Constantine); H3: Hodna plain (N Saharan enclave). – **Saharan Atlas:** AS1: W Saharan Atlas (Ain Sefra region); AS2: C Saharan Atlas (Djelfa region); AS3: Aurès and E Saharan Atlas (Tébessa region). – **Sahara:** SS1: NW Sahara; SS2: NE Sahara; SO: W Sahara; SC: C Sahara including Ahaggar and Tassili n'Ajjer; SM: S Sahara.

Algerian plant species. Therefore, the globally assessed endemic flora of Algeria is limited to 16 endemic taxa (6.4%), out of which 14 are threatened (5.6%) and listed as follows: five taxa Critically Endangered (CR), three Endangered (EN), two Vulnerable (VU), four Data Deficient (DD) and two Least Concern (LC) (Table 3).

Overall, the law protects only 110 endemic taxa (44% of the total), which are included in the *List of non-cultivated plant species protected throughout Algeria*. The remaining endemics are not yet legally protected. We recommend inclusion of the range-restricted endemic taxa in the national list of protected plants, in particular the threatened ones (noted by an asterisk in Table 3).

Of the 248 endemic taxa, 107 (c. 43%) are already benefitting from protected area status. Indeed, the protected areas network overlaps totally or partially the distribution areas of these endemics, especially the National Parks situated in the Kabylias-Numidia area that play a vital role (Djurdjura, Babor-Tababort, Taza, El Kala and Gouraya). These protected areas harbour a flora with a particularly high proportion of Algerian endemics (Fig. 5): Djurdjura National Park (36 taxa), Babor-Tababort NP (30), Taza NP (14), El Kala NP (13) and Gouraya NP (12); and also Ahaggar CP (12) in the C Sahara. However, endemic species occur in Algeria everywhere, so there are many such species (141 taxa) outside the existing protected areas network.

Altogether, 167 taxa (67%) are protected in Algeria by being on the national Red List and/or by overlapping partially or completely the protected areas network. Therefore, 81 taxa are without any protection, from which 45 are range-restricted and deserve urgent protection, at least national Red-Listing, e.g. *Silene auriculifolia* Pomel (see Table 3 and Appendix 1).

Discussion

Taxonomic diversity

Among the Mediterranean countries, Algeria, in spite of being a desertic country over 84% of its territory, occupies the seventh position in terms of richness in number of plant taxa (Quézel 1995) and the second position in North Africa, with 3951 native taxa (Dobignard & Chatelain 2010–2013). With 248 endemic taxa (6.3% of the overall flora), strict-endemism in Algeria is slightly higher than in other North African arid countries, such as Libya (6%), Tunisia (2.6%) and Egypt (2.3%), but substantially lower than in Morocco (18%), which is recognized as having the highest plant diversity in North Africa (Dobignard & Chatelain 2010–2013; Abdelaal & al. 2018). Likewise, in comparison with some European countries characterized by a Mediterranean climate, diverse topography and islands, such as Italy (13.4%) and Greece (15.6%) (cf. Rankou & al. 2013), the number of endemics in Algeria is very much lower. Moreover, according to Aedo & al. (2013), endemism reached 21% in the Spanish flora (the Canary Archipelago excluded).

The preponderance of *Asteraceae* (20%), followed by *Fabaceae*, *Caryophyllaceae*, *Lamiaceae* and *Brassicaceae*, which support a speciose number of endemic taxa, is remarkable in this endemic flora. This is not surprising, because families with the largest number of endemic plants are the largest families of Algeria (Quézel 1964, 1978; Dobignard & Chatelain 2010–2013). This is likewise the case in Morocco (Fennane & Rejdali 2019) and the overall Mediterranean Maghreb (Quézel 2002). Nevertheless, the *Poaceae*, which is the second largest family, falls unexpectedly outside the top ten families for endemics. It is significant to note that, far from Algeria, Darbyshire & al. (2019) made the same observation about the endemic flora of Mozambique.

Table 2. Ranking of larger genera that contribute four or more endemic taxa to Algeria. nET: number of endemic taxa; %ET: % of endemic taxa (n = 248).

Rank	Genus	Family	nET	%ET
1	*Silene*	*Caryophyllaceae*	12	4.8
2	*Rupicapnos*	*Papaveraceae*	11	4.4
3	*Ononis*	*Fabaceae*	9	3.6
4	*Centaurea*	*Asteraceae*	8	3.2
5	*Salsola*	*Amaranthaceae*	7	2.8
6	*Genista*	*Fabaceae*	6	2.4
	Teucrium	*Lamiaceae*	6	2.4
	Anthemis	*Asteraceae*	6	2.4
9	*Crepis*	*Asteraceae*	5	2
	Festuca	*Poaceae*	5	2
	Fumaria	*Papaveraceae*	5	2
12	*Limonium*	*Plumbaginaceae*	4	1.6
	Campanula	*Campanulaceae*	4	1.6
	Hieracium	*Asteraceae*	4	1.6
	Erodium	*Geraniceae*	4	1.6

The Genera *Anthemis*, *Centaurea*, *Crepis*, *Festuca*, *Fumaria*, *Genista*, *Ononis*, *Rupicapnos*, *Salsola*, *Silene* and *Teucrium* are the richest in endemic species (at least four endemic species per genus). This is also the case in Morocco (Rankou & al. 2013) and the whole of North Africa (Quézel 1978, 2002), except for the genera *Rupicapnos* and *Salsola*.

The case of the critical genus *Rupicapnos* is probably the most obvious (Quézel 1978), because it has the highest endemic diversity (11 taxa) in Algeria. Actually, species concepts and the number of species recognized in *Rupicapnos* vary considerably between authors, and this genus has been subject of very different taxonomic treatments. Pugsley (1919) already recognized some 30 species in North Africa, nearly one per locality, while Maire (1952–1987) and Quézel & Santa (1962–1963) kept only three collective species in the genus. Then, following Lidén (1986), Dobignard & Chatelain (2010–2013) retained for Algeria 17 taxa (seven species and ten subspecies), including 11 endemics, against only five taxa (including only one endemic) in Morocco. Therefore, this Ibero-Maghrebian (Spain, North Africa) genus is most developed in Algeria, its centre of diversity (Battandier 1922a).

Widely distributed in arid and semi-arid regions of the world (ElNaggar & al. 2022), the genus *Salsola* is represented in Algeria by 11 species and varieties (Quézel & Santa 1962–1963) to 22 species and subspecies (Dobignard & Chatelain 2010–2013). The number of endemics has in the meantime increased from one Algerian endemic (*Salsola cruciata* L. Chevall. ex Batt.) to seven strict-endemic species, following the work of Botschantzev (1975). However, the genus *Salsola*, due to the physical similarity between many species, is regarded as exceedingly difficult and is frequently overlooked (Murshid & al. 2022). Indeed, these Algerian endemic taxa have remained cryptic and unknown, as they have never been cited afterward, notably by Le Houérou (1995) in the steppe region, nor by Ozenda (2004) in the Algerian Sahara. They are to be actively sought out in the field and require a taxonomic revision. Otherwise, generic endemism is manifested in Algeria by the presence of two exclusively Algerian genera, namely *Agropyropsis* (*Poaceae*) and *Otocarpus* (*Brassicaceae*), both monospecific and having a restricted distribution (Quézel 1964, 1978).

Distribution patterns, chorology and regional hotspots

The distribution of endemic plant taxa in Algeria is not random, and not all areas are equally rich in endemic species, as previously shown by Quézel (1964). Within the floristic regions of Algeria, the Oran sector and Kabylia-Numidia sector (Quézel & Santa 1962–1963) are indicated as the most important centres of endemism, a well-known fact commented on previously by Quézel (1964), Enríquez-Barroso & Gómez-Campo (1991) and

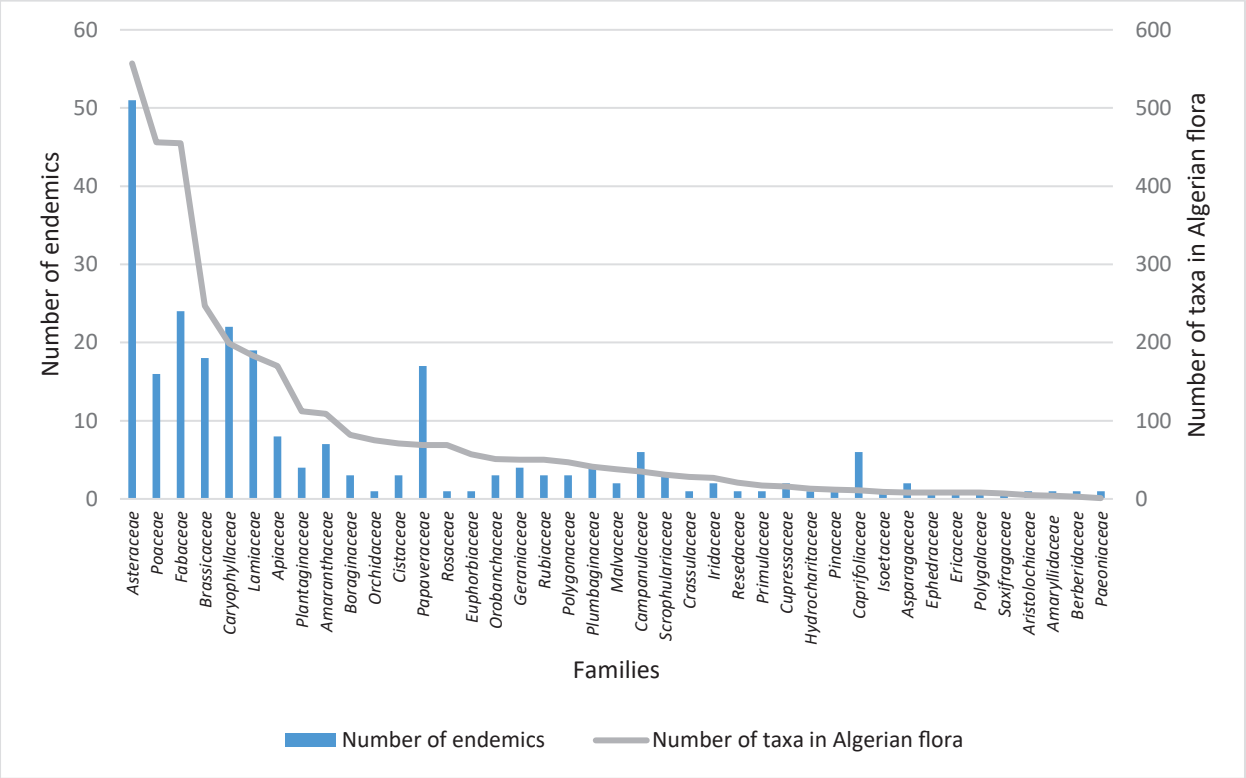

Fig. 3. Plant families of Algeria, representing their contribution to the overall flora (derived from Dobignard & Chatelain 2010–2013), as well as their contribution of endemics.

Véla & Benhouhou (2007). According to these authors, the most remarkable floristic regions for endemism are the Oran coast (O1), followed by the Small Kabylia (K2) and the Great Kabylia (K1). However, when considering the strict-endemism, the floristic regions with the highest number of endemics are the same, but their ranking is different in the two cases. We have recorded important centres of endemism in Algeria, in this rank: K2 including Babors (25%), K1 including Djurdjura (20%), AS3 including Aurès (17%), C1+C2 including the Belezma and Hodna chains (16%) and lastly the Oran coast O1 (c. 16%). The latter is especially rich in Algerian-Moroccan endemics, as shown by Medjahdi & al. (2009).

The high-altitude flora of the Atlas Mountains of Algeria is recognized to be rich in endemics, including orophytes (cf. Quézel 1964, 1957, 1978), as well as in Morocco (Neffati & al. 1999; Rankou & al. 2013). This high richness in endemics is probably linked to high rainfall and short dry season incidence in these areas (Fennane & Ibn Tattou 1999). It is likewise the case for the high mountains of the Algerian C Sahara (SC: Ahaggar, Tassili n'Ajjer) (Ozenda 2004), which harbour a noteworthy rate (7%) in a desertic environment. These mountains (highest peak: Mount Tahat, 2908 m, Ahaggar) are cooler and wetter than other S Saharan regions of the Maghreb (Walas & Taib 2022). The higher number of endemic plant taxa in mountainous (as well as coastal) regions is a common pattern observed in the Mediterranean Basin (Verlaque & al. 1997; Abdelaal & al. 2020; Walas & Taib 2022) and other mountainous areas, such as Iran (Noroozi & al. 2018).

The analysis of distribution patterns of richness in endemic taxa in Algeria supported that the areas richest in endemic taxa match well the regional hotspots (cf. Médail & Quézel 1997; Véla & Benhouhou 2007) and putative refugia (Médail & Diadéma 2009) already described in Algeria. These areas are of high priority to preserve plant diversity (Myers & al. 2000) and to promote the sustainable management of these critical sites and their species (Darbyshire & al. 2019).

Furthermore, this analysis allows the most narrowly distributed species to be highlighted: the 147 range-restricted endemic taxa (59%). They are sometimes sporadically distributed, form small populations in the wild (Carbutt & Edwards 2006; Libiad & al. 2020) and in some cases are known from a single population of few individuals (e.g. *Atractylis caerulea* Batt. and *Tricholemma breviaristatum* (Barratte) Röser). In the Mediterranean region, Greuter (1994) similarly demonstrated that a remarkable number of narrow endemics reflects plant species presenting small mean distributional ranges. Their conservation needs to be prioritized (Laffan & Crisp 2003).

Conservation status, redlisting and protected areas

With regard to their conservation status, new evaluations by IUCN (2022) in Algeria are very scarce, and the

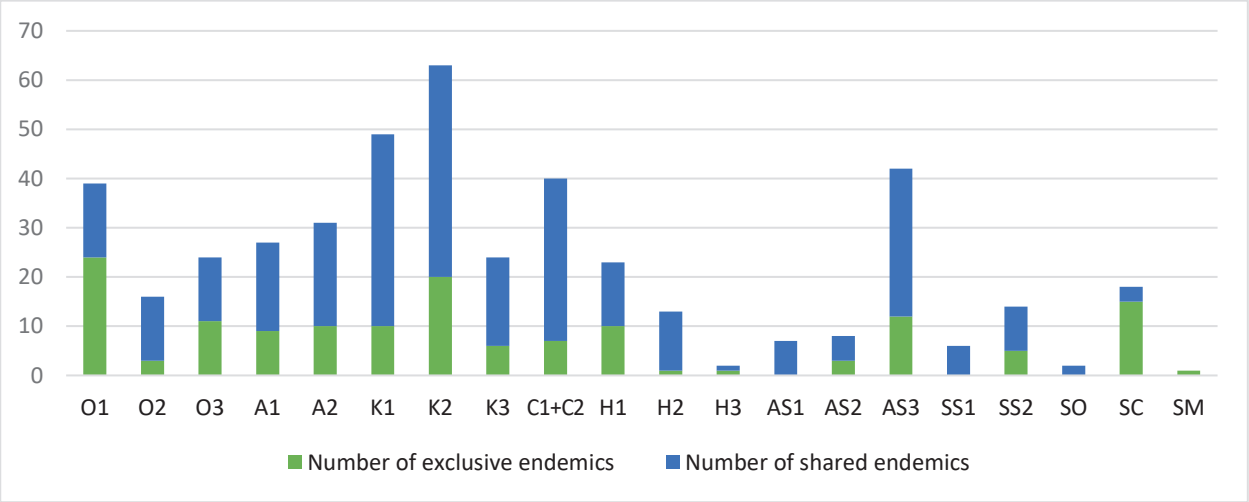

Fig. 4. Distribution of Algerian endemic taxa (range-restricted and shared) across floristic regions. Codes for floristic regions are explained in Fig. 2.

globally assessed endemic flora of Algeria is limited to only 16 endemic taxa (6.4%), of which 14 are threatened. Therefore, 93.6% of Algerian endemic taxa are as yet Not Evaluated (NE) by IUCN (2022). According to Gallagher & al. (2020), 67% of country-based endemic species do not have a completed threat assessment, particularly in North Africa. Effectively, the task of assessing the conservation status of the endemics is a difficult one, because insufficient data are available to evaluate many endemic species, such as estimates of population size, distribution range, number of locations, etc. (Carbutt & Edwards 2006). This is especially the case in Algeria.

Fortunately, relevant literature sources provide additional information on the conservation status of four other endemic taxa: (1) *Salvia balansae* de Noé is suggested as Vulnerable, according to criteria C1+2a(ii) (Mostari & al. 2016); (2) *Onopordum algeriense* (Munby) Pomel is suggested as Critically endangered (IUCN criteria are not specified) (Djelid & al. 2020); (3) *Erica numidica* (Maire) Romo & Borat. is proposed as Critically Endangered fulfilling two criteria A and D (Hamel & al. 2021), and (4) *Adenocarpus faurei* Maire, one of the rarest Algerian endemics, is considered as Extinct (Miara & al. 2018b).

The list of protected plants in Algeria (JORA 2012) includes 452 taxa. However, strict-endemic plants are underrepresented in this list, because it contains only 110 endemic taxa (44% of the endemic flora). Therefore, the national legislation does not protect a great number (138) of strict-endemic taxa. Additionally, 107 taxa (43%) are already benefitting from indirect protection status, because they are by chance included in the national network of protected areas. In order to complete the National Red List of plants, we must add all the range-restricted endemic taxa, especially those that are not present in protected areas (46 taxa), mainly the threatened ones (see Table 3 and Appendix 1).

On the other hand, many areas, such as the Aurès massif and the Oran coast (except the Habibas Islands and Lindlès Cape, recently established as natural marine reserves), do not have any designated protection, despite hosting a great number of endemic taxa (14 and 27, respectively). Both these regions are of high priority for establishing as additional protected areas. However, the Oran coastal region has undergone much greater anthropization, compared to Aurès, where mountain habitats are more preserved. It therefore requires priority conservation action.

Shortfalls of knowledge

Studies relating to the inventory of the flora endemic to Algeria are very rare. Some recent observations, dealing with endemics in the broad sense, have been published for the Oran coast, Ksour mountains, Saida mountains, Tiaret region, Edough, Souk Ahras and Skikda (see Hamel & al. 2013; Miara & al. 2017, 2018a; Mansouri & al. 2018; Djebbouri & Terras 2019; Gordo & Hadjadj-Aoul 2019; Aouadj & al. 2020; Sakhraoui & al. 2020; Touati & al. 2021).

Even so, knowledge on Algerian endemic plants is not well documented and there is insignificant data on their threat status, distribution or even their existence (Miara & al. 2018a). Algerian endemic plants are insufficiently known, and most of them have never been observed since their discovery 60 years to over a century ago. For others, the type material has not yet been found in a herbarium. In particular, taxa known only from the type locality (or the type specimen) are to be underlined:

Artemisia alba subsp. *kabylica* (Chabert) Greuter has not been re-collected since the type was gathered at Ait Bou Youcef (Kabylia) in 1888 (Ouyahia 1989).

Asyneuma rigidum subsp. *aurasiacum* (Batt. & Trab.) Damboldt was gathered in Sgag (Aurès) in 1892 but was

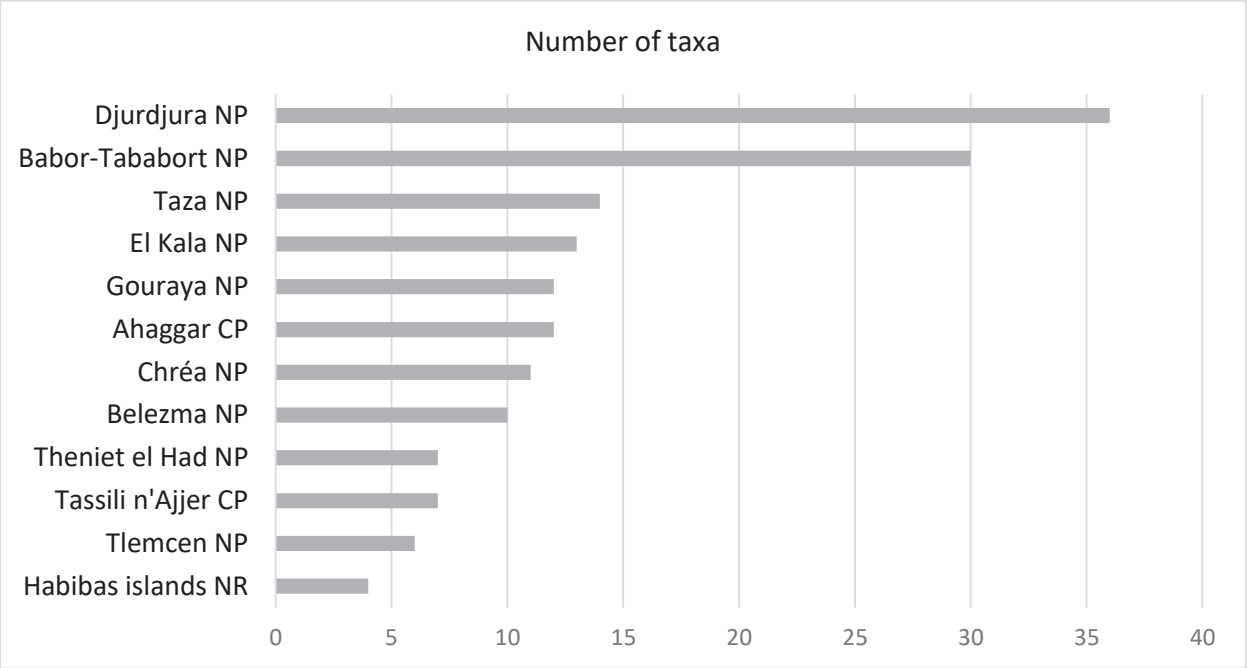

Fig. 5. Number of Algerian endemic taxa occurring in the protected areas network.

not found again (Quézel 1953) and has never been re-collected since.

Atractylis caerulea is known from only three collections in 1919 at the south of Sersou (Quézel & Santa 1962–1963) and has not been re-collected since.

Erodium guinochetianum Guitt. is known from only one location (Tiaret) and has never been re-collected since 1963 (Guittonneau 2017).

Legousia juliani (Batt.) Briq., has not been re-collected since the type was gathered at Djebel Ouahch (Constantine) in 1889 (Wahlsteen & Tyler 2019).

Tricholemma breviaristatum was collected only once in Ouled Sahari (1882) and has never been re-collected since (Gabriel & al. 2020).

Vulpia obtusa Trab. has never been re-collected since its description in 1902. Little is known about this species from Lake Oubeira (El Kala), and Maire (1952–1987) had seen no material, despite searching in the Trabut herbarium (Stace 2022).

They are all obviously in danger of extinction or even already extinct, as is the case with *Adenocarpus faurei* (Miara & al. 2018b). Several other species may be extinct in areas that are not protected in Algeria.

Faurel (1959), Mathez & al. (1985) and Meddour (1988) had already drawn attention to many rare and endangered endemic species, which have still not been found again up to now, e.g. *Agropyropsis lolium* (Balansa ex Coss. & Durieu) A. Camus, *Noccaea atlantica* (Batt.) Al-Shehbaz, *Ononis megalostachys* Munby, *Sideritis maura* de Noé, *Sorghum annuum* (Trab.) Maire and *Verbascum pinnatisectum* (Batt.) Benedí. Currently, some authors (Miara & al. 2017; Mansouri & al. 2018; Mostari & al. 2020; Sakhraoui & al. 2020; Bouchibane & al. 2021; Meddour & Sahar 2021) reported that they were not lucky enough to find certain endemics. In NW Algeria, this is the case for *Adenocarpus umbellatus* Batt., *Anacyclus linearilobus* Boiss. & Reut., *Bellevalia pomelii* Maire, *Centaurea obtusiloba* Batt., *Crepis arenaria* subsp. *suberostris* (Batt.) Greuter, *Mecomischus pedunculatus* (Coss. & Durieu) Oberpr. & Greuter, *Najas marina* subsp. *arsenariensis* (Maire) Triest, *Pulicaria filaginoides* Pomel, *Silene ghiarensis* Batt., *Teucrium santae* Quézel & Simonn. ex Greuter & Burdet and *Trisetaria nitida* (Desf.) Maire. In NE Algeria, this is the case for *Bunium chabertii* (Batt.) Batt., *Pedicularis numidica* Pomel, *Romulea penzigii* Bég., *Silene colorata* subsp. *amphorina* (Pomel) Batt. and *S. reverchonii* Batt. Nevertheless, it would not be reasonable to declare all these taxa extinct without having searched for them in a targeted way.

Some of these allegedly extinct endemics (Faurel 1959; Mathez & al. 1985), not seen since after their first description in Algeria, have actually been rediscovered in their loci classici or new sites. We have to mention *Allium seirotrichum* Ducell. & Maire (temporarily considered as a synonym of *A. trichocnemis* J. Gay) (Khedim & al. 2016), *Anthemis maritima* subsp. *bolosii* Benedí & Molero (Sakhraoui & al. 2021), *Crepis arenaria* (Pomel) Pomel subsp. *arenaria* (Gordo & al. 2021), *Cyclamen repandum* var. *baborense* (Meddour, pers. obs., 30 Mar 2022, https://www.inaturalist.org/observations/111505790), *Digitalis atlantica* Pomel (Chelli-Tabti & al. 2020), *Onopordum algeriense* (Djelid & al. 2020), *Otocarpus virgatus* Durieu (Miara & al. 2014) and *Pulicaria vulgaris* subsp. *pomeliana* (Faure & Maire) E. Gamal-Eldin (Babali & Bouazza 2016).

Table 3. Classification of 16 evaluated taxa endemic to Algeria according to IUCN threat categories (IUCN 2022). Red List categories: CR: Critically Endangered; EN: Endangered; VU: Vulnerable; DD: Data Deficient; LC: Least Concern. An asterisk (*) indicates plants that are not protected by law in Algeria. Note: 232 other endemic taxa are not evaluated by the IUCN (2022).

Taxa	Red List categories	Red List criteria
Abies numidica Carrière	CR	B1ab(i,ii,iii)+2ab(i,ii,iii)
Cupressus dupreziana A. Camus	CR	C1
Najas marina subsp. *arsenariensis* (Maire) Triest	CR	B1ab(iii)+2ab(iii)
Pulicaria filaginoides Pomel	CR	B2ab(iii)+2ab(iii)
**Silene auriculifolia* Pomel	CR	B1ab(iv,v)+2ab(iv,v)
**Drimia anthericoides* (Poir.) Véla & Bélair	EN	B2ab(i,ii,iii)
Rumex algeriensis Barratte & Murb.	EN	B2ab(iii,v); D
Silene sessionis Batt.	EN	D
Allium trichocnemis J. Gay	VU	B1ab(iii)+2ab(iii)
**Silene aristidis* Pomel	VU	A3c
**Brassica fruticulosa* subsp. *numidica* (Coss.) Maire	DD	
**Brassica fruticulosa* subsp. *pomeliana* Maire ex Greuter	DD	
Romulea penzigii Bég.	DD	
Romulea vaillanti Quézel	DD	
**Dactylorhiza maculata* subsp. *battandieri* (Raynaud) Baumann & Künkele	LC	
**Daucus gracilis* Steinh.	LC	

As a result, the data shortfalls on endemic plants do not only concern chorological, biological or taxonomic data, but above all the real presence of these species. It is therefore urgent to carry out targeted field expeditions, on the scale of the entire national territory, in order to find and re-collect these taxa, most of which are strictly localized, either in their classic localities or in new locations.

Conclusion

The level of plant endemism in Algeria is high, and it is treated here within a conservation framework to draw attention to the local and global significance of its biodiversity. We collected data from literature including Floras, herbaria and our expertise to compile the most comprehensive dataset on endemic vascular plants to Algeria. We have tried to be exhaustive, but our intention is to maintain this working list and publish additions as taxonomic revisions over time occur. This will require the periodic updating of our checklist. There is likewise a need to update plant statuses (distribution, biology, threats), in particular those threatened and range-restricted endemics that occupy a place of first importance in conservation programs. This study not only provides a picture of the endemic flora to Algeria, but it also identifies shortfalls in knowledge on which future research efforts could focus. In this case, the search for taxa that have not been seen for a very long time is regarded as an urgent task.

Author contributions

RM contributed to the research conception, acquisition of data, analysis and interpretation, prepared the manuscript and reviewed the final draft. OS contributed to the preparation of the list of endemic taxa and reviewed the final draft. SJ contributed to the improvement of the English language, provided additions and comments and revised the final draft.

Acknowledgements

The authors would like to thank Prof. M. B. Crespo (Universidad de Alicante) and two anonymous reviewers for their critical reviews of the manuscript and, together with the editor, for their valuable comments and suggestions.

References

Abdelaal M., Fois M., Fenu G. & Bacchetta G. 2018: Critical checklist of the endemic vascular plants of Egypt. – Phytotaxa **360:** 19–34. https://doi.org/10.11646/phytotaxa.360.1.2

Abdelaal M., Fois M., Fenu G. & Bacchetta G. 2020: Biogeographical characterisation of Egypt based on environmental features and endemic vascular plants

distribution. – Appl. Geogr. **119**(a102208). https://doi.org/10.1016/j.apgeog.2020.102208

Aedo C., Medina L. & Fernández-Albert M. 2013: Species richness and endemicity in the Spanish vascular flora. – Nordic J. Bot. **31:** 478–488. https://doi.org/10.1111/j.1756-1051.2012.00009.x

Aouadj S. A., Nasrallah Y., Hasnaoui O. & Khatir H. 2020: La flore rare, endémique et menacée des Monts de Saida (Algérie). – Agrobiologia **10:** 1986–1998.

APD [African Plant Database] 2022: African Plant Database (version 4.0.0). Genève: Conservatoire et Jardin botaniques de la ville de Genève. Pretoria: South African National Biodiversity Institute. – Published at https://africanplantdatabase.ch/ [accessed Jul 2022].

APG IV 2016: An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. – Bot. J. Linn. Soc. **181:** 1–20. https://doi.org/10.1111/boj.12385

Babali B. & Bouazza M. 2016: Redécouverte de *Pulicaria vulgaris* subsp. *pomeliana* (Faure et Maire) E. Gamal-Eldin (*Asteraceae*) dans la région de Tlemcen (Algérie occidentale). – Bull. Soc. Linn. Provence **67:** 45–52.

Battandier J. A. 1895: Note sur quelques plantes récoltées en Algérie et probablement adventices. – Bull. Soc. Bot. France **42:** 289–296. https://doi.org/10.1080/00378941.1895.10830598

Battandier J. A. 1922: Un groupe de plantes difficile à classer, les *Rupicapnos* Pomel. – Bull. Soc. Hist. Nat. Afr. N. **13:** 239–242.

Battandier J. A. & Trabut L. 1888–1890: Flore de l'Algérie. Ancienne Flore d'Alger transformée. Contenant la description de toutes les plantes signalées jusqu'à ce jour comme spontanées en Algérie **1.** Dicotylédones. – Alger: A. Jourdan, Paris: J.-B. Baillière.

Battandier J. A. & Trabut L. 1895: Flore de l'Algérie: Contenant la description de toutes les plantes signalées jusqu'à ce jour comme spontanées en Algérie **2.** Monocotylédones. – Alger: A. Jourdan, Paris: J.-B. Baillière.

Battandier J. A. & Trabut L. 1905 ["1902"]: Flore analytique et synoptique de l'Algérie et de la Tunisie. – Alger: Vve Giralt.

Benhouhou S., Yahi N. & Véla E. 2018: Status of threatened flora: Algeria. – Pp. 25–27 in: Valderrábano M., Gil T., Heywood V. & de Montmollin B. (ed.), Conserving wild plants in the south and east Mediterranean region. – Malaga: IUCN, Centre for Mediterranean Cooperation.

Botschantzev V. P. 1975: Новые виды *Salsola* L. New species of *Salsola* L. – Bot. Zhurn. (Moscow & Leningrad) **60:** 498–505. http://en.arch.botjournal.ru/?t=issues&id=19750404

Bouchibane M., Zemouri M. & Toumi R. 2021: Contribution à l'étude de la végétation de certains massifs montagneux de la Kabylie des Babors (Nord-Est algérien). – Bull. Soc. Roy. Sci. Liège **91:** 317–360. https://doi.org/10.25518/0037-9565.10696

Carbutt C. & Edwards T. J. 2006: The endemic and near-endemic angiosperms of the Drakensberg Alpine Centre. – S. African J. Bot. **72:** 105–132. https://doi.org/10.1016/j.sajb.2005.06.001

Carvalho G. & Gillet H. 1960: Catalogue raisonné et commenté des plantes de l'Ennedi (suite). – J. Agr. Trop. Bot. Appl. **7:** 193–240. https://doi.org/10.3406/jatba.1960.2605

Chelli-Tabti D., Markhouf S., Derradji S., Hamitouche S., Bouchareb A. & Bougaham A. F. 2020: New data on the distribution area of the Atlas foxglove *Digitalis atlantica* (Pomel). – Ecol. Medit. **46:** 41–47. https://doi.org/10.3406/ecmed.2020.2097

Darbyshire I., Timberlake J., Osborne J., Rokni S., Matimele H., Langa C., Datizua C., de Sousa C., Alves T., Massingue A., Hadj-Hammou J., Dhanda S., Shah T. & Wursten B. 2019: The endemic plants of Mozambique: diversity and conservation status. – PhytoKeys **136:** 45–96. https://doi.org/10.3897/phytokeys.136.39020

Djebbouri M. & Terras M. 2019: Floristic diversity with particular reference to endemic, rare or endangered flora in forest formations of Saïda (Algeria). – Int. J. Environ. Stud. **76:** 990–1003. https://doi.org/10.1080/00207233.2019.1620541

Djelid S. A., Calvão T. & Bensaid S. 2020: Redécouverte et écologie d'*Onopordum algeriense* (Munby) Pomel = *Carduus algeriensis* Munby, endémique stricte en voie d'extinction du secteur algérois. – Acta Bot. Malacit. **45:** 117–125. https://doi.org/10.24310/abm.v45i.5805

Dobignard A. & Chatelain C. 2010–2013: Index synonymique et bibliographique de la Flore d'Afrique du Nord **1–5.** – Genève: Conservatoire et Jardin botaniques de la Ville de Genève.

Domina & al. 2015: Taxonomy and conservation in higher plants and bryophytes in the Mediterranean area. – Biodivers. J. **6:** 197–204.

eflora Maghreb 2022: eflora du Maghreb. Genève: Conservatoire et Jardin botaniques de la ville de Genève. – Published at https://efloramaghreb.org/ [accessed Jul 2022].

ElNaggar M. H., Eldehna W. M., Abourehab M. A. S. & Abdel Bar F. M. 2022: The old world *Salsola* as a source of valuable secondary metabolites endowed with diverse pharmacological activities: a review. – J. Enzyme Inhib. Med. Chem. **37:** 2036–2062. https://doi.org/10.1080/14756366.2022.2102005

Enríquez-Barroso A. & Gómez-Campo C. 1991: Les plantes endémiques de l'Afrique du Nord-Ouest: Algérie, Maroc et Tunisie. – Bot. Chron. (Patras) **10:** 517–520.

Euro+Med 2022: Euro+Med PlantBase – the information resource for Euro-Mediterranean plant diversity. – Published at https://europlusmed.org/ [accessed Jul 2022].

Faurel L. 1959: Plantes rares et menacées d'Algérie. – Terre & Vie, Suppl. **1959:** 140–155. https://doi.org/10.3406/revec.1959.5222

Fennane M. & Ibn Tattou M. 1999: Observations sur la flore vasculaire endémique, rare ou menacée du Maroc. – Fl. Medit. **9:** 113–124.

Fennane M. & Rejdali M. 2019: Moroccan vascular plant Red Data Book: a basic tool for plant conservation. – Bocconea **28:** 273–284. https://doi.org/10.7320/Bocc28.273

Fois M., Farris E., Calvia G., Campus G., Fenu G., Porceddu M. & Bacchetta G. 2022: The endemic vascular flora of Sardinia: a dynamic checklist with an overview of biogeography and conservation status. – Plants **11**(601). https://doi.org/10.3390/plants11050601

Gabriel J., Tkach N. & Röser M. 2020: Recovery of the type specimen of *Avena breviaristata*, an endemic Algerian grass species collected only once (1882): morphology, taxonomy and botanical history. – Taxon **69:** 142–152. https://doi.org/10.1002/tax.12187

Gallagher R. V., Allen S., Rivers M. C., Allen A. P., Butt N., Keith D., Auld T. D., Enquist B. J., Wright I. J., Possingham H. P., Espinosa-Ruiz S., Dimitrova N., Mifsud J. C. & Adams V. M. 2020: Global shortfalls in extinction risk assessments for endemic flora. – bioRxiv. https://doi.org/10.1101/2020.03.12.984559

Gordo B. & Hadjadj-Aoul S. 2019: L'endémisme floristique algéro-marocain dans les monts des Ksour (Naâma, Algérie). – Fl. Medit. **29:** 129–142. https://doi.org/10.7320/FlMedit29.129

Gordo B., Hadjadj-Aoul S. & Gherib M. 2021: Redécouverte de *Crepis arenaria* (Pomel) Pomel subsp. *arenaria* (*Asteraceae*) en Algérie (Monts des Ksour, Aïn Sefra). – Bull. Soc. Roy. Sci. Liège **90:** 361–370. https://doi.org/10.25518/0037-9565.10672

Greuter W. 1991: Botanical diversity, endemism, rarity, and extinction in the Mediterranean area: an analysis based on the published volumes of Med-Checklist. – Bot. Chron. (Patras) **10:** 63–79.

Greuter W. 1994: Extinctions in Mediterranean areas. – Philos. Trans., Ser. B **344:** 41–46. https://doi.org/10.1098/rstb.1994.0049

Guittonneau G.-G. 2017: Aperçu sur la taxonomie, l'écologie et la physiologie du genre *Erodium* L'Hér. dans le bassin méditerranéen. – Published at https://www.tela-botanica.org/wp-content/uploads/2017/03/apercu_de_la_taxonomie_du_genre_erodium.pdf [accessed Jul 2022].

Hamel T., de Bélair G., Slimani A. & Meddad-Hamza A. 2021: De nouvelles données sur l'état critique d'*Erica numidica* (Maire) Romo & Borat. en Numidie (Algérie orientale). – Lejeunia **205:** 1–16. https://doi.org/10.25518/0457-4184.2416

Hamel T., Seridi R., de Bélair G., Slimani A. R. & Babali B. 2013: Flore vasculaire rare et endémique de la péninsule de l'Edough (Nord–Est algérien). – Synthèse **26:** 65–74.

Helme N. A. & Trinder-Smith T. H. 2006: The endemic flora of the Cape Peninsula, South Africa. – S. African J. Bot. **72:** 205–210. https://doi.org/10.1016/j.sajb.2005.07.004

Hobohm C. (ed.) 2014: Endemism in vascular plants. – Dordrecht: Springer. https://doi.org/10.1007/978-94-007-6913-7

IUCN 2012: IUCN Red List categories and criteria, version 3.1, second edition. – Gland & Cambridge: SSC Commission, IUCN. – Published at https://portals.iucn.org/library/node/10315 [accessed Jul 2022].

IUCN 2020: Algeria and Morocco acknowledge biodiversity value of cultural parks, biosphere and hunting reserves through OECMs. – Published at https://www.iucn.org/news/mediterranean/202009/algeria-and-morocco-acknowledge-biodiversity-value-cultural-parks-biosphere-and-hunting-reserves-through-oecms [accessed Jan 2023].

IUCN 2022: The IUCN Red List of threatened species. Version 2022-2. – Published at https://www.iucnredlist.org/ [accessed Jul 2022].

JORA 2012: Décret exécutif no 12-03 du 10 Safar 1433 correspondant au 4 janvier 2012 fixant la liste des espèces végétales non cultivées protégées. – Journal Officiel de la République Algérienne, n° 03 du 18 janvier 2012.

Khedim T., Amirouche N. & Amirouche R. 2016: Morphological and cytoxanomic data of *Allium trichocnemis* and *A. seirotrichum* (*Amaryllidaceae*) endemic to northern Algeria, compared with *A. cupanii* group. – Phytotaxa **243:** 247–259. https://doi.org/10.11646/phytotaxa.243.3.3

Laffan S. W. & Crisp M. D. 2003: Assessing endemism at multiple spatial scales, with an example from the Australian vascular flora. – J. Biogeogr. **30:** 511–520. https://doi.org/10.1046/j.1365-2699.2003.00875.x

Le Houérou H. N. 1995: Bioclimatologie et biogéographie des steppes arides du Nord de l'Afrique. Diversité biologique, développement durable et désertisation. – Options Médit. **10:** 1–396.

Libiad M., Khabbach A., El Haissoufi M., Bourgou S., Megdiche-Ksouri W., Ghrabi-Gammar Z., Sharrock S. & Krigas N. 2020: Ex-situ conservation of single-country endemic plants of Tunisia and northern Morocco (Mediterranean coast and Rif region) in seed banks and botanic gardens worldwide. – Kew Bull. **75**(46). https://doi.org/10.1007/s12225-020-09903-6

Lidén M. 1986: Synopsis of *Fumarioideae* (*Papaveraceae*) with a monograph of the tribe *Fumarieae*. – Opera Bot. **88:** 1–133.

Maire R. 1952–1987: Flore de l'Afrique du Nord (Maroc, Algérie, Tunisie, Tripolitaine, Cyrénaïque et Sahara). – Paris: Lechevalier.

Mansouri S., Miara M. D. & Hadjadj-Aoul S. 2018: Etat des connaissances et conservation de flore endémique dans la région d'Oran (Algérie occidentale). – Acta

Bot. Malacit. **43:** 23–30. https://doi.org/10.24310/abm.v43i0.4361

Mathez J., Quézel P. & Raynaud C. 1985: The Maghreb countries. – Pp. 141–157 in: Gomez-Campo C. (ed.), Plant conservation in the Mediterranean area. – Dordrecht: Junk Publishers.

Médail F. & Diadéma K. 2009: Glacial refugia influence plant diversity patterns in the Mediterranean basin. – J. Biogeogr. **36:** 1333–1345. https://doi.org/10.1111/j.1365-2699.2008.02051.x

Médail F. & Quézel P. 1997: Hot-spots analysis for conservation of plant biodiversity in the Mediterranean basin. – Ann. Missouri Bot. Gard. **84:** 112–127. https://doi.org/10.2307/2399957

Meddour R. 1988: Quelques commentaires sur la liste des plantes rares et menacées d'Algérie. – Ann. Rech. Forest. Algérie **3(3):** 43–65. https://www.asjp.cerist.dz/en/article/109777

Meddour R. 2012: Bioclimatologie, phytogéographie & phytosociologie en Algérie (exemple des écosystèmes forestiers et préforestiers en Kabylie djurdjuréenne. – Mauritius: Presses Académiques Francophones.

Meddour R. & Sahar O. 2021: Floristic inventory of Djurdjura National Park, northern Algeria: a first checklist of its vascular flora. – Phytotaxa **490:** 221–238. https://doi.org/10.11646/phytotaxa.490.3.1

Meddour R., Sahar O. & Médail F. 2021: Checklist of the native tree flora of Algeria: diversity, distribution, and conservation. – Pl. Ecol. Evol. **154:** 405–418. https://doi.org/10.5091/plecevo.2021.1868

Medjahdi B., Ibn Tattou M., Barkat D. & Benabdeli K. 2009: La flore vasculaire des Monts des Trara (Nord Ouest algérien). – Acta Bot. Malacit. **34:** 57–75. https://doi.org/10.24310/abm.v34i0.6917

Miara M. D., 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 Bot. Malacit. **43:** 63–69. https://doi.org/10.24310/abm.v43i0.4453

Miara M. D., Ait Hammou M., Hadjadj Aoul S. & Rebbas K. 2014: Redécouverte d'*Otocarpus virgatus* Durieu (*Brassicaceae*) dans la région de Tiaret (Nord–Ouest de l'Algérie). – Bull. Soc. Linn. Provence **65:** 31–35.

Miara M. D., Ait Hammou M., Rebbas K. & Bendif H. 2017: Flore endémique, rare et menacées de l'Atlas tellien occidental de Tiaret (Algérie). – Acta Bot. Malacit. **42:** 271–285. https://doi.org/10.24310/abm.v42i2.3590

Miara M. D., Ait Hammou M. & Skipper J. 2018b: The extinction of Faure's broom *Adenocarpus faurei* Maire (*Leguminosae*) in Algeria. – J. Threat. Taxa **10:** 11595–11598. https://doi.org/10.11609/jott.3887.10.5.11595-11598

Millaku F., Krasniqi E., Berisha N. & Rexhepi F. 2016: Conservation assessment of the endemic plants from Kosovo. – Hacquetia **16:** 35–47. https://doi.org/10.1515/hacq-2016-0024

Mostari A., Benabdelli K. & Véla E. 2020: Le littoral de Mostaganem (Algérie), une "zone importante pour les plantes" (ZIP) autant négligée que menacée. – Fl. Medit. **30:** 207–233. https://doi.org/10.7320/FlMedit30.207

Mostari A., Limam M. & Véla E. 2016: Données préliminaires à l'évaluation des menaces selon les critères de la liste rouge UICN pour *Salvia balansae* de Noé, endémique d'Algérie. – Poster at XV OPTIMA Meeting, June 6–11, 2016, Montpellier. https://doi.org/10.13140/RG.2.2.27359.61607

Murshid S. S. A., Atoum D., Abou-Hussein D. R., Abdallah H. M., Hareeri R. H., Almukadi H. & Edrada-Ebel R. 2022: Genus *Salsola*: chemistry, biological activities and future prospective—a review. – Plants **11**(714). https://doi.org/10.3390/plants11060714

Myers N., Mittermeier R. A., Mittermeier C. G., da Fonseca G. A. B. & Kent J. 2000: Biodiversity hotspots for conservation priorities. – Nature **403:** 853–858. https://doi.org/10.1038/35002501

Neffati M., Ghrabi-Gammar Z., Akrimi N. & Henchi B. 1999: Les plantes endémiques de la Tunisie. – Fl. Medit. **9:** 163–174.

Noroozi J., Talebi A., Doostmohammadi M., Rumpf S. B., Linder H. P. & Schneeweiss G. M. 2018: Hotspots within global biodiversity hotspot – areas of endemism are associated with high mountain ranges. – Sci. Rep. **8:** 1–10. https://doi.org/10.1038/s41598-018-28504-9

Ouyahia A. 1989: Etude anatomique de quelques armoises du Bassin Méditerranéen Occidental. – Bull. Inst. Sci. Univ. Mohammed V **13:** 63–74.

Ozenda P. 2004: Flore et végétation du Sahara. – Paris: CNRS.

POWO [Plants of the World Online] 2022: Plants of the world online. Kew: Royal Botanic Gardens, Kew. – Published at https://powo.science.kew.org/ [accessed Jul 2022].

Pugsley H. W. 1919: A revision of the genera *Fumaria* and *Rupicapnos*. – J. Linn. Soc., Bot. **44:** 233–353. https://doi.org/10.1111/j.1095-8339.1919.tb00705.x

Quézel P. 1953: Les Campanulacées d'Afrique du Nord. – Feddes Repert. **56:** 1–65. https://doi.org/10.1002/fedr.19530560102

Quézel P. 1957: Peuplement végétal des hautes montagnes de l'Afrique du Nord, essai de synthèse biogéographique et phytosociologique. Encyclopédie biogéographique et écologique **10.** – Paris: Lechevalier.

Quézel P. 1964: L'endémisme dans la flore de l'Algérie. – Compt. Rend. Séances Soc. Biogéogr. **361:** 137–149.

Quézel P. 1978: Analysis of the flora of Mediterranean and Saharan Africa. – Ann. Missouri Bot. Gard. **65:** 479–534. https://doi.org/10.2307/2398860

Quézel P. 1995: La flore du bassin méditerranéen: origine, mise en place, endémisme. – Ecol. Medit. **21:** 19–39. https://doi.org/10.3406/ecmed.1995.1752

Quézel P. 2002: Réflexions sur l'évolution de la flore et de la végétation au Maghreb méditerranéen. – Paris: Ibis press.

Quézel P. & Santa S. 1962–1963: Nouvelle flore de l'Algérie et des régions désertiques méridionales **1–2.** – Paris: CNRS.

Rabinowitz D. 1981: Seven forms of rarity. – Pp. 205–217 in: Synge H. (ed.), The biological aspects of rare plants conservation. – New York: John Wiley and Sons.

Rankou H., Culham A., Jury S. L. & Christenhusz M. J. M. 2013: The endemic flora of Morocco. – Phytotaxa **78:** 1–69. https://doi.org/10.11646/phytotaxa.78.1.1

Romo A. M. & Boratyński A. 2010: A new combination in *Erica* (*Ericaceae*). – Collect. Bot. (Barcelona) **29:** 95–98. https://doi.org/10.3989/collectbot.2010.v29.009

Sakhraoui N., Boussouak R. & Chefrour A. 2021: Redécouverte d'une endémique algérienne méconnue, *Anthemis maritima* subsp *bolosii* Benedí et Molero, et mise en évidence de nouvelles caractéristiques d'identification. – Bull. Soc. Linn. Provence **72:** 75–80.

Sakhraoui N., Boussouak R., Metallaoui S., Chefrour A. & Hadef A. 2020: La flore endémique du Nord–Est algérien face à la menace des espèces envahissantes. – Acta Bot. Malacit. **45:** 67–79. https://doi.org/10.24310/abm.v45i.6138

Stace C. A. 2022: Conspectus of and key to the world's species of *Vulpia* C.C. Gmel. (*Poaceae*: *Loliinae*) and seven related genera. – Brit. Irish Bot. **4:** 74–94. https://doi.org/10.33928/bib.2022.04.074

Touati L., Hamel T., Meddad-Hamza A. & de Bélair G. 2021: Analysis of rare and endemic flora in northeastern Algeria: the case of the wilaya of Souk Ahras. – Bull. Soc. Roy. Sci. Liège **90:** 213–240. https://doi.org/10.25518/0037-9565.10514

Treurnicht H., Colville J. F., Joppa G., Huyser J. & Manning J. 2017: Counting complete? Finalising the plant inventory of a global biodiversity hotspot. – PeerJ **5**(e2984). https://doi.org/10.7717/peerj.2984

Véla E. & Benhouhou S. 2007: Evaluation d'un nouveau point chaud de biodiversité végétale dans le Bassin méditerranéen (Afrique du Nord). – Compt. Rend. Biol. **330:** 589–605. https://doi.org/10.1016/j.crvi.2007.04.006

Véla E., de Bélair G., Rosato M. & Rosselló J. A. 2016: Taxonomic remarks on *Scilla anthericoides* Poir. (*Asparagaceae*, *Scilloideae*), a neglected species from Algeria. – Phytotaxa **288:** 154–160. https://doi.org/10.11646/phytotaxa.288.2.5

Véla E. & Schäfer P. A. 2013: Typification de *Juniperus thurifera* var. *africana* Maire, délimitation taxonomique et conséquences nomenclaturales sur le Genévrier thurifère d'Algérie. – Ecol. Medit. **39:** 69–80. https://doi.org/10.3406/ecmed.2013.1293

Verlaque R., Médail F., Quézel P. & Babinot J. F. 1997: Endémisme végétal et paléogéographie dans le bassin méditerranéen. – Geobios **30:** 159–166. https://doi.org/10.1016/S0016-6995(97)80083-6

Vicente A., Alonso M. Á. & Crespo M. B. 2016: Taxonomic circumscription of the N African endemic *Biscutella raphanifolia* (*Brassicaceae*) based on morphological and molecular characters. – Willdenowia **46:** 411–422. https://doi.org/10.3372/wi.46.46309

Vicente A., Alonso M. Á. & Crespo M. B. 2020: Born in the Mediterranean: comprehensive taxonomic revision of *Biscutella* ser. *Biscutella* (*Brassicaceae*) based on morphological and phylogenetic data. – Ann. Missouri Bot. Gard. **105:** 195–231. https://doi.org/10.3417/2020554

Wahlsteen E. & Tyler T. 2019: Morphometric analyses and species delimitation in *Legousia* (*Campanulaceae*). – Willdenowia **49:** 21–33. https://doi.org/10.3372/wi.49.49104

Walas L. & Taib A. 2022: Environmental regionalization and endemic plant distribution in the Maghreb. – Environm. Monit. Assessm. **194:** 100. https://doi.org/10.1007/s10661-021-09707-6

Walter K. S. & Gillett H. J. (ed.) 1998: 1997 IUCN Red List of threatened plants. – Gland: SSC, IUCN.

Appendix 1

Annotated checklist of vascular plants endemic to Algeria

Taxa in the checklist are ordered alphabetically by family, genus, species and subspecies. Family circumscription follows the Angiosperm Phylogeny Group IV (APG IV 2016). The following information is provided after the accepted (according to APD 2022) taxon name:

Regional distribution in Algeria based on floristic regions (derived from taxonomic literature, herbarium specimens, fieldwork): O1-O2-O3-A1-A2-K1-K2-K3-C1-H1-H2-H3-AS1-AS2-AS3-SS1-SS2-SO-SC-SM (acronyms according to Quézel & Santa 1962–1963).

Global conservation status (IUCN 2022): CR = Critically Endangered; EN = Endangered; VU = Vulnerable; DD = Data Deficient; LC = Least Concern.

National protection by decree (**PL**) or in protected areas (**PA**).

Range-restricted (**RR**) distribution, i.e. found solely in one floristic region.

An asterisk (*) before the name indicates range-restricted and/or threatened taxa deserving legal protection (national Red Listing).

Amaranthaceae

Salsola algeriensis* Botsch., SS2, **RR
Salsola chellalensis* Botsch., H1, **RR
Salsola cruciata L. Chevall. ex Batt., H2-SS1-SS2-SO-SC
Salsola gypsacea* Botsch., H1, **RR
Salsola mairei* Botsch., H1, **RR

Salsola praemontana* Botsch., H1, **RR
Salsola subglabra* Botsch., H1, **RR

Amaryllidaceae
Allium trichocnemis J. Gay, A2-K2, [VU B1ab(iii)+2ab(iii)], **PL**, **PA**

Apiaceae
Ammoides atlantica (Coss. & Durieu) H. Wolff, A2-K1-K2-K3-C1-AS3, **PA**
Bunium chabertii (Batt.) Batt., K1, **PL**, **PA**, **RR**
Bunium elatum (Batt.) Batt., C1, **PL**, **RR**
Bupleurum plantagineum Desf., K2, **PL**, **PA**, **RR**
Daucus gracilis Steinh., K2-K3-C1, [LC]
Heracleum sphondylium subsp. *algeriense* (Coss. ex Batt. & Trab.) Dobignard, K1-K2-AS3, **PA**
Heracleum sphondylium* subsp. *aurasiacum* (Maire) Dobignard, AS3, **RR
Pimpinella battandieri Chabert, K1-K2, **PL**, **PA**

Aristolochiaceae
Aristolochia fontanesii Boiss. & Reut., A1-K1-K2, **PA**

Asparagaceae
Bellevalia pomelii Maire, O1, **PL**, **RR**
Drimia anthericoides* (Poir.) Véla & Bélair, K2-K3, [EN B2ab(i,ii,iii)], **PA

Asteraceae
Anacyclus linearilobus Boiss. & Reut., O1-A1
Anthemis boveana* J. Gay, O1, **RR
Anthemis maritima subsp. *bolosii* Benedí & Molero, K1-K2, **PA**
Anthemis maritima subsp. *pseudopunctata* Oberpr., K1-K2, **PA**
Anthemis punctata subsp. *kabylica* (Batt.) Oberpr., A1-K1-K2-K3-C1
Anthemis stiparum subsp. *sabulicola* (Pomel) Oberpr., SS1-SS2
Anthemis stiparum Pomel subsp. *stiparum*, H1-H2-SS1-SS2
Artemisia alba subsp. *kabylica* (Chabert) Greuter, K1, **PA**, **RR**
Artemisia algeriensis* Filatova, AS3, **RR
Atractylis caerulea Batt., H1, **PL**, **RR**
Calendula suffruticosa subsp. *balansae* (Boiss. & Reut.) Ohle, O1-O3
Calendula suffruticosa subsp. *monardii* (Boiss. & Reut.) Ohle, A1, **PL**, **RR**
Carduus numidicus Durieu, K1-K2-K3-C1, **PA**
Carthamus chouletteanus (Pomel) Greuter, H2, **PL**, **RR**
Carthamus ilicifolius (Pomel) Greuter, H1, **PL**, **RR**
Carthamus strictus (Pomel) Batt., K1-K2-C1, **PL**, **PA**
Centaurea djebel-amouri* Greuter, AS2, **RR
Centaurea ferox Desf., O1-O2-O3-A1-AS1
Centaurea foucauldiana Maire, SC, **PL**, **PA**, **RR**
Centaurea obtusiloba* Batt., O3, **RR
Centaurea phaeolepis Coss., O3, **PL**, **RR**
Centaurea resupinata* subsp. *vulnerariifolia* (Pomel) Breitw. & Podlech, H1, **RR
Centaurea tougourensis Boiss. & Reut., C1-AS2-AS3, **PA**
Centaurea vesceritensis Boiss., C1-AS3
Chiliadenus sericeus subsp. *virescens* (Maire) Greuter, SC, **PL**, **PA**, **RR**
Cirsium kirbense Pomel, A1-A2-K1, **PL**, **PA**
Coleostephus multicaulis (Desf.) Durieu, O1-O2-O3-H1
Crepis arenaria (Pomel) Pomel subsp. *arenaria*, O2-H1-AS1
Crepis arenaria subsp. *suberostris* (Batt.) Greuter, O1, **PL**, **RR**
Crepis claryi Batt., AS2, **PL**, **RR**
Crepis faureliana Maire, AS3, **PL**, **RR**
Crepis pulchra* susbsp. *africana* Babcock, A1, **RR
Helminthotheca balansae (Coss. & Durieu) Lack, O1-O2-A2-C1
Hieracium amplexicaule subsp. *peyerimhoffii* (Maire) Zahn, AS3, **PL**, **RR**
Hieracium cerinthoides subsp. *ernesti* (Maire) Greuter, K2, **PL**, **PA**, **RR**
Hieracium faurelianum Maire, C1-AS3, **PL**, **PA**
Hieracium grandifolium Sch. Bip., K1-K2, **PL**, **PA**
Hypochaeris claryi Batt., H1-AS2, **PL**
Hypochaeris saldensis Batt., K2, **PL**, **PA**, **RR**
Jacobaea gallerandiana (Coss. & Durieu) Pelser, K1-K2-AS3, **PL**, **PA**
Leontodon balansae Boiss., O3-A2-C1-AS2-AS3, **PA**
Leontodon djurdjurae Batt., K1, **PA**, **RR**
Mecomischus pedunculatus (Coss. & Durieu) Oberpr. & Greuter, O1, **PL**, **RR**
Onopordum algeriense (Munby) Pomel, A1, **PL**, **RR**
Pallenis maritima subsp. *sericea* (Maire & Wilczek) Véla, O1, **PA**, **RR**
Phagnalon garamantum Maire, SC, **PL**, **PA**, **RR**
Pulicaria filaginoides Pomel, O1, [CR B1ab(iii)+2ab(iii)], **PL**
Pulicaria lothei Maire, SC, **PL**, **PA**, **RR**
Pulicaria vulgaris subsp. *pomeliana* (Faure & Maire) E. Gamal-Eldin, O3, **PL**, **PA**, **RR**
Sonchus tenerrimus subsp. *amicus* (Maire & Wilczek) Véla, O1, **PA**, **RR**

Berberidaceae
Epimedium perralderianum Coss., K2, **PL**, **PA**, **RR**

Boraginaceae
Cynoglossum gymnandrum (Coss.) Greuter & Burdet, K1, **PL**, **PA**, **RR**
Echium clandestinum* Pomel, H3, **RR
Myosotis speciosa Pomel, K1-K2-C1, **PA**

Brassicaceae
Alyssum luteolum Pomel, A2, **PA**, **RR**
Arabis doumetii Coss., K1-K2, **PL**, **PA**

Biscutella raphanifolia var. *algeriensis* (Jord.) A. Vicente & al., O3-A2, **PA**
Brassica fruticulosa* subsp. *numidica* (Coss.) Maire, K3, [DD], **RR
Brassica fruticulosa* subsp. *pomeliana* Maire ex Greuter, O1, [DD], **RR
Brassica spinescens Pomel, O1, **PL**, **PA**, **RR**
Crambe kralikii subsp. *garamas* (Maire) Podlech, SC, **PL**, **PA**, **RR**
Diplotaxis erucoides subsp. *cossoniana* (Reut. ex Boiss.) Mart.-Laborde, C1-H3-AS1-AS2-AS3
Erysimum cheiri subsp. *inexpectans* Véla, Ouarmim & Dubset, K2, **PA**, **RR**
Erysimum semperflorens* subsp. *elatum* (Pomel) Maire, O1, **RR
Hirschfeldia incana* subsp. *consobrina* (Batt.) Maire, O3, **RR
Iberis peyerimhoffii Maire, A2, **PL**, **RR**
Lepidium rigidum Pomel, A2-K1-K2-K3-C1-H2-AS3, **PA**
Moricandia spinosa* Pomel, SS2, **RR
Noccaea atlantica (Batt.) Al-Shehbaz, K2, **PL**, **RR**
Otocarpus virgatus Durieu, H1, **PL**, **RR**
Sinapis pubescens subsp. *aristidis* (Pomel) Maire & Weiller, O2, C1
Sinapis pubescens subsp. *indurata* (Coss.) Batt., K2-C1-H2, **PA**

Campanulaceae
Asyneuma rigidum subsp. *aurasiacum* (Batt. & Trab.) Damboldt, AS3, **PL**, **RR**
Campanula baborensis Quézel, K2, **PL**, **RR**
Campanula bordesiana Maire subsp. *bordesiana*, SC, **PA**, **RR**
Campanula jurjurensis Pomel, K1-AS3, **PA**
Campanula numidica Durieu, C1, **PL**, **RR**
Legousia juliani (Batt.) Briq., C1, **PL**, **RR**

Caprifoliaceae
Fedia graciliflora subsp. *calycina* (Maire) Mathez & Xena, K1, **PA**, **RR**
Fedia graciliflora subsp. *sulcata* (Pomel) Mathez & Xena, K1-K2-K3, **PA**
Lomelosia camelorum (Coss. & Durieu) Greuter & Burdet, SS2, **PL**, **RR**
Lonicera kabylica (Batt.) Rehder, K1-K2, **PL**, **PA**
Sixalix cartenniana (Pons & Quézel) Greuter & Burdet, A1, **PL**, **RR**
Valerianella leptocarpa Pomel, O3, **PL**, **RR**

Caryophyllaceae
Bufonia chevallieri Batt., AS3, **PL**, **RR**
Bufonia duvaljouvei* subsp. *battandieri* (Rouy ex Batt.) Maire, AS3, **RR
Dianthus sylvestris subsp. *aristidis* (Batt.) Greuter & Burdet, K2-K3
Herniaria oranensis* Chaudhri subsp. *oranensis*, O1, **RR
Minuartia tenuissima* subsp. *numidica* (Maire) Greuter & Burdet, C1, **RR
Moehringia stellarioides Coss., K2, **PL**, **PA**, **RR**
Paronychia haggariensis subsp. *sahariensis* Chaudhri, SC, **PA**, **RR**
Polycarpaea robbairea subsp. *garamantum* (Quézel) Dobignard, SS1-SS2-SO-SC, **PA**
**Silene aristidis* Pomel, A1-A2-K2, [VU A3c]
Silene auriculifolia* Pomel, O1, [CR B1ab(iv,v)+2ab(iv,v)], **RR
Silene choulettii Coss., K1-K2-K3-C1, **PA**
Silene cirtensis Pomel, K3-C1, **PL**
Silene claryi Batt., H1-AS1-AS2-AS3
Silene colorata subsp. *amphorina* (Pomel) Batt., K3, **PL**, **PA**, **RR**
Silene ghiarensis Batt., O2-A2-C, **PL**
Silene glaberrima Faure & Maire, O2, **PL**, **RR**
Silene kremeri Soy.-Will. & Godr., C1-H2
Silene pseudovestita Batt., A2, **PL**, **RR**
Silene reverchonii Batt., K2, **PL**, **PA**, **RR**
Silene sessionis Batt., K2, [EN D], **PL**, **PA**, **RR**
Spergularia microsperma subsp. *fontenellei* (Maire) Greuter & Burdet, SC, **PL**, **PA**, **RR**
Spergularia pycnorrhiza Foucaud ex Batt., O1, **PL**, **PA**, **RR**

Cistaceae
Helianthemum eriocephalum Pomel, SS2, **PL**, **RR**
Helianthemum geniorum Maire, SC, **PL**, **PA**, **RR**
Helianthemum maritimum Pomel, O1, **PL**, **RR**

Crassulaceae
Sedum multiceps Coss. & Durieu, K2-C1, **PL**, **PA**

Cupressaceae
Cupressus dupreziana A. Camus, SC, [CR C1], **PL**, **PA**, **RR**
Juniperus thurifera subsp. *aurasiaca* (Véla & P. Schäf.) Véla, AS3, **PL**, **RR**

Ephedraceae
Ephedra alata* subsp. *monjauzeana* Dubuis & Faurel, SS2, **RR

Ericaceae
Erica numidica (Maire) Romo & Borat., K3, **PA**, **RR**

Euphorbiaceae
Euphorbia hieroglyphica* Coss. & Durieu ex Boiss., C1, **RR

Fabaceae
Adenocarpus faurei Maire, O3, **PL**, **RR**
Adenocarpus umbellatus Batt., O1, **PL**, **RR**
Astragalus reinii subsp. *nemorosus* (Batt.) Maire, A2, **PL**, **RR**
Coronilla valentina subsp. *speciosa* (Uhrová) Greuter & Burdet, A1-A2-K1-K2-C1-AS3, **PA**

Genista numidica subsp. *filiramea* (Pomel) Batt., K1, **PA**, **RR**
Genista numidica* subsp. *ischnoclada* (Pomel) Batt., O1, **RR
Genista numidica Spach subsp. *numidica*, K1-K2-K3, **PA**
Genista numidica* subsp. *sarotes* (Pomel) Batt., A2, **RR
Genista spinulosa Pomel, O1, **PL**, **RR**
Genista triacanthos subsp. *vepres* (Pomel) P. E. Gibbs, K1-K2-K3, **PL**, **PA**
Hedysarum naudinianum Coss. & Durieu, A1-A2-C1, **PA**
Hedysarum perrauderianum Coss. & Durieu, C1-AS3, **PL**, **PA**
Ononis alba subsp. *monophylla* (Desf.) Murb., A1-K2-K3, **PA**
Ononis aurasiaca* Förther & Podlech, AS3, **RR
Ononis avellana Pomel, O1, **PL**, **RR**
Ononis cephalantha* Pomel subsp. *cephalantha*, A2, **RR
Ononis clausonis (Pomel) Pomel, A1-A2
Ononis crinita Pomel, O1, **PL**, **RR**
Ononis incisa Batt., H1-H2
Ononis megalostachys Munby, O2, **PL**, **RR**
Ononis serotina Pomel, O3-A1
Trigonella balachowskyi Leredde, SC, **PL**, **PA**, **RR**
Vicia ochroleuca subsp. *atlantica* (Pomel) Greuter & Burdet, A2-K1-K2-C1, **PA**
Vicia ochroleuca subsp. *baborensis* (Batt. & Trab.) Greuter & Burdet, K2, **PA**, **RR**

Geraniaceae
Erodium battandierianum Rouy, K2, **PL**, **PA**, **RR**
Erodium guinochetianum* Guitt., O3, **RR
Erodium malacoides subsp. *floribundum* (Batt.) Batt., O3-A2, **PA**
Erodium medeense Batt., O3-A2

Hydrocharitaceae
Najas marina subsp. *arsenariensis* (Maire) Triest, O1, [CR B1ab(iii)+2ab(iii)], **PL**, **RR**

Iridaceae
Romulea penzigii Bég., K1, [DD], **PL**, **PA**
Romulea vaillantii Quézel, AS3, [DD], **PL**

Isoetaceae
Isoetes longissima subsp. *perralderiana* (Milde) Troia & Greuter, K1-K2

Lamiaceae
Ballota hirsuta subsp. *saharica* (Diels) Greuter & Burdet, SC, **PA**, **RR**
Calamintha candidissima (Munby) Benth., O1-O2-A1-AS3
Calamintha hispidula Boiss. & Reut., K2-K3, **PL**, **PA**
Calamintha nervosa Pomel, K2, **PL**, **PA**, **RR**
Origanum floribundum Munby, A2-K1, **PA**
Salvia balansae de Noé, O1-AS3, **PL**
Sideritis guyoniana Boiss. & Reut., O1-K2-C1-AS3
Sideritis maura de Noé, O1, **PL**, **RR**
Stachys guyoniana Batt., C1-AS3, **PL**
Stachys mialhesii de Noé, A2-K1-K2, **PL**, **PA**
Stachys saxicola* subsp. *chelifensis* Quézel & Simonn., O2, **RR
Teucrium albidum Munby, O3, **PA**, **RR**
Teucrium aureiforme* Pomel, O1, **RR
Teucrium kabylicum Batt., K1-K2-K3, **PL**, **PA**
Teucrium polium subsp. *chevalieri* Maire, SC, **PA**, **RR**
Teucrium santae Quézel & Simonn. ex Greuter & Burdet, O2, **PL**, **RR**
Teucrium thymoides Pomel, AS2-AS3
Thymus guyonii de Noé, H1-H2-SS2
Thymus lanceolatus Desf., O3-A2-H1-H2, **PA**

Malvaceae
Malope malacoides subsp. *asterotricha* (Pomel) Greuter & Burdet, K3-C1-H2-AS3
Malope malacoides subsp. *laevigata* (Pomel) Greuter & Burdet, O2-C1-H2-AS3

Orchidaceae
Dactylorhiza maculata subsp. *battandieri* (Raynaud) Baumann & Künkele, K2, [LC], **PA**, **RR**

Orobanchaceae
Odontites discolor subsp. *ciliatus* (Pomel) Bolliger, K3, **PL**, **RR**
Odontites discolor Pomel subsp. *discolor*, K3, **PL**, **RR**
Pedicularis numidica Pomel, K2, **PL**, **PA**, **RR**

Paeoniaceae
Paeonia algeriensis Chabert, K1-K2, **PA**

Papaveraceae
Corydalis solida subsp. *bracteosa* (Batt. & Trab.) Greuter & Burdet, K1-K2, **PA**
Fumaria capitata* Lidén, A2, **RR
Fumaria dubia Pugsley, O2-A1
Fumaria mairei Pugsley ex Maire subsp. *mairei*, K1, **PL**, **RR**
Fumaria mairei subsp. *saxicola* Lidén, A2, **PL**, **RR**
Fumaria normanii Pugsley, A2, **PA**, **RR**
Rupicapnos africana* (Lam.) Pomel subsp. *africana*, O3, **RR
Rupicapnos africana subsp. *cerefolia* (Pomel) Maire, A1-A2
Rupicapnos africana* subsp. *oranensis* (Pugsley) Maire, O2, **RR
Rupicapnos calcarata* Lidén, AS2, **RR
Rupicapnos longipes* subsp. *aurasiaca* Maire ex Lidén, AS3, **RR
Rupicapnos longipes* (Coss. & Durieu) Pomel subsp. *longipes*, AS3, **RR
Rupicapnos longipes* subsp. *reboudiana* (Pomel) Lidén, C1, **RR
Rupicapnos muricaria Pomel, SS2, **PL**, **RR**

Rupicapnos numidica subsp. *delicatula* (Pomel) Maire, H1-AS2, **PL**
Rupicapnos ochracea Pomel, H2-AS2
Rupicapnos sarcocapnoides (Coss. & Durieu) Pomel, C1, **PA**, **RR**

Pinaceae
Abies numidica Carrière, K2, [CR B1ab(i,ii,iii)+2ab(i,ii,iii)], **PL**, **PA**

Plantaginaceae
Kickxia elatinoides (Desf.) Rothm., O1-H1
Linaria decipiens Batt., K1-K2-C1-AS3, **PL**, **PA**
Linaria parviracemosa D. A. Sutton, K1-K2, **PA**
Plantago atlantica Batt., O3-A2-K1, **PA**

Plumbaginaceae
Limonium afrum* (Pignatti) Domina, O1, **RR
Limonium cyrtostachyum (Girard) Brullo, O1-A1
Limonium gougetianum subsp. *multiceps* (Pomel) Greuter & Burdet, A1, **PL**, **RR**
Limonium letourneuxii (Coss. ex Batt.) Greuter & Burdet, A1, **PL**, **RR**

Poaceae
Agropyropsis lolium (Balansa ex Coss. & Durieu) A. Camus, K2-C1-H1-H2-AS1-AS2, **PL**, **PA**
Avena macrostachya Balansa ex Coss. & Durieu, K1-C1-AS3, **PA**
Corynephorus articulatus* subsp. *oranensis* (Murb.) Maire & Weiller, O1, **RR
Festuca algeriensis Trab., O3-A1-K1-K2-C1-AS3, **PL**, **PA**
Festuca atlantica Duval-Jouve ex Clauson subsp. *atlantica*, A2-K1-K2-C1-AS3, **PA**
Festuca aurasiaca (Trab.) Trab., A1-K1-C1-AS3, **PA**
Festuca djurdjurae (Trab.) Romo, K1, **PA**, **RR**
Festuca trabutii* E. B. Alexeev, C1, **RR
Sorghum annuum (Trab.) Maire, K2, **PL**, **RR**
Stipa atlantica Smirn., K1-AS3, **PA**
Stipa hoggarensis Chrtek & Martinovský, SC, **PA**, **RR**
Tricholemma breviaristatum (Barratte) Röser, H1, **PL**, **RR**
Trisetaria nitida (Desf.) Maire, O2-O3, **PL**
Trisetum flavescens* subsp. *macratherum* (Maire & Trabut) Dobignard, O1, **RR
Vulpia geniculata* subsp. *monanthera* (Maire) Maire, A1, **RR
Vulpia obtusa Trab., K3, **PL**, **PA**, **RR**

Polygalaceae
Polygala rosea Desf., O3, **PA**, **RR**

Polygonaceae
Rumex algeriensis Barratte & Murb. A1-K3, [EN B2ab(iii,v); D], **PL**
Rumex cyprius subsp. *coloratus* Sam., SS1-SS2
Rumex cyprius subsp. *vesceritensis* (Murb.) Sam., AS3-SS2-SC, **PA**

Primulaceae
Cyclamen repandum var. *baborense* Batt. ex Debussche & Quézel, K2, **PL**, **PA**, **RR**

Resedaceae
Reseda tefedestica (Maire) Abdallah & de Wit, SC, **PA**, **RR**

Rosaceae
Potentilla caulescens subsp. *djurdjurae* (Chabert) Romo, K1-K2, **PA**

Rubiaceae
Galium bourgaeanum* Coss. ex Ball subsp. *bourgaeanum*, O3, **RR
Galium numidicum Pomel, AS3, **PL**, **RR**
Galium perralderii Batt., K1-K2, **PL**, **PA**

Saxifragaceae
Saxifraga numidica Maire, K2, **PL**, **PA**, **RR**

Scrophulariaceae
Digitalis atlantica Pomel, K2, **PL**, **PA**, **RR**
Verbascum fontanesii Benedí, O1-O2-O3-A1-A2-K1-K2-K3-C1-AS2
Verbascum pinnatisectum (Batt.) Benedí, O1-H1, **PL**

Willdenowia
Open-access online edition bioone.org/journals/willdenowia
Online ISSN 1868-6397 · Print ISSN 0511-9618 · 2021 Journal Impact Factor 1.460
Published by the Botanic Garden and Botanical Museum Berlin, Freie Universität Berlin