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Moroccan vascular plant Red Data Book: A basic tool for plant conservation*

Abstract

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Morocco's ecosystems, like the ones of the other southern and eastern Mediterranean countries, have been for decades undergoing very harsh anthropo-zoogenic pressure. Threats of regression or even extinction of plant (and animal) species are real and serious. Researchers and decision makers are all encouraged to work hard for the conservation of the national biodiversity. In order to achieve this goal with full knowledge, an inventory of the situation seemed essential. This is how the idea of a Red Data Book emerged.
The project "Red Data Book of the vascular flora of Morocco" is currently very well advanced. A first version was published, between November 2016 and November 2018, in ten fascicles, via the website of the Tela-Botanica Association, in order to collect suggestions, comments and complements from the botanical community.
The Red Data Book deals with all the existing or doubtful plant species in Morocco, whatever their status: natural, naturalized or adventitious. They are classified according to the IUCN Red List Categories (World Union for Nature), slightly amended. For Categories VU (Vulnerable), EN (Endangered) and CR (Critically Endangered) species, the following information is provided: biological type, world distribution and distribution in Morocco.
The Red Data book also provides an updated national floristic inventory, with updated nomenclature and taxonomy.

Key words: vascular flora, inventory, Morocco, IUCN Red List.

Introduction

For decades, the IUCN Red List has provided a global assessment of the threat status of species and their extinction risk and has played a major role in influencing conservation strategies. Many countries have used it as a basis for the preparation of National Red Lists and Books.

*Extended and enriched version of the oral presentation given at the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

The first known list of Morocco, by Sauvage (unpulished list) was distributed by IUCN in 1970s. This list of nearly 500 species, almost all national endemics, remained for a long time the one adopted by the IUCN with very slight modifications.

In 1998 was published a catalog of more than 1600 species, endemics, rare or very rare in Morocco (Fennane & Ibn Tattou 1988). This work has remained up to now the main source of information of threatened flora.

In 2015, were published more details on endemic monocotyledons (Rankou & al. 2015). As research and knowledge advance, the "official" Red List of Morocco is regularly enriched and improved by IUCN on its web page "iucnredlist.org".

The project "Red Data book of the vascular flora of Morocco", object of this article, is also the occasion to draw up an inventory of the national vascular flora at a time when the pressure and the threats on the whole of the biodiversity are more and more intense and a source of major concern.

Alarming context

It is worth noting that Morocco, with a population exceeding 35 millions (Haut Commissariat au Plan 2018), depends heavily on agriculture and livestock. Such dependence combined with the irrational management of plant communities and species, has caused several degradation problems. Over grazing in forests, *Stipa tenacissima* L. steppes and alpine vegetation has led to the vulnerability of many species some of which have become rare and threatened with extinction. It was reported by Ellatifi (2012) that Morocco forest domain was losing about 10.000 hectares per year. As for plant species, preliminary studies showed that over one thousand plant species are either rare or threatened of extinction (Fennane & Ibn Tattou 1998).

The green heritage is subject to strong pressure because of the various ways humans use plants for their survival and wellbeing. For centuries, it has been customary to use plants as a major source for therapy and folk medicine. It is also common to use plants for timber, industrial purposes and as fuel wood and energy as well as utensils in daily life. This wide reliance on plants threatens their sustainability and requires special care and particular attention to make the best and sustainable use of them.

Governance and planning policies and management

The over exploitation of Morocco's natural resources is exacerbated by dubious and unfortunate modes of governance and management. The main ones are:

- Inappropriate modes of exploitation;
- Lack of rigour and firmness in monitoring operating markets;
- Difficulty in controlling and regularizing pastoral activities;
- Predominance of the economic component over the ecological one;
- Absence or low adoption of the ecosystem approach.

Legislation vs Protection and Conservation

Despite the many legislative efforts made during the last decades, overall, legislation for the protection and conservation of national biodiversity remains far behind the quick changing patterns of use and rate of exploitation.

The current state can be summarized as follows:
- Laws in force mainly concern: water, forest estates, agricultural domains, rangelands, hunting and fishing;
- A unique law on protected areas (Loi 19-07, 2010);
- CITES law: national list of protected species (Loi 29-05, 2015), comprising only nine species;
- Absence of regional lists of protected species;
- Absence of national lists of threatened ecosystems and habitats;
- Administrative and executive staff with little or no qualification in floristic competence.

Material and method

The present paper is a summary of a presentation of the finding of a research work leading to the production of a "Red data Book of the Moroccan vascular flora".

New updated data on the Moroccan flora are provided and discussed, especially on endemic, rare or endangered species. They all come from the analysis of ten fascicles prepared in the framework of this project and distributed in digital format by the Tela-Botanica association on its website "tela-botanica.org" between November 2016 and November 2018 (Fig. 1).

Red data Book of the Vascular Flora of Morocco

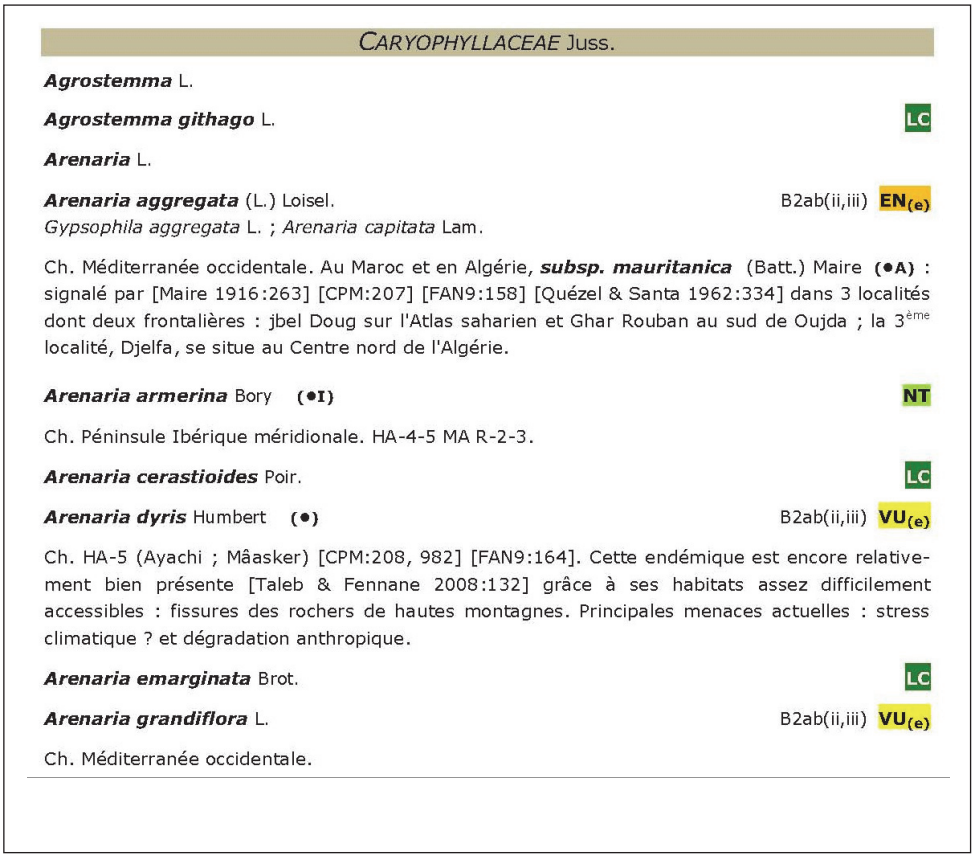
The main features of the projected book are the following:
- All Moroccan vascular flora (indigenous + naturalized + adventitious), including species of doubtful presence covered;
- Updated Nomenclature and Taxonomy;
- IUCN Red List category (IUCN 2012), slightly adapted to the proposals of Fennane & Montmollin (2015); the categories are: EX (Extinct), RE (Regionally Extinct), CR (Critically Endangered), EN (Endangered), VU (Vulnerable), NT (Not Threatened), LC (Least Concern), DD (Data Deficient), NA (Not Applicable);
- Biological type, World distribution and distribution in Morocco for threatened categories (VU, EN and CR);
- Detailed bibliography, especially about geographical distribution.

Quantitative and qualitative analysis

a. Total flora (Figs. 2 & 3, Tables 1 & 2)

The total Moroccan vascular flora is about 4,800 species, including:
- 90 hybrids;
- 298 naturalized or adventitious;
- 482 of doubtful presence;
- 144 of dubious taxonomic status;

The eight richest families (more than 100 species) (Table 2), are the same as those designated in the work of Fennane & Ibn Tattou (2012), namely: *Asteraceae, Fabaceae,*



CARYOPHYLLACEAE Juss.

Agrostemma L.

Agrostemma githago L. LC

Arenaria L.

Arenaria aggregata (L.) Loisel. B2ab(ii,iii) EN(e)
Gypsophila aggregata L. ; *Arenaria capitata* Lam.

Ch. Méditerranée occidentale. Au Maroc et en Algérie, ***subsp. mauritanica*** (Batt.) Maire (•A) : signalé par [Maire 1916:263] [CPM:207] [FAN9:158] [Quézel & Santa 1962:334] dans 3 localités dont deux frontalières : jbel Doug sur l'Atlas saharien et Ghar Rouban au sud de Oujda ; la 3ème localité, Djelfa, se situe au Centre nord de l'Algérie.

Arenaria armerina Bory (•I) NT

Ch. Péninsule Ibérique méridionale. HA-4-5 MA R-2-3.

Arenaria cerastioides Poir. LC

Arenaria dyris Humbert (•) B2ab(ii,iii) VU(e)

Ch. HA-5 (Ayachi ; Mâasker) [CPM:208, 982] [FAN9:164]. Cette endémique est encore relativement bien présente [Taleb & Fennane 2008:132] grâce à ses habitats assez difficilement accessibles : fissures des rochers de hautes montagnes. Principales menaces actuelles : stress climatique ? et dégradation anthropique.

Arenaria emarginata Brot. LC

Arenaria grandiflora L. B2ab(ii,iii) VU(e)

Ch. Méditerranée occidentale.

Fig. 1. Extract from "Eléments pour un Livre rouge de la flore vasculaire du Maroc, Fasc. 5". Edit. Tela-Botanica, january 2018.

Table 1. Number of species* by IUCN Red List Category (* incl. adventitious, naturalized and hybrids).

	NA	DD	LC	NT	VU	EN	CR	RE/EX	Total
Pteridophyta	18	3	29	5	1	8	7	2	73
Gymnospermae	1	-	9	2	3	2	1	-	18
Dicotyledonae	802	284	1536	345	238	266	284	17	3772
Monocotyledonae	262	116	337	62	43	49	67	1	937
Total	1083	403	1911	414	285	325	359	20	4800

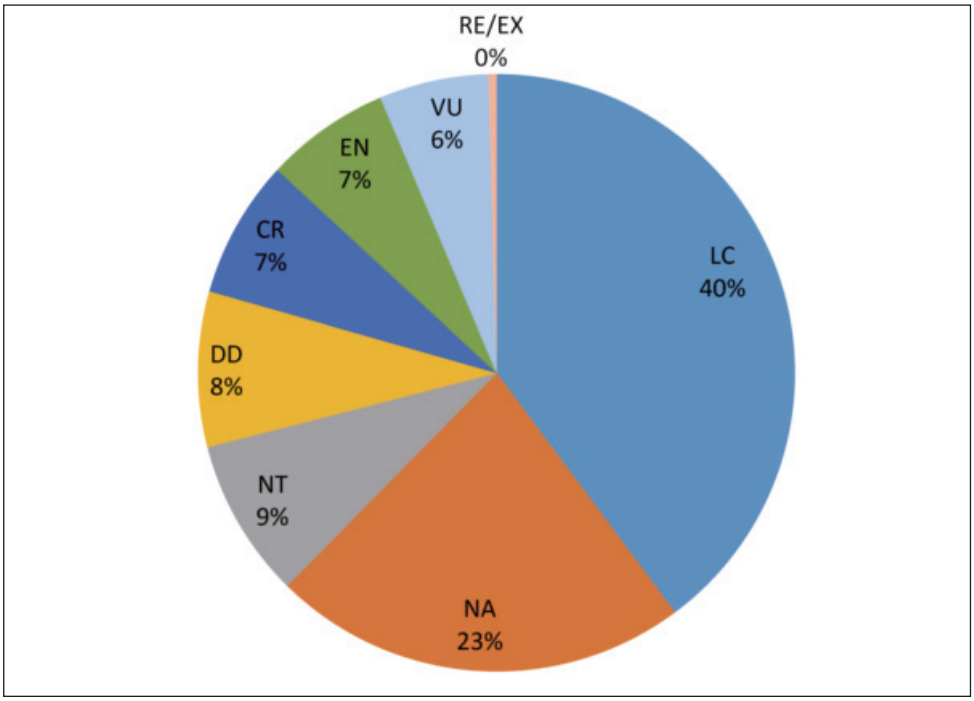


Fig. 2. Percentage of different IUCN Red List Categories.

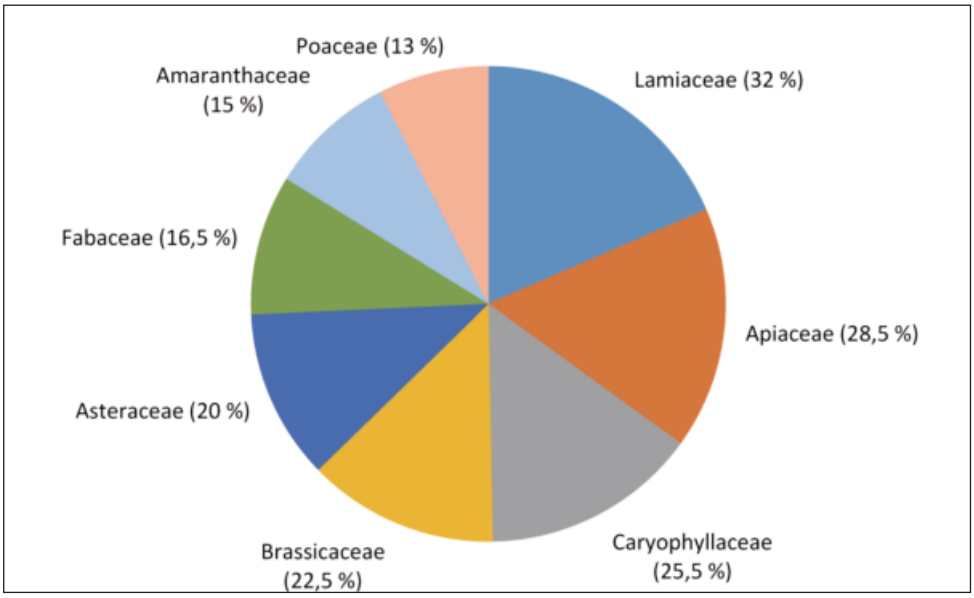


Fig. 3. Percentage of threatened species (VU, EN, CR) in the main families (> 100 sp).

Table 2. Number of species* in the main families (> 100 sp) by IUCN Red List Category (* incl. adventitious, naturalized et hybrids).

	NA	DD	LC	NT	VU	EN	CR	RE/EX	Total
Asteraceae	124	48	276	58	32	53	44	5	640
Fabaceae	107	40	220	41	25	35	21	3	492
Poaceae	136	59	184	29	16	15	31	0	470
Lamiaceae	58	24	59	23	21	26	30	1	242
Brassicaceae	44	13	104	24	24	21	9	1	240
Caryophyllaceae	23	8	115	20	19	18	20	0	223
Apiaceae	30	15	78	10	12	15	26	1	187
Amaranthaceae (incl. Chenopodiaceae)	26	15	53	0	3	7	7	1	112

Table 3. Biological types / IUCN Red List Categories.

	NA	DD	LC	NT	VU	EN	CR	RE	Total
Phanerophytes /Nanophaneroph.	79	20	152	56	35	28	19	1	390
Chamephytes	63	39	162	65	55	59	70	0	513
Hémicryptoph.	177	92	330	106	74	70	113	1	963
Geophytes	79	49	152	29	35	39	36	5	424
Therophytes /Th-bisannuals	248	127	817	93	46	68	60	8	1467
Hydrophytes	19	18	26	10	6	6	7	0	92

Table 4. Number of endemics / IUCN Red List Categories.

Endemics	NA	DD	LC	NT	VU	EN	CR	RE/EX	Total
Moroccco	117	35	56	113	100	141	163	4	729
Morocco + Algeria	35	32	44	37	24	30	29	3	234
Morocco + Iberian Peninsula	61	24	27	36	34	39	43	2	266
Morocco + Algeria + Iberian Peninsula	10	15	78	16	11	11	0	1	142

Poaceae, Lamiaceae, Brassicaceae, Caryophyllaceae, Apiaceae and Amaranthaceae (incl. Chenopodiaceae).

23 % of the species are in the Category NA (Not Applicable): hybrids + adventitious + naturalized + species of dubious presence + species of dubious taxonomic status (Fig. 2).

20 % of native species are threatened (categories VU, EN, CR) (Fig. 2). The *Lamiaceae* are more threatened (32 % the species) (Fig. 3). Members of the *Poaceae* appear to be the least threatened (13 % of species) (Fig. 3).

b. Biological types (Table 3)

The main observations are:

55.7% of therophytes are in the LC category;

35.8% of chamaephytes are threatened (VU, EN, CR);

19.5% of the hydrophytes are insufficiently known (DD).

c. Endemism (Table 4, Figs. 4 to 9)

The main observations are:

55.3% of Moroccan endemic are threatened (VU, EN, CR);

43.6% of Moroccan-Iberian endemics are threatened (VU, EN, CR);

35.4% of Moroccan-Algerian endemics are threatened (VU, EN, CR).

d. Species extincted or presumed extincted (Table 5)

49 species are extincted or presumed extinct:

13 Moroccan endemics;

7 Moroccan-Iberian endemics;

5 Moroccan-Algerian endemics;

12 woody species (Ch, Nph, Ph);

9 geophytes;

28 herbaceous species (Th, Th-b, Hém).

Table 5. Extinct or presumed extinct species.

Family	species	Biological type	Endemism
Pteridaceae	*Paragymnopteris marantae* (L.) K.H. Shing	GR	
Pteridaceae	*Pteris incompleta* Cav.	GR	
Adoxaceae	*Adoxa moschatellina* L.	GR	
Amaranthaceae	*Atriplex rosea* L.	Th	
Apiaceae	*Carum asinorum* Litard. & Maire	Hém	Morocco
Apiaceae	*Carum foetidum* (Batt.) Drude	Hém	Morocco, Algeria, Iberian peninsula
Araliaceae	*Hydrocotyle vulgaris* L.	Th	
Asteraceae	*Andryala atlanticola* H. Lindb.	Th-b	Morocco

Table 5. continued.

Asteraceae	*Andryala maroccana* (Caball.) Maire	Ch	Morocco, Algeria
Asteraceae	*Centaurea ducellieri* Batt. & Trab.	Hém?	Morocco
Asteraceae	*Crepis salzmannii* Babc.	Hém	Morocco, Algeria
Asteraceae	*Cynara tournefortii* Boiss. & Reut.	G	Morocco, Iberian Peninsula
Asteraceae	*Rhaponticum longifolium* (Hoffm. & Link) Soskov	Hém	Morocco, Iberian Peninsula
Boraginaceae	*Echium arenarium* Guss.	Th (Th-b)	
Boraginaceae	*Heliotropium antiatlanticum* Emb.	Ch	Morocco
Brassicaceae	*Maresia nana* (DC.) Batt.	Th	
Caryophyllaceae	*Moehringia glochidisperma* J.M. Monts.-Marti	Hém (GR)	Morocco
Cistaceae	*Halimium ocymoides* (Lam.) Willk	Ch	Morocco, Iberian Peninsule
Cistaceae	*Helianthemum pomeridianum* Dunal	Ch	Morocco, Algeria
Convolvulaceae	*Ipomoea sagittata* Poir.	GR?	
Fabaceae	*Ononis tridentata* L.	Nph	Morocco, Iberian Peninsula
Fabaceae	*Ononis villosissima* Desf.	Th	Morocco, Algeria
Fabaceae	*Trifolium acutiflorum* Murb.	Th	Morocco
Fabaceae	*Trifolium sylvaticum* Gérard	Th	
Fabaceae	*Vicia fairchildiana* Maire	Th	Morocco
Fabaceae	*Vicia leucantha* Biv.	Th	
Gentianaceae	*Centaurium barrelieroides* Pau	Th	Morocco
Hypericaceae	*Hypericum australe* Ten.	Ch	
Lamiaceae	*Clinopodium acinos* (L.) Kuntze	Th Th-b	
Lamiaceae	*Galeopsis angustifolia* Hoffm.	Th	
Lamiaceae	*Glechoma hederacea* L.	Hém	
Lamiaceae	*Marrubium atlanticum* Batt.	Ch	Morocco
Lamiaceae	*Marrubium werneri* Maire	Ch	Morocco
Lamiaceae	*Micromeria brivesii* Batt.	Ch	Morocco
Lamiaceae	*Phlomis italica* L.	Ch, Nph	Morocco, Iberian Peninsula
Lamiaceae	*Sideritis imbricata* H. Lindb. f.	Ch	Morocco
Lamiaceae	*Stachys brachyclada* Noë ex Coss.	Th	
Malvaceae	*Malva microphylla* (E. G. Baker) J. Molero & J.M. Monts.	Th?	Morocco
Menyanthaceae	*Menyanthes trifoliata* L.	HyF (GR)	
Orchidaceae	*Orchis palustris* Jacq.	G	
Poaceae	*Agrostis nebulosa* Boiss. & Reut.	Th	Morocco, Iberian peninsula

Table 5. continued.

Poaceae	*Agrostis nevadensis* Boiss.	Hém	Morocco, Iberian Penisula
Primulaceae	*Cyclamen africanum* Boiss. & Reut.	GT	
Primulaceae	*Lysimachia ephemerum* L.	Hém	
Ranunculaceae	*Ranunculus rectirostris* Coss. & Durieu	Hém	Morocco, Algeria
Rosaceae	*Prunus padus* L.	Nph, Ph	
Rosaceae	*Spiraea hypericifolia* L.	Nph	
Rubiaceae	*Oldenlandia capensis* L. f.	Th	
Scrophulariaceae	*Verbascum densiflorum* Bertol.	Th-b(Hém)	

Practical interest

The analysis of the data of the Red Book of the Moroccan vascular flora presented above, although concise, shows interesting features, that can provide guidance to researchers and decision-makers for the good of the national phytodiversity.

We give here (Tables 6, 7 and 8) those that seem most important to us, with concrete and practical proposals and recommendations for each of the three following levels: Knowledge (Table 6), Exploitation / Valorization (Table 7) and Protection / Conservation (Table 8).

Table 6. Observations and recommendations concerning Knowledge.

Observations	Recommendations
49 extincted or presumed extincted species of Moroccan flora	To check / search in the field
810 species (21 %) threatened: 240 VU ; 275 EN ; 292 CR	Danger and types of threats to be studied
780 sp. (20 %) of NA Category (doubtful taxa, dubious presence, hybrid, naturalized...)	More laboratory research and field investigation
282 sp. (7 %) of DD Category	More laboratory research and fieldinvestigation
362 sp. (57 %) threatened Moroccan endemic: 240 VU ; 275 EN ; 292 CR	More laboratory research and field investigation Specific research on endemics
76 sp. (36 %) Moroccan endemic + threatened Algerian: 20 VU ; 30 EN ; 26 CR	Bilateral work and projects Morocco / Algeria
90 sp. (44 %) Moroccan endemic + Ibérian Peninsula threatened: 26 VU ; 29 EN ; 35 CR	Bilateral work and projects Morocco / Iberian Peninsula

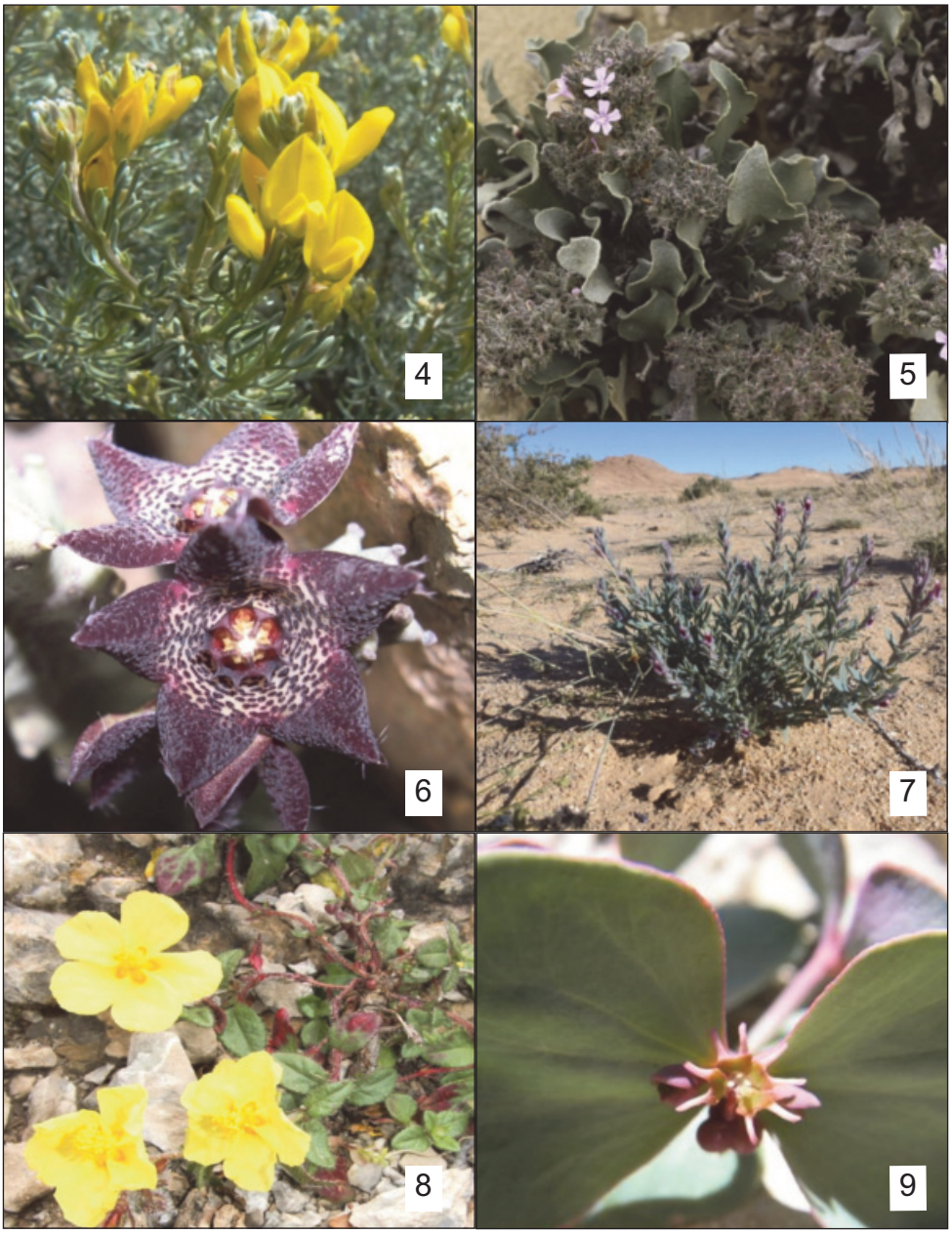


Fig. 4. *Adenocarpus artemisifolius*, Moroccan endemic [CR] (Ph. Msanda).
Fig. 5. *Limoniastrum weygandiorum*, Moroccan endemic [CR] (Ph. Thiaudière).
Fig. 6. *Caralluma joannis*, Moroccan endemic [CR] (Ph. Sébastien).
Fig. 7. *Echiochilon simonneaui*, Moroccan endemic [CR] (Ph. Garcin).
Fig. 8. *Helianthemum grosii*, Moroccan endemic [CR] (Ph. Dobignard).
Fig. 9. *Euphorbia mazicum*, Moroccan endemic [CR] (Ph. Chatelain).

Table 7. Observations and recommendations concerning Exploitation / Valorisation.

Observations	Recommendations
1574 species (41 %) of LC category	Expand exploitation / valorisation operations to LC taxa to ease the pressure on those threatened
362 sp. (57 %) threatened Moroccan endemics	Maximum precaution , rigor and restrictions for exploitation
77 sp. (32 %) of threatened *Lamiaceae* (mainly Aromatic and medicinal plants)	Rigor, organization and control of exploitation ofthe aromatic and medicinal plants

Table 8. Observations and recommendations concerning Protection / Conservation.

Observations	Recommendations
Large number of endangered species (810, i.e. 21%) of all biological types and thus diverse environments Insufficient knowledge of threats dangers and species responses	Ecosystem approach for : - Maximum protection of species - Protect habitats Approach centered around 'key' species, patrimonial, emblematic…
57 % of threatened Moroccan endemics : 292 CR ; 275 EN ; 240 VU.	Priority species for *in situ* and *ex-situ* conservation programs and actions

Conclusion

The Red Data Book of Morocco's vascular flora provides an update of information on the vascular flora of the country in terms of inventory, taxonomy and nomenclature. From this point of view, it is a basic reference for researchers to focus and prioritize their studies.

In terms of management, protection and conservation of biodiversity, this book is a tool at the service of decision-makers for the choice of species and the target regions of programmes and practical actions.

This first version of the Red Data Book could be subject to corrections, additions and modifications. In all cases, this is a work that needs to be regularly reviewed and updated according to the progress of research on the flora, on the one hand, and the evolution of the ranges of the species on the other hand. This cannot be achieved without the support of a large number of motivated and committed researchers in the laboratory and in the field.

Acknowledgment

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