



## **GEMWET PROJECT**

**Conservation and Sustainable Development of High Ecological Value Coastal Wetlands**

### **EVALUATION OF GHAR EL MELH'S TERRESTRIAL FLORA AND ITS HABITAT**



#### **FINAL REPORT**

**Zeineb Ghrabi-Gammar**

Institut National Agronomique de Tunisie (43 Avenue Charles Nicolle, 1082 Tunis)

**Amina Daoud-Bouattour**

Faculty of Sciences of Tunis (University Campus, 1060 Belvedere, Tunis)

**Imtinen Ben Haj Jilani**

Institut National Agronomique de Tunisie (43 Avenue Charles Nicolle, 1082 Tunis)

**R.V. Lansdown**

Ardeola Environmental Services (45 The Bridle, Stroud, Glos., UK, GL5 4SQ)

**Errol Véla**

AMAP - Botany and Modelling of Plant and Vegetation Architecture, University of Montpellier / CIRAD / CNRS / INRAE / IRD (CIRAD, TA A51/PS2, 34398 Montpellier cedex 5, FR)

**2020**

## Contents

<b>1. THE MAIN OBJECTIVES OF THE STUDY</b>	<b>8</b>
<b>2. DELIMITATION AND CONFIRMATION OF THE STUDY AREA</b>	<b>8</b>
<b>3. PRELIMINARY ASSESSMENT OF HABITATS: COLLECTION AND ANALYSIS OF BIBLIOGRAPHICAL DATA</b>	<b>10</b>
<b>3.1. The Phytoecological Map of the study area</b>	<b>11</b>
<b>3.2. “ Sidi Ali El Mekki Coastal Sensitive Zone “ Study</b>	<b>12</b>
<b>3.3. “Expertise on the terrestrial flora of the coastal site of Sidi Ali el Mekki (Ghar el Melh/Raf Raf, Tunisia)” Study.</b>	<b>12</b>
<b>4. METHODOLOGY</b>	<b>14</b>
<b>4.1. Floristic inventory</b>	<b>15</b>
<b>4.2. Identification, description, distribution of the different habitat types</b>	<b>15</b>
<b>4.3. Inventory, distribution and assessment of notable taxa populations</b>	<b>15</b>
<b>4.4. Identification of different types of threats and assessment of the conservation status of habitats</b>	<b>16</b>
<b>5. FLORISTIC DIVERSITY OF THE SITE</b>	<b>16</b>
<b>6. IDENTIFICATION OF THE MAIN HABITAT UNITS: DESCRIPTION AND ASSESSMENT OF THEIR CONSERVATION STATUS</b>	<b>16</b>
<b>6.1. Sandy coastal fringe</b>	<b>17</b>
<b>6.2. The rocky coastal fringe</b>	<b>19</b>
<b>6.3. The semi-natural forest</b>	<b>20</b>
<b>6.4. The garrigue</b>	<b>24</b>
<b>7. NOTABLE TAXA</b>	<b>27</b>
<b>7.1. List of notable taxa</b>	<b>27</b>
<b>7.2. Endemic taxa</b>	<b>27</b>



<b>7.2.1. Endemic taxa Tunisia</b>	<b>27</b>
<b>Limonium intricatum Brullo &amp; Erben</b>	<b>27</b>
<b>Endemic Tunisia</b>	<b>27</b>
<b>Limonium pyramidatum Brullo &amp; Erben</b>	<b>28</b>
<b>Linaria heterophylla Desf. var. dichroa Litard. &amp; Maire</b>	<b>28</b>
<b>Endemic Tunisia?</b>	<b>28</b>
<b>7.2.2. Endemic taxa Algeria-Tunisia</b>	
<b>Allium maghrebinum Brullo, Pavone &amp; Salmeri</b>	<b>29</b>
<i>Bituminaria tunetana</i> C.Brullo, Brullo, Cambria, El Mokni & Giusso	<b>30</b>
<b>Bunium crassifolium Batt.</b>	<b>31</b>
<b>Prospero pulchellum (Munby) Speta</b>	<b>32</b>
<b>Sedum pubescens Vahl.</b>	<b>33</b>
<b>8.1.1. Endemic taxon Tunisia-Libya</b>	<b>34</b>
<b>Malcolmia doumetiana (Coss.) Rouy</b>	<b>34</b>
<b>Endemic Tunisia-Libya***</b>	<b>34</b>
<b>Onopordum platylepis (Murb.) Murb.</b>	<b>35</b>
<b>Endemic Tunisia-Libya</b>	<b>35</b>
<b>8.1.2. Algerian-Tunisian-Sicilian endemic taxon</b>	<b>36</b>
<b>Genista aspalathoides Lam.</b>	<b>36</b>
<b>8.1.3. Endemic taxon</b>	<b>37</b>
<b>Ibiza-Algeria-Tunisia-Lybia?</b>	<b>37</b>
<b>Barnardia numidica (Poir.) Speta</b>	<b>37</b>
<b>8.2. Rare/threatened taxa</b>	<b>38</b>
<b>Muscari maritimum Desf.</b>	<b>38</b>
<b>Rosmarinus officinalis L. var. prostratus</b>	<b>40</b>
<b>Rouya polygama (Desf.) Coincy</b>	<b>41</b>
<b>Satureja barceloi (Willk.) Pau</b>	<b>42</b>
<b>8.3. Bio-indicator taxa</b>	<b>42</b>

8.3.1. Threatened ecosystems bio-indicator taxa	42
<i>Juniperus oxycedrus</i> L. subsp. <i>macrocarpa</i> (Sm.) Ball and J.	
<i>phoenicea</i> L. subsp. <i>turbinata</i> (Guss.) Arcang.	42
<i>Quercus coccifera</i> L. subsp.	44
8.3.2. Biological upwelling bio-indicator taxa	46
<i>Malva subovata</i> (DC.) Molero & J.M. Monts.	46
<i>Teucrium fruticans</i> L.	47
8.3.3. Overgrazing Bio-indicator taxa	47
<i>Asphodelus ramosus</i> L. subsp. <i>Ramosus</i>	47
<i>Calicotome Villosa</i> (Poir.) Link	48
FABACEAE	48
<i>Thymelaea hirsuta</i> (L.)Endl.	49
THYMELEACEAE	49
8.4. Invasive taxa	50
<i>Agave americana</i> L.	50
<i>Carpobrotus edulis</i> (L.) N.E.. Br. var. <i>edulis</i>	51
<i>Opuntia stricta</i> (Haw.) Haw.	52
<i>Oxalis pes-caprae</i> L.	53
9. DISTRIBUTION OF NOTABLE TAXA AND ASSESSMENT OF THEIR POPULATIONS	53
9.1. Endemic taxa	53
9.1.1. Endemic taxa Tunisia	53
<i>Limonium intricatum</i> Brullo & Erben	53
<i>Limonium pyramidatum</i> Brullo & Erben	54
PLUMBAGINACEAE	54
<i>Linaria heterophylla</i> Desf. var. <i>dichroa</i> Litard. & Maire	55
PLANTAGINACEAE	55
9.1.2. Endemic taxa Algeria-Tunisia	56

<i>Bituminaria tunetana</i> C.Brullo, Brullo, Cambria, El Mokni & Giusso	57
<b>FABACEAE</b>	57
<b>Bunium crassifolium Batt.</b>	57
<b>9.1.3. Endemic taxa</b>	58
Tunisia-Libya	58
<b>Malcolmia doumetiana (Coss.) Rouy</b>	58
<b>9.1.4. Endemictaxon</b>	59
Algeria-Tunisia-Sicily	59
<b>Barnardia numidica (Poir.) Speta</b>	60
<b>9.2. Rare/threatened taxa</b>	60
<b>Muscari maritimum Desf.</b>	60
<b>Rosmarinus officinalis L. var. prostratus</b>	60
<b>Rouya polygama (Desf.) Coincy</b>	60
<b>Satureja barceloi (Willk.) Pau</b>	61
<b>9.3. Bio-indicating taxa</b>	61
<b>9.3.1. Threatened ecosystems bio-indicating taxa</b>	61
<b>Juniperus phoenicea L. subsp. turbinata (Guss.) Arcang. and J. oxycedrus L. subsp. macrocarpa (Sm.) Ball</b>	61
<b>Quercus coccifera subsp. Pseudococcifera</b>	61
<b>9.3.2. Biological upwelling bioindicator Taxa</b>	62
<b>Malva subovata (DC.) Molero &amp; J. M. Monts.</b>	62
<b>Teucrium fruticans L.</b>	62
<b>9.3.3. Overgrazing bio-indicator taxa</b>	62
<b>Asphodelus ramosus L. subsp. Ramosus</b>	62
<b>Villosa (Poir.) Link calico.</b>	62
<b>Thymelaea hirsuta (L.)Endl</b>	63
<b>9.4. Invasive taxa</b>	63
<b>Agave americana L.</b>	63

<b>Carpobrotus edulis (L.) N.D. Br. var. edulis</b>	<b>63</b>
<b>Opuntia ficus-indica (L.) Mill.</b>	<b>63</b>
<b>Opuntia stricta (L.) Mill.</b>	<b>64</b>
<b>Oxalis pes-caprae L.</b>	<b>64</b>
<b>10. THREATS</b>	<b>64</b>
<b>10.1. Urbanisation</b>	<b>64</b>
<b>10.2. Uncontrolled tourism</b>	<b>66</b>
<b>10.3. Overgrazing</b>	<b>67</b>
<b>10.4. Agriculture</b>	<b>68</b>
<b>10.5. Fire</b>	<b>68</b>
<b>10.6. Invasion by exotic species</b>	<b>69</b>
<b>11. EVALUATION OF THE CONDITIONS OF SPECIFIC HABITATS CONSERVATION ON WHICH DEPEND NOTABLE TAXA 70</b>	
<b>11.1. Sandy coastal fringe</b>	<b>70</b>
<b>11.2. The rocky coastal fringe</b>	<b>71</b>
<b>11.3. The semi-natural forest</b>	<b>71</b>
<b>11.4. The garrigue</b>	<b>74</b>
<b>12. TRENDS IN FLORISTIC DIVERSITY</b>	<b>75</b>
<b>12.1. Floral richness</b>	<b>75</b>
<b>12.2. Vegetation of the main habitat units identified</b>	<b>77</b>
<b>12.2.1. The pioneer vegetation of the sandy coastal fringe</b>	<b>77</b>
<b>12.2.2. The pioneering vegetation of the rocky coastal fringe</b>	<b>78</b>
<b>12.2.3. Natural forest vegetation</b>	<b>78</b>
<b>12.2.4. The garrigue's vegetation</b>	<b>79</b>
<b>12.3. Heritage plants and vegetation health bio-indicators of the site</b>	<b>80</b>
<b>12.3.1. Tunisian endemics</b>	<b>81</b>
<b>12.3.2. Tunisian-Algerian endemic species</b>	<b>81</b>

<b>12.3.3. Endemic Tunisia Libya</b>	<b>83</b>
<b>12.3.4. Endemic Tunisia-Algeria-Sicily</b>	<b>83</b>
<b>12.3.5. Endemic Ibiza-Algeria-Tunisia-Lybia?</b>	<b>83</b>
<b>12.3.6. Rare and endangered taxa in Tunisia</b>	<b>84</b>
<b>12.3.7. Bio-indicator taxa for the site's vegetation health</b>	<b>84</b>
<b>12.4. Bio-indicating plants for the degradation of vegetation and the natural landscape</b>	<b>86</b>
<b>REFERENCES</b>	<b>88</b>

This report is part of the GEMWET Project “*Conservation and Sustainable Development of High Ecological Value Coastal Wetlands*” conducted in Ghar El Melh-Tunisia. The study region is part of the Key Biodiversity Areas (KBA) of Ghar el Melh located in North-Eastern Tunisia, about 50 km North of Tunis (Fig. 1). Administratively, it is attached to the governorate of Bizerte, and to the delegations of Ghar El Melh (formerly known as Porto

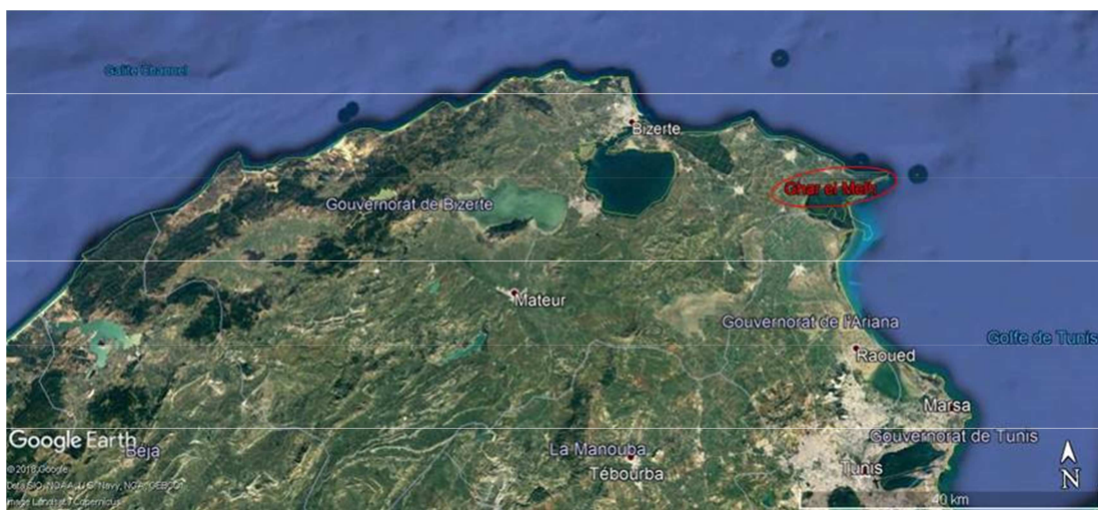


Figure 1. Location of the Ghar el Melh site.

## 1. THE MAIN OBJECTIVES OF THE STUDY

The work carried out mainly concerns the study of notable taxa of the site (endemic, rare, threatened). Having delimited and confirmed the study area, collected and analysed the available bibliographical data, the objective is:

- To identify the different types of habitats in the study area;
- To draw up a complete list of notable taxa;
- To specify their distribution;
- To assess their populations;
- To identify threats;
- To assess the conditions and conservation status of these habitats;
- To collect information on biodiversity trends

## 2. DELIMITATION AND CONFIRMATION OF THE STUDY AREA

The scope of the “*Assessment of the state of the terrestrial flora in Ghar el Melh*” study has been defined in agreement with WW MEDITERRANEAN NORTH AFRICA. It corresponds to the habitats of the spontaneous terrestrial vegetation of the Jbel Ennadhour mountainous massif. J. Eddmina (Figs. 2a, 2b). Their boundaries are:

- \* To the North and South, the foot of the massif delimited by the urbanisation and cultivation zone;
- \* To the East, Ras Ettarf;
- \* To the West, the C69 road.



Figure 2a. Topographic map of the site (taken from the Ghar el Melh NE map, 1/2500)



Figure 2b. Delineation of the study area on aerial background (Google Earth, 2020).

### 3. PRELIMINARY ASSESSMENT OF HABITATS: COLLECTION AND ANALYSIS OF BIBLIOGRAPHICAL DATA

The study area is located in the sub-humid Mediterranean bioclimatic with warm winter variants (INRF 1975).



The flora and vegetation of the study area is known to date through Gounot & Schoenenberger's work on the "Phyto ecological map of Northern Tunisia" (1967), and two other studies carried out on behalf of APAL, the first in 2003, titled "Zone sensible du littoral Sidi Ali Makki", the second in 2008, titled "Expertise on the terrestrial flora of the coastal site of Sidi Ali el Mekki (Ghar el Melh / Raf Raf, Tunisia)" (APAL 2003; Ghrabi-Gammar & Véla 2008)

### 3.1. The Phytoecological Map of the study area

According to sheet 2 (Bizerte) of the phytoecological map drawn up by Gounot & Schoenenberger (1967), the vegetation in the study sector consists of the groupings listed below (Fig. 3).



Figure 3: Distribution of plant groupings in the study zone, according to the phytoecological map (Gounot & Schoenenberger 1967).

In the southern part, on Ghar el Melh side:

- The southern slope of the jbel is covered by the facies with *Thymbra capitata* (= *Thymus capitatus*) of the group with *Ceratonia siliqua*, *Olea europaea*, *Origanum onites* (KE) of the carob-lentisk series. This facies is described as a degraded group where only a few carob trees remain scattered here and there, and is characterised by the abundance of *T. capitata*, *Hyparrhenia sinaica*, and the presence of some *Calicotome villosa* and *Rhamnus lycioides* subsp. *oleoides*.
- The coastal sands, at the foot of the jbel, are fixed by the group *Ammophila arenaria*, *Crucianella maritima* (MB) of the kermes oak series described as very

open and composed in addition to *A. arenaria* and *C. maritima*, *Achillea maritima* (= *Diotis maritima*), *Crithmum maritimum*, *Eryngium maritimum*, *Euphorbia paralias*, *Lotus cytisoides* (= *L. creticus* subsp. *cytisoides*), *Medicago marina*, *Pancratium maritimum*, *Polygonum maritimum*, and in the hollows of the dunes richer in water, *Imperata cylindrica* is associated with *Juncus acutus* and *J. mariti*

In the northern part, on Raf Raf's side;

- On the northeastern slope, the sharp seafront dunes are also fixed by the pioneer group *Ammophila arenaria*, *Crucianella maritima* (MB), of the Kermes oak series, described above.

### **3.2. “ Sidi Ali El Mekki Coastal Sensitive Zone “ Study**

This study (APAL 2003) is only interested in Sidi Ali El Mekki's part of the massif (Sidi Khalifa-Jbel Eddmina-Ras Ettarf), and does not take into account neither the northern slope (Raf-Raf side) nor the Jbel Ennadhour. It lists the 81 species (except “cultivated species and weeds”) encountered in May 2001, in the coastal zone of the study area.

The authors subdivide the study area into three sectors based mainly on topography and vegetation structures, which they briefly describe, and list the main species:

- The coastal fringe with mobile or semi-fixed dunes and dunes fixed by plantations or natural vegetation;
- The rocky coastal fringe ;
- The mountain range.

### **3.3. “Expertise on the terrestrial flora of the coastal site of Sidi Ali el Mekki (Ghar el Melh/Raf Raf, Tunisia)” Study.**

This study (Sharabi-Grammar & Véla 2008) takes into account the northern and southern slopes of the entire peninsula of Sidi Ali el Mekki, a sort of natural extension of Jbel Ennadhour, to the East of a virtual line linking Raf-Raf beach to Ghar el Melh beach. It presents the data collected during spring (2007) and autumn (2008) surveys, as well as a few free outings carried out in May 2001.

Based on the topography and vegetation structures, the authors define the following areas, without describing the corresponding vegetation:

- The rocky or sandy coastal fringe (mobile or semi-fixed dunes) ;
- The southern slope of the mountain range, alternating sandy areas (flattened dunes, with reforestation and/or natural vegetation) and rocky areas (natural vegetation) ;
- The summit ridge of the mountain massif, composed of a ridge where rocky outcrops (frequent) and sandy veneers (rare) alternate, and which surmounts a quasi-continuous rocky bar (north-facing) ;
- The northern slope of the mountainous massif, essentially made up of immense sandy veneers (fixed by plantations or natural vegetation).

More than 230 taxa belonging to terrestrial vascular plants have been identified, but the complete list has not been published. However, through this study, the authors highlight three groups of important plants: heritage species (endemic and/or rare), species indicating the state of health of the environment, and exotic species. These taxa are all listed, and their endemic or rare status, as well as their level of abundance and their location on the site are specified. These are:

- Heritage species :

-

- *Linaria* “*cossoni* Baratte” (mistakenly indicated as *L. heterophylla* var.
- *dichroa*, cf. *infra*): strict endemic of northeastern Tunisia ;
- *Malcolmia doumetiana* (Cosson) Rouy (= *Maresia doumetiana*): endemic of Tunisia and Tripolitania (NW-Libya) ;
- *Genista aspalathoides* Lam. Endemic of Sicily and Numidia (from El Kala to Cape Bon) ;
- *Thapsia polygama* Rouy (= *Rouya polygama*) : endemic of Corsica-Sardinia and Numidia (from El Kala to Sousse) ;
- *Muscari maritimum* Desf. : endemic of the Maghreb (from Melilla to Benghazi) ;
- *Scilla lingulata* Poir. (= *Hyacinthoides lingulata*): endemic of the Maghreb (from Morocco to Tunisia) ;
- *Satureja barceloi* (Willk.) Pau (= *Micromeria inodora*): a southwestern Mediterranean species with a disjunct range, isolated in Sidi Ali el Mekki, the only Tunisian locality, and therefore very rare in the country;
- *Rosmarinus officinalis* var. *prostratus* (= var. *laxiflorus*, var. *palaui*): south-western Mediterranean variety with a disjointed area, present from the Gulf of Naples to the Strait of Gibraltar ;
- Species indicating the environment’s state of health: *Quercus coccifera* subsp. *pseudococcifera*, *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa* ;
- Exotic species more or less widespread on the site: *Oxalis pes-caprae* (= *O. cernua*), *Agave americana*, *Carpobrotus* sp., *Opuntia* sp. and exotic species or simply species not native to the site, planted for reforestation to fix the sand: *Acacia cyanophylla* and *A. cyclops*, *Pinus pinea* and *P. pinaster*, and certain strains of *P. halepensis*.

#### 4. METHODOLOGY

Three field missions carried out in all types of habitats over the entire study area (more than 50 sites prospected), allowed to collect the data. The three missions were carried out according to the following schedule:

<b>Missions</b>	<b>Date</b>	<b>Participants</b>
Mission 1	06-09 June 2019	- Tunisian team
Mission 2	10-12 July 2019	Tunisian team Richard V. Lansdown, in charge of developing a biodiversity monitoring strategy for Ghar el Melh
Mission 3	5-7 November 2019	Tunisian team R.V. Lansdown, responsible for the development of a biodiversity monitoring strategy for Ghar el Melh Errol Véla, botanist at the University of Montpellier

The objectives of these surveys were:

- To get an overview of the site's flora and vegetation;
- To delineate the study area with more precision;
- To draw up an exhaustive list of the taxa which develop on the site between June and November;
- To identify the different types of terrestrial habitats, to locate them and to assess their conservation status, focusing in particular on the specific habitats on which depend notable taxa;
- To detect, especially, and as far as possible, where the vegetation of the site is best preserved in Sidi Ali el Mekki;
- To also explore the large western half of the site, with sectors yet unstudied in previous works;

- To complete the exhaustive list of notable taxa, to specify their distribution and to evaluate their populations;
- To identify the threats to habitats, vegetation and significant flora;
- To collect information on biodiversity trends.

#### 4.1. Floristic inventory

All taxa were recorded at each surveyed site. Most of them were identified in the field. In the case of complex taxonomic groups, samples were taken to the laboratory for determination or verification.

The taxonomic and nomenclatural status selected for all this work is the *commented Synonymic Catalogue of the Flora of Tunisia* (Le Floc'h et al. 2010), and the *Synonymic Index of the Flora of North Africa* (Dobignard & Chatelain 2010- 2013). All the collected samples are deposited and preserved at the INAT herbarium (Tunis).

A list of all the vascular taxa encountered during the three missions was drawn up.

#### 4.2. Identification, description, distribution of the different habitat types

The different types of terrestrial habitats were identified in agreement with R.V. Lansdown, who is responsible for the development of a biodiversity monitoring strategy for Ghar el Melh, and E. Véla, botanist at the University of Montpellier. They have been established according to the substrate, the vegetation and the state of its conservation.

The distribution of each terrestrial habitat type was specified, using field data, as well as current Google Earth satellite imagery to delineate units of equal appearance and converted into vegetation types associated with a habitat type.

A map of the distribution of habitats was also drawn up.

#### 4.3. Inventory, distribution and assessment of notable taxa populations

The list of notable taxa was set up according to the following criteria:

- Endemic: taxa **strictly endemic to Tunisia** but also endemic to neighbouring countries, have been selected;
- Rare/threatened: **rare/threatened** taxa have been selected for **Tunisia**;
- Indicators of threatened ecosystems: woody species have been selected whose presence, abundance, state of conservation of individuals, and level of regeneration, are indicative of the **ecosystem's state of health**;
- Indicators of overgrazed ecosystems: taxa not eaten by livestock were selected, being thorny or toxic, their **abundance is an indicator of overgrazing**;

- Indicators of biological recovery: taxa indicating a trend towards **environment and natural vegetation regeneration** were selected;
- Introduced and invasive: exotic taxa, introduced by man in gardens or to protect plots of land for cultivation, were selected, which are now **invading all habitats**.

Each notable taxon has been described (Cuénod 1954; Pottier-Alapetite 1979-1981; Sharabi-Grammar & Véla 2008).

The distribution area of each notable taxon present on the site during the investigation, was specified in the survey. A distribution map was drawn for each notable taxon.

An assessment of the populations of notable taxa in each habitat type was estimated, using the following indices: *0, absent taxon; 1, sparse; 2, fairly abundant; 3, abundant*.

#### **4.4. Identification of different types of threats and assessment of the conservation status of habitats**

The different types of threats have been identified on all the prospected sites.

We have also tried to assess the level of these threats, and to determine their seniority.

The conservation status of each type of terrestrial habitat was estimated, based on the structure and floristic composition of its plant communities, on the notable species selected, and on the importance of the impact of the main threats to these habitats.

### **5. FLORISTIC DIVERSITY OF THE SITE**

260 taxa belonging to 69 families and 195 genera of vascular terrestrial flora have been inventoried on the site ([Annex1](#)), 11 of which are taxa exotic to Tunisia, and more or less naturalised. To be exhaustive, this list must be completed by spring surveys.

### **6. IDENTIFICATION OF THE MAIN HABITAT UNITS: DESCRIPTION AND ASSESSMENT OF THEIR CONSERVATION STATUS**

During field surveys carried out in the study area, and in agreement with R.V. Lansdown and E. Véla, four main habitat types were identified: i) sandy coastal fringe, ii) rocky coastal fringe, iii) semi-natural forest and iv) garrigues ([Fig. 4](#)). The location and description of these habitats, particularly from a phytoecological and dynamic point of view, the assessment of their conservation status, and the potential threats that may weigh on these taxa, are also indicated





Frange littorale sableuse 
 Frange littorale rocheuse 
 Forêt semi-naturelle 
 Garrigue

*Sandy coast fringe  
natural forest*

*Rocky coast fringe*

*Semi*

*Figure 4. Location of the different habitat types on the study site.*

### **6.1. Sandy coastal fringe**

This habitat consists mainly of beach shreds and the sharp dunes located at the foot of the southern slope and running along it from the car park of Sidi Ali el Mekki beach to Ras Ettarf (Fig. 5). The characteristic grouping associated with this type of habitat is very open, composed of pioneer, sand-binding species, including *Ammophila arenaria*, *Aeluropus litoralis*, *Cakile maritima*, *Elymus farctus* subsp. *farctus*, *Eryngium maritimum*, *Crithmum maritimum*, *Euphorbia paralias*, *Lotus creticus*, *Medicago marina*, *Polygonum maritimum*, *Salsola kali*, *Crucianella maritima*, *Cyperus capitatus*, *Pancratium maritimum*..., as well as the rare and endangered species, *Rouya polygama*.



*Figure 5: Sandy coastal fringe (Sidi Ali el Mekki). At the front, a grouping of pioneer psammophilic taxa; behind it, dunes in the process of fixation thanks to *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa*.*

This habitat also includes taller dunes that are becoming fixed thanks to the development of *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa* as trees or shrubs, *Retama raetam* subsp. *bovei*, *Quercus coccifera* subsp. *pseudococcifera*. In addition to these species, there are also beautiful plants of *Ephedra fragilis* subsp. *fragilis* and *Pistacia lentiscus*. At the foot of these woody plants are the aforementioned psammophilic herbaceous plants, as well as *Dianthus sylvestris* subsp. *siculus*, *Delphinium verdunense*, the Tunisian-Lybian endemic *Malcolmia doumetiana*, *Scrophularia sambucifolia* subsp. *mellifera*, *Pseudorlaya pumila* var. *pumila* (= *Orlaya maritima*). At the foot of the southern slope of Sidi Ali el Mekki, and more particularly near the anarchic constructions and the track where the dune is heavily cut, several large juniper trees are seriously weakened, or even threatened with extinction, due to the destruction of an important part of their root system (Fig.6)



*Figure 6. A fine specimen of *Juniperus oxycedrus* subsp. *macrocarpa* which has been greatly weakened by the destruction of its root system (Sidi Ali el Mekki).*



In addition, some species have been introduced in order to further fix these maritime dunes (Fig. 7): *Acacia saligna* (= *A. cyanophylla*), *A. cyclops*, *Pinus pinea*, *P. pinaster*, as well as *Carpobrotus edulis* which has been planted near dwellings and frequented beaches, where this species had an invasive behaviour.



Figure 7. Dune fixation by plantations of *Acacia saligna* and *A. cyclops* (Sidi Ali el Mekki).

## 6.2. The rocky coastal fringe

The rocky coastal fringe forms the extreme southeastern end of the Ras Ettarf Peninsula. It is the characteristic habitat of the Mediterranean sea cliffs, described in CORINE (Bissardon et al. 1997). At the intertidal level, vegetation is absent, whereas higher up, the more or less sandy rocky soil is colonised by sparsely distributed *aerhaline chasmophyte* species (Fig.8). The most characteristic of these are the Tunisian endemics *Limonium intricatum* and *L. pyramidatum*, as well as the Mediterranean *L. virgatum*, *Crithmum maritimum*, *Limbarda crithmoides* subsp. *longifolia* (= *Inula crithmoides*), *Pallenis maritima* (= *Asteriscus maritimus*) to which are added *Plantago macrorhiza* (= *P.coronopus* subsp. *macrorhiza*) on the sand and *Rouya polygama*. Further up, at the upper limit of this habitat, this vegetation mixes with the low woody plants (*Pistacia lentiscus*, *Calicotome villosa*...) of the semi-natural forest.



Figure 8. Rocky coastal fringe at Ras Ettarf, where the two Tunisian endemics *Limonium intricatum* and *L. pyramidatum* develop.

### 6.3. The semi-natural forest

It is a semi-natural forest background, reforested in places by *Acacia saligna*, *A. cyclops*, *Pinus halepensis*, *P. pinea*, *P. pinaster*. It develops on limestone soil, mainly on the southern and northern slopes of the J. Eddmina.

On the southern slope, the forest is dense, except for a vast burnt area (July 2010) located above the marabout, Sidi Ali el Mekki (Figs. 9a, 9b). It is dominated by a tree-like stratum, consisting mainly of *Pinus halepensis* associated with *Juniperus phoenicea* subsp. *turbinata*. These woody trees are mixed in different places with exotic species: *Acacia saligna*, *A. cyclops* and *Pinus pinaster*. *P. halepensis* is in this native area, but this species has also been planted, and is therefore found mixed with strains foreign to the site.

The undergrowth consists notably of *Quercus coccifera* subsp. *pseudococcifera*, *J. oxycedrus* subsp. *macrocarpa*, *Pistacia lentiscus*, *Phillyrea media*, the Algerian-Tunisian-Sicilian endemic *Genista aspalathoides*, *Rhamnus lycioides* subsp. *oleoides*, *Smilax aspera*, *Erica multiflora*, *Calicotome villosa*, *Retama raetam* subsp. *bovei*, *Teucrium fruticans*, *Prasium majus*, *Ruta chalepensis*, *Asparagus acutifolius*, *Rubia peregrina*, *Galium lucidum*, and associated with thermophilic taxa: *Rosmarinus officinalis* var. *officinalis*, *Thymbra capitata*, *Thymus algeriensis*, *Cistus salviifolius*, *C. creticus* subsp. *eriocephalus* (= *C. villosus*), *C. clusii*. (= *C. libanotis*), *Globularia alypum*, Rock Phagnalon, the rare and endangered taxon *Satureja barceloi*, *Teucrium capitatum*, *Helichrysum conglobatum*, *Fumana laevipes*, *F. scoparia*, *F. thymifolia*, *F. viridis*, *Helianthemum syriacum* subsp. *thibaudii* (= *H. lavandulifolium*)... A large number of plants of *Opuntia stricta* have infiltrated the natural vegetation.

Finally, the herbaceous stratum is diverse: *Brachypodium retusum* (= *B. ramosum*), *Cutandia divaricata*, *Blackstonia perfoliata* subsp. *grandiflora*, *Centaureum erythraea* subsp. *grandiflorum*, *Anthyllis vulneraria*, *Ajuga reptans*, *Hedysarum spinosissimum* subsp. *capitatum*, *Linum usitatissimum* subsp. *angustifolium* (= *L. bienne*), *L. strictum* subsp. *spicatum*, *Briza maxima*, *Dactylis glomerata* subsp. *hispanica*, *Coris monspeliensis*....



*Figure 9a. Dense semi-natural forest on the southern slope of Sidi Ali el Mekki.*



*Figure 9b. Burnt sector (July 2010) of the natural forest of Sidi Ali el Mekki.*

At the foot of J. Eddmina, behind the beach of Sidi Ali el Mekki, and close to the houses, this forest is enriched by very large and beautiful *Quercus coccifera* subsp. *pseudococcifera* trees, some of which are partially uprooted, bearing witness to a forest that probably was once remarkable (Fig.10)





Figure 10. Very beautiful *Quercus coccifera* subsp. *pseudococcifera* trees, behind the beach of Sidi Ali el Mekki, and close to the houses.

To the west of the peninsula of Sidi Ali el Mekki, the forest is getting more sparse and fragmented. The threatened ecosystem bio-indicator taxa, the juniper and kermes oak, become more and more scattered, disappearing in some places where the forest is then clearly dominated by *Pinus halepensis*.

To the west of Ennjila, on the J. Ennadhour, the forest remains only in the valleys. On the other hand, and at several points on the southern slope, there are degraded remnants of an old higher forest, including, here and there, a few well-developed trees of *Ceratonia siliqua* and *Quercus coccifera* subsp. *pseudococcifera*, some of which have persisted on private land. The floristic composition of the undergrowth and the herbaceous stratum of this forest is the same as elsewhere.

On the crest of this sector alternate rocky outcrops dominated by *Pinus halepensis*, associated with thermophilic low woody plants (mainly *Rosmarinus officinalis* var. *officinalis*, *R. officinalis* var. *prostratus*, *Thymbra capitata*, *C. creticus* subsp. *eriocephalus*, *Globularia alypum*, Rock Phagnalon, *Satureja barceloi* and *Teucrium capitatum*) and areas of sandy veneers most often dominated by plantations of *Acacia cyclops*. which form either monospecific feet or are associated with *Retama raetam* subsp. *bovei* and the rare taxon *Rouya polygama*.

The forest cover on the southern slope is interrupted by several firebreaks where the ground is often skeletal and crusted (Fig. 11), and where low vegetation grows consisting mainly of *Brachypodium ramosum*, *Hyparrhenia sinaica*, *Stipa tenacissima* and thermophilic shrubs develops: *Thymbra capitata*, *Rosmarinus officinalis* var. *prostratus*, *Cistus creticus*, *C. salviifolius*, *Satureja barceloi*, *Fumana scoparia*, Rock Phagnalon, *Globularia alypum*..



*Figure 11. Firebreak interrupting the forest cover at Sidi Ali el Mekki. On the left, the natural forest, on the right, a plantation of Pinus pinea.*

On the northern side of the massif, on Raf Raf side, the semi-natural forest is dense and relatively well preserved because of the very steep slope.

At the bottom of the slopes, particularly towards the west, cultivated plots of land, dotted with remnants of the forest, form a mosaic of spontaneous vegetation.

Finally, the plated dunes are fixed by a huge plantation of *Pinus pinea* in the northeast of the peninsula (Fig. 12).



*Figure 12. Reforestation of the dunes by a huge plantation of Pinus pinea behind Ghar el Melh beach.*

#### **6.4. The garrigue**

Pastoralists and farmers had long been clearing the Mediterranean forest to provide better pasture for their livestock and gain more land for cultivation (Le Houérou 1980). These traditional practices have led to the long-term degradation of the natural forest, which has been replaced, over a large part of the study site, by garrigues, scattered in places, with a few trees that survived anthropisation: *Pinus halepensis*, *P. pinaster*, *Juniperus phoenicea* subsp. *Turbinata* *Cerantonia siliqua*. This garrigue is made up of the whole woody undergrowth cortège: *Quercus coccifera* subsp. *pseudococcifera*, *Pistacia lentiscus*, *Phillyrea media*, *Rhamnus lycioides* subsp. *oleoides*, *Erica multiflora*, *Genista aspalathoides*..., and more particularly the heliophilic and thermophilic taxa, namely *Rosmarinus officinalis* var. *officinalis*, *Thymbra capitata*, *Globularia alypum*, Rock Phagnalon, the rare and endangered taxon *Satureja barceloi*, and the various species of *cistus*, *heliantha*, and *Fumana*. The herbaceous stratum of the semi-natural forest can also be found here: *Brachypodium ramosum*, *Hyparrhenia sinaica*, *Stipa tenacissima*... This garrigue is particularly rich in species that are not edible because they are thorny (*Calicotome villosa*, the endemic Algerian-Tunisian-Sicilian *Genista aspalathoides*) or poisonous (*Asphodelus ramosus*, *Thymelaea hirsuta*, *Drimia numidica*, *Daphne gnidium*), indicating chronic and often intense grazing

The garrigue covers the entire southern slope of Jbel Ennadhour, the crest of the mountain range near the semaphore above the village of Ghar el Melh, as well as several sectors of the northern slope where the less steep slope allows access to cattle.

On the southern slope, the scrubland is low and clear, still rich in species indicative of overgrazing, although this activity seems to have ceased in most of this area. Notable taxa, *Genista aspalathoides* and *Satureja barceloi* are abundant here, a few individuals of



the Algerian-Tunisian endemic, *Bunium crassifolium* and *Prospero pulchellum* are growing here and there, and only a few feet of the Algerian-Tunisian endemic, *Sedum pubescens*, have been observed in this sector, especially above the restaurant Le Pirate. *Capparis spinosa*, absent in the forest, is regularly found on rocky outcrops. Above the Chedli café, in Ghar el Melh, there are about twenty feet of *Euphorbia dendroides*, the only site where this taxon has been observed in the massif. Scattered all along the southern slope, several large specimens of *Agave americana*, *Opuntia ficus-indica* and *O. stricta*, exotic taxa, which have become sub-spontaneous and contribute to modifying the natural landscape of this area.

On the ridge of J. Ennadhour, above the village of Ghar el Melh (semaphore level), the garrigue is very bushy and dense. Strong traces of grazing indicate a resumption of grazing. This garrigue is characterised, among other things, by beautiful shrubs of *Quercus coccifera* subsp. *pseudococcifera*, dense populations of *Genista aspalathoides* and *Satureja barceloi*, as well as several individuals of *Rosmarinus officinalis* var. *prostratus*. In open areas, the lawn settles as a result of clearing, excessive trampling of the soil and fertilisation by cattle excrement (Fig. 13). A herbaceous carpet develops, including bulbous plants: *Hyacinthoides lingulata* (= *Scilla lingulata*), *Drimia purpurascens* (= *Urginea undulata*), *Ambrosina bassii*, and a few individuals of the Algerian-Tunisian endemics *Allium maghrebinum*, *Barnardia numidica* and *Bunium crassifolium*, and a large population of *Prospero pulchellum*



Figure 13. Dense garrigue on the crest of the J. Ennadhour at the semaphore, dotted with sectors cleared and packed by the trampling of livestock where notable bulbous plants settle: *Allium maghrebinum*, *Barnardia numidica*, *Bunium crassifolium*, *Prospero pulchellum*.

Finally, on the northern slope, the garrigue is relatively high and dense, except for the housing lots by Raf Raf beach, and especially above the Dar Hmouda douar, strongly marked by a current intense grazing (Fig. 14). The low, clear vegetation is totally devoid of kermes oak and juniper, but consists mainly of thorny shrubs (*Calicotome villosa*, *Genista aspalathoides*), of taxa poisonous to livestock (*Asphodelus ramosus*, *Thymelaea*

*hirsuta*, *Drimia numidica*, *Daphne gnidium*), and small heliophilic and thermophilic bushes: *Erica multiflora*, *Satureja barceloi*, *Cistus creticus* subsp. *eriocephalus* and *C. salviifolius*.



*Figure 14. Low and clear sgarrigue on the southern slope dotted with a few Aleppo pines, and low and dense, marked by shifting grazing (northern slope, Dar Hmouda douar).*



## 7. NOTABLE TAXA

### 7.1. List of notable taxa

A total of 26 notable taxa were selected for the study site ([Appendix 2](#)):

- 12 endemic taxa: Tunisia (3); Algeria-Tunisia (5); Tunisia-Libya (2); Algeria-Tunisia-Sicily (1); Ibiza-Algeria-Tunisia-Libya? (1) ;
- 4 rare and endangered taxa in Tunisia;
- 8 bio-indicator taxa: of threatened ecosystems (3); of biological upwelling (2) ; overgrazing (3) ;
- 5 invasive taxa.

### 7.2. Endemic taxa

#### 7.2.1. Endemic taxa Tunisia

##### *Limonium intricatum* Brullo & Erben

PLUMBAGINACEAE

##### *Endemic Tunisia*

Brullo & Erben collected this taxon for the first time on 27 August 1984 on the rocky coast on the south side of Ras Ettarf at Sidi Ali El Mekki, and on 31 August 1984 on greasy rocks along the northwest coast of Raf Raf village ([Brullo & Erben 1989](#)). These authors have classified it as endemic to Tunisia, and Plants of the World Online acknowledges it as such. It was also reviewed by E. Véla (pers. obs. 2008), at the bottom of the northern slope of the Jbel Eddmina, as well as on the coastal path in the same sector ([Fig. 15](#)).



*Figure 15. Limonium intricatum* Brullo & Erben (*Plumbaginaceae*), Tunisian endemic taxon

## **Limonium pyramidatum Brullo & Erben**

PLUMBAGINACEAE

Endemic Tunisia

Brullo & Erben, collected this taxon on 27 August 1984, on the rocky limestone coast on the south side of Ras Ettarf, Sidi Ali El Mekki; and on 28 August 1984, on the rocky west coast of Cap Blanc in direction of the semaphore. These authors classified this taxon as endemic to Tunisia, and Plants of the World Online also recognises it as such. [Brullo & Erben \(1989\)](#) also identified it from the collections of Barratte, on Ile Plane, on 31 May 1888, and those of Barratte & Cosson and Barratte & Duval on Ile des Chiens, on 9 and 31 May 1888 respectively (Fig. 16).



*Figure 16. Limonium pyramidatum Brullo & Erben (Plumbaginaceae), Tunisian endemic taxon (photo: E. Véla).*

## **Linaria heterophylla Desf. var. dichroa Litard. & Maire**

= *L. multicaulis* (L.) Mill. subsp. *heterophylla* (Desf.) D.A.Sutton, pro parte  
PLANTAGINACEAE

Endemic Tunisia?

[René Maire](#), in his contributions ([1932](#)), published a *Linaria heterophylla* var. *dichroa* Lit. & Maire, which remained unknown in later flores and catalogues ([Véla et al. in prep.](#)). Indeed, for [Dobignard & Chatelain \(2010-2013\)](#) and Plants of the World Online, this taxon is included in *L. multicaulis* subsp. *heterophylla*, whereas Le [Floc'h et al. \(2010\)](#) make no mention of the var. *dichroa*.

This taxon now needs to be re-evaluated, and would probably deserve, within the *L. heterophylla/L. multicaulis* complex, the same rank of subspecies as the many other recognised taxa. In this respect, it would probably be an endemic of the dune complexes northeastern Tunisia, and therefore rare and threatened on a global scale. We regularly

observe it in the dunes and sandy veneers of the southern and northern slopes of the Jbel Eddmina as far as Rass Ettarf (Fig. 17)



Figure 17. *Linaria heterophylla* Desf. var. *dichroa* Litard. & Maire (Plantaginaceae), Tunisian endemic taxon, (right photo E. Vêla)

### 7.2.2. Endemic taxa Algeria-Tunisia *Allium maghrebinum* Brullo, Pavone & Salmeri

= *A. cupanii* Raf, pro parte

AMARYLLIDACEAE

Endemic Algeria-Tunisia

Cuénod (1954) reports two varieties for *A. cupani* in Tunisia: var. *typicum* Maire (Tunisia: Cap Bon, Dorsale Tunisienne, Central Tunisia, South Tunisia; in the world: from Italy to Asia Minor, Iran, Algeria, Morocco), and var. *hirtovaginatatum* (Kunth) Halacsy (Tunisia: Dorsale Tunisienne, Central Tunisia; in the world: Greece, Algeria, Morocco). It indicates that the species grows on mountain slopes and wadi beds, and flowers from May to October (Fig.18).

Le Floc'h et al (2010), based on the work of Garbari et al (1979), *A. hirtovaginatatum* retained it for Tunisia, while indicating that *A. cupani* subsp. *cupani* would be limited to the mountains of Sicily, southern Italy, the Balkans and southwestern Anatolia, a position followed by Dobignard & Châtelain (2010-2013).



Since then, [Brullo et al \(2015\)](#) have described *A. maghrebinum* as the true Tunisian and East Algerian taxon (status approved by Plants of the World Online) without mentioning a 2<sup>nd</sup> taxon, whose presence remains to be proven and whose identity needs to be specified. Beyond this range, whose western limit (in Algeria) is not precisely known, the species appears widespread and rather abundant, in an otherwise frequent habitat little degraded on the whole by reasoned pastoralism (E. Véla, pers. obs. 2019)



*Figure 18. Allium maghrebinum* Brullo, Pavone & Salmeri (Amaryllidaceae), endemic Algerian-Tunisian taxon (photos E. Véla, flowers and fruits obtained in culture, from the neighbouring Jbel Korbous)

***Bituminaria tunetana* C.Brullo, Brullo, Cambria, El Mokni & Giusso**  
FABACEAE

Endemic Algeria-Tunisia

*Bituminaria tunetana* is a new species in Tunisia reported by [Brullo et al \(2017\)](#). According to these authors, it can be distinguished from *B. butiminosa*, the only species of this genus known for Tunisia ([Pottier-Alapetite 1979](#); [Le Floc'h et al. 2010](#); [Dobignard & Châtelain 2010-13](#)) particularly by its leaves, characterised by scattered and non-hairy hairs, and its corolla of a pink-lilac colour, 13-14 mm long, longer than the calyx and the pod (including its beak) 13.5-14.5 mm long, with a 9-10 mm long beak

(Fig. 19). Its distribution in Tunisia was determined from recent (2015) collections made near Tunis, and older collections material of the northeastern herbarium of Tunisia, the Tunisian Dorsale, central and southern Tunisia (Brullo et al. 2017).

This species, considered by Brullo et al. (2017) as endemic to Tunisia, has been observed in Algeria (E. Véla, pers. obs. 2019). It flowers from April to early June, and grows on roadsides, in uncultivated fields, wadi beds, and orchards... Brullo et al (2017).



Figure 19. *Bituminaria tunetana* C. Brullo, Brullo, Cambria, El Mokni & Giusso (Fabaceae), Algerian-Tunisian endemic taxon (photos E. Véla)

***Bunium crassifolium* Batt.**

APIACEAE

**Endemic** Algeria-Tunisia

*Bunium crassifolium* (Fig. 20) was classified as Vulnerable by IUCN in 1997 (Walter & Gillett 1998) according to pre-1994 criteria, and has not been re-evaluated since.

It is a species that grows on sandy maritime rocks (sandstone, calcarenites, fossil dunes), and flowers from April to June. It is very rare in Tunisia: Pottier-Alapetite (1979) report it only in Korbous (Cap Bon). Sidi Ali el Mekki is therefore a new locality. It is also very rare in Algeria, where it is only recorded in Numidia, between Bône and la Calle (Quézel & Santa 1963). This species is also acknowledged by Plants of the World Online as a Tunisian-Algerian endemic.



Figure 20 *Bunium crassifolium* Batt. (Apiaceae), Algerian-Tunisian endemic taxon.

### **Prospero pulchellum (Munby) Speta**

= *Scilla autumnalis* var. *gracillima* Batt. = *S. pulchella* Munby ASPARAGACEAE

A possible endemic of Algeria-Tunisia?

*Scilla autumnalis* var. *gracillima* has been reported in Tunisia by [Cuénod \(1954\)](#). In his systematic review of the genus *Scilla*, [Speta \(1998\)](#) distinguished a species *Prospero pulchellum* (Munby) Speta, present in Tunisia. Described from Algeria where it might have been found ([Véla 2019](#)), its presence in Tunisia is now suggested, on morphological and ecological grounds, in various places such as Sidi Ali el Mekki, but also Zembra ([Médail & Véla 2020](#)). In the absence of other karyological or phylogenetic studies, its presence elsewhere is not to be excluded, even if to date it has not been anticipated, and if care is taken to exclude erroneous conceptions such as those about Flora Gallica ([Tison & De Foucault 2014](#)).



*Prospero pulchellum* flowers from October to November and grows in the light bushes, lawns and sandy rocks of the fairly shady areas of northern Tunisia and Algeria (Fig. 21). Although the number of known localisations is limited today (two in Algeria, two in Tunisia), the number of individuals and the dynamism of the population are considerable. Nonetheless, given the state of knowledge, which is still far too limited, the species has been assessed as *Data Deficient* (Vela 2019)



Figure 21. *Prospero pulchellum* (Munby) Speta (*Asparagaceae*), Algerian-Tunisian endemic taxon ? (photos E Vela)

### ***Sedum pubescens* Vahl.**

= *S. hispidum* Desf.

CRASSULA Endemic

Algeria-Tunisia

This taxon flowers from May to June and develops in cracks in rocks and rocky pastures (Fig. 22). It is recorded in Tunisia in the North-East (J. Ichkeul), in the Mogods (Kef en Nesour), in the Medjerda Valley (Béja), in Kroumirie, in the Cap Bon and on the Tunisian Dorsale. Its endemism status is in debate. Indeed, Pottier- Alapetite (1979) notes it as endemic to Morocco-Algeria-Tunisia. Plants of the World Online and Dobignard & Chatelain (2010-2013) also retain this status. The latter are based on the flora of Morocco (Fennane et al. 1999). However, in this flora, it is written that it is likely to be confused with *S. maireanum*. As a result, African Plant Databases on the site of the Conservatoire et Jardin botaniques de la Ville de Genève (CJB) only includes Algeria and Tunisia; this is consistent, as this taxon does not exist in western Algeria, but only in the Centre and the East, and in Tunisia



8. Figure 22. *Sedum pubescens* Vahl. (Crassulaceae), Algerian-Tunisian endemic taxon

### 8.1.1. Endemic taxon Tunisia-Libya

*Malcolmia doumetiana* (Coss.) Rouy

= *Maresia doumetiana* (Coss.) Batt.

BRASSICACEES

***Endemic Tunisia-Libya*\*\*\***

\*\*\* : The only mention in Algeria comes from [Ozenda](#) in his [Flore du Sahara \(p. 495\)](#) where he lists the species among the endemics of Constantina and Tunisian Sahara. However, in his own Key of Species (p. 547), he lists it as endemic to southern Tunisia and Tripolitania: this is in line with all known literature, including the *Flore de Tunisie* ([Pottier-Alapetite 1979](#)).

It is an annual that flowers from April to June and grows on sea sands and inland salt sands ([Fig. 23](#)). It is widespread in Tunisia, as reported in Kroumirie (Aïn Sebaa), in the Mogods (Sejenane, Cap Serrat, Tabarka), in the Cap Bon, in the North-East (Porto Farina, at present named Ghar el Melh, in Menzel Jmil, Bizerte), in Central Tunisia (Bou Fichta) and in Southern Tunisia (Douz).





Figure 23. *Malcolmia doumetiana* (Coss.) Rouy (Brassicaceae), Tunisian-Libyan endemic taxon

***Onopordum platylepis* (Murb.) Murb.**

= *O. nervosum* subsp. *platylepis* Murb.

ASTERACEAE

***Endemic Tunisia-Libya***

This taxon (Fig. 24) is recorded in the *flore de Tunisie* (Pottier-Alapetite 1981) under *Onopordum nervosum* subsp. *platylepis* Murb. and bears the status of endemic Tunisia. Presently, it is known with the specific rank *Onopordum platylepis* (Murb.) Murb (Le Floch et al. 2010; Dobignard & Châtelain 2010-2013; African Plant Database, Euro+Med PlantBase, Plants of the World Online). According to the sources, its level of endemism has been reversed. It has been described from Tunisia and is synonymous with *O. confusum* Pamp, and later described from Tripolitania and considered as a Tunisian-Libyan endemic. Nevertheless, its presence at several points close to the Algerian border (Tabarka, Le Kef, Kalaat Senan) suggests its possible presence in Algeria, but to date it

has never been reported there. Thus, the [African Plant Database](#) locates it in Algeria, but no associated bibliography justifies this positioning. Conversely, [Euro+Med Plantbase](#) assigns it only to Tunisia and Libya, in accordance with the bibliographical sources it cites.

This taxon is recorded in wastelands, roadsides and rubble throughout Tunisia, and is common in the North and Centre of the country ([Pottier-Alapetite 1981](#)).



*Figure 24. Onopordum platylepis (Murb.) Murb., Tunisian-Libyan endemic taxon (photo R.V. Lansdown)*

### **8.1.2. Algerian-Tunisian-Sicilian endemic taxon**

***Genista aspalathoides Lam.***

FABACEAE

Endemic Algeria-Tunisia-Sicily

It is a shrub that flowers from March to May and grows in bushes and on mountain slopes ([Fig. 25](#)). [Pottier-Alapetite \(1979\)](#) reported it in Kroumirie, Cap Bon and on the Tunisian Dorsale, but it is also found in the Mogods ([E. Véla & A. Gasmi, pers. obs. 2009](#)). It has been reported to be endemic in Sicily and Pantelleria ([Pignatti 1982](#)), in Tunisia ([Pottier-Alapetite 1979](#)), and in Algerian Numidia ([Ghrabi-Gammar & Véla 2008](#)) but only East of Annaba ([E. Véla & A. Gasmi, pers. obs. 2009](#)).



Figure 25. *Genista aspalathoides* Lam. (Fabaceae), endemic Algerian-Tunisian-Sicilian taxon (right, photo E. Véla)

### 8.1.3. Endemic taxon

*Ibiza-Algeria-Tunisia-Lybia?*

*Barnardia numidica* (Poir.) Speta

= *Scilla numidica* Poir.

ASPARAGACEAE

Endemic Ibiza-Algeria-Tunisia-Lybia?

The only Libyan record of this taxon is attributed to [Maire \(1958, Fl. Afr. N, vol. 5\)](#) who gave it to Gharian from Letourneux. However, neither Letourneux nor any other Libyan botanist is mentioned in the Maire herbarium (MPU), nor in any of the North African herbaria that can be consulted via [eReColNat\(P,MPU...\)](#).



Conversely, the mentions of the Balearic Islands in Ibiza (Spain) are confirmed and the populations are considered as indigenous (cf. [Bolós & Vigo 2001](#)). This taxon is therefore no longer to be considered as endemic to North Africa.

It grows in grassy areas and on wooded slopes. and flowers from September to October ([Fig. 26](#)). It is recorded in Northern Tunisia, in Kroumirie (Fernana, Aïn Draham), in the North East (J. Ichkeul), in the Mogods (Sejenane), in the Cap Bon (Korbous, El Haouaria, J. Abderrahmen) and on the Tunisian Dorsale (Bou Kornine) ([Cuénod 1954](#)). In Algeria, it is quite common at low altitude on the Numidian, Kabyle and the Algerian Tell up to Cherchell ([Quézel & Santa 1962](#)).



Figure 26. *Barnardia numidica* (Poir.) Speta (Asparagaceae), endemic taxon Ibiza-Algeria-Tunisia-Lybia? (photos E. Véla, those in bloom from Algeria)

## 8.2. Rare/threatened taxa

*Muscari maritimum* Desf.

= *M. maritima*

ASPARAGACEAE

This is a plant that flowers from March to May and grows on maritime or sometimes continental sands (Fig. 27).

Cuénod (1954) mentions it in the North-East of Tunisia (La Marsa, Hammam Lif, La Soukra) and in the Cap Bon.

According to Cuénod (1954) it is a taxon with a wide distribution (Tripolitania, Algeria, Crete, Palestine, Syria), but Feinbrun-Dothan (1986, Flora Palaestina, vol. 4) restricts its distribution to the Maghreb countries after he has examined oriental plants as *M. Bicolor* Boiss. Similarly, the old mentions of Sicily were later described as *Muscari gussonei* (Parl.) Tod. For Dobignard & Chatelain (2010-13), the taxon is currently considered endemic to the Maghreb (from Melilla to Benghazi). It is uncommon throughout its range and is limited to a few sectors of the coast, or to the interior (in Algeria only). In Tunisia, Sidi Ali el Mekki constitutes a locality which was not previously referenced and where this taxon abounds on the dunes of the northern slope (East of Raf Raf Plage), but it is rare on the southern slope (Ghrabi-Gammar & Vêla 2008). Similarly, it is present in the dunes of Guerbès-Senhadja between Skikda and Annaba in North-Eastern Algeria (E. Vêla & G. de Bélair, pers. obs.), where it was not previously reported. No assessment is available to date for *M. maritimum*, but *M. bicolor* has been assessed as Quasi-threatened (Lansdown et al. 2017) and *M. gussonei* assessed as in Danger (Bilz et al. 2011).



Figure 27. *Muscari maritimum* Desf. (Asparagaceae), rare and endangered taxon (photo E. Vêla, Sebkhah Khniss)

***Rosmarinus officinalis* L. var. *prostratus***

= *R. officinalis* var. *laxiflorus*,

= *R. officinalis* var. *palaui*

LAMIACEAE

Le Floc'h et al (2010) retain *Rosmarinus officinalis* var. *laxiflorus* cited for the flore de Tunisie by Pottier-Alapetite (1981), while for Dobignard & Châtelain (2010-2013) this variety is included along with *R. officinalis*.

According to Ghrabi-Gammar & Véla (2008), *R. officinalis* var. *prostratus* (= var. *laxiflorus*, var. *palaui*) is a prostrate and rare form of common rosemary, south-western Mediterranean, present from the Gulf of Naples on to the Strait of Gibraltar. It is strictly rupicolous, and remains little known, as it has been little studied (Fig. 28).





Figure 28. *Rosmarinus officinalis* L. var. *prostratus* (Lamiaceae), rare and threatened taxon (photo E. Véla).

***Rouya polygama* (Desf.) Coincy**

= *Thapsia polygama* Desf.

= *Daucus rouyi* Spalik & Reduron

APIACEAE

It is a species that flowers from June to October and grows on the coastal sands (Fig. 29). It has been recorded in Kroumirie (Tabarka), in the North-East (Menzel Jemil, Ras Jbel, Bir Bou Kerba dunes), in the Cap Bon (Menzel Temime) and in central Tunisia (Sebkhet Halkel Menjel) (Pottier-Alapetite 1979). It is endemic to Corsica-Sardinia and Numidia (from El Kala to Sousse) (Ghrabi-Gammar & Véla 2008).

According to Ghrabi-Gammar & Véla (2008), this species is perennial, sometimes woody at the base, not very frequent throughout its range, and is limited in Tunisia to four coastal sectors, including the one from Bizerte to Ras Jbel. The study site is an extension to the East which was not referenced by Pottier-Alapetite (1979).

The species is considered Critically Endangered in France (Red List of Threatened Species in France 2012), Endangered in Europe (Bilz et al. 2011; Gigot & July 2011) and has not yet been assessed in Algeria and Tunisia. It is rare in Algeria, located on the Numidian coast, especially on the sub-fossil dune bar, on both sides of El Kala, where the stations are still present, but gradually degraded by tourism or destroyed by urbanisation/industrialisation (E. Véla & G. De Bélair, pers. obs.). In Tunisia, it is more widespread on the coast and seems still quite present for the moment (E. Véla, Z. Ghrabi & A. Daoud- Bouattour, pers. obs.), even though it has not been the subject of any official evaluation.



Figure 29. *Rouya polygama* (Desf.) Coincy (Apiaceae), rare and threatened taxon

*Satureja barceloi* (Willk.) Pau

= *S. fontanesii* Briq.

= *Micromeria inodora* (Desf.) Benth.

#### LAMIACEAE

It is a small, autumnal flowering shrub that grows in scrub and limestone rocks (Fig. 30). It is rare in Tunisia, where it has only been reported by Pottier-Alapetite (1981) on the southern slope of the Cape of Ghar El Melh. It is south-western Mediterranean with a disjunct area (Morocco, Algeria, Tunisia, Spain, Italy). the site of Sidi Ali el Mekki being a remarkable isolate.



Figure 30. *Satureja barceloi* (Willk.) Pau (Lamiaceae), rare and endangered taxon

### 8.3. Bio-indicator taxa

#### 8.3.1. Threatened ecosystems bio-indicator taxa

*Juniperus oxycedrus* L. subsp. *macrocarpa* (Sm.) Ball and *J. phoenicea* L. subsp. *turbinata* (Guss.) Arcang.

#### CUPRESSACEAE

These two taxa of Mediterranean distribution, favour soils composed of sand. They are widespread in Tunisia, and are particularly able to settle on deep sands and to contribute



to forest maturation (Figs. 31, 32). They thus participate very effectively and naturally in reforestation following dune fixation (Ghrabi-Gammar & Véla 2008). The first flowering is in spring (March-April) and the second in winter (December-February) (Cuénod 1954)



Figure 31. *Juniperus oxycedrus* L. subsp. *macrocarpa* (Sm.) Ball (Cupressaceae), *t* bioindicator axon of threatened ecosystems (right, photo E. Véla).



Figure 32. *Juniperus phoenicea* L. subsp. *turbinata* (Guss.) Arcang. (Cupressaceae), bioindicator taxon of threatened ecosystem

***Quercus coccifera* L. subsp.**  
*pseudococcifera* (Desf.) Arcang.

FAGACEAE

[Pottier-Alapetite \(1979\)](#) does not report any subspecies for Tunisia for this taxon, which flowers from April to May and grows in scrub, hillsides and dry woods ([Fig. 33](#)). Indeed, *Quercus coccifera* subsp. *pseudococcifera*, the “faux-kermes oak” is a tree often confused with the “real” kermes oak (subsp. *coccifera*) or the “oriental” kermes oak (subsp. *calliprinos*) ([Ghrabi-Gammar & Véla 2008](#)). It seems that this south-western Mediterranean subspecies is the only one present in Tunisia (E. Véla, pers. obs.). It has the particular capacity of easily and regularly giving more or less large trees, just like the eastern subspecies ([Ghrabi-Gammar & Véla 2008](#)).



*Figure 33. Quercus coccifera L. subsp. pseudococcifera (Desf.) Arcang. (Fagaceae), bioindicator taxon of threatened ecosystems, in shrub and tree state (Sidi Ali el Mekki) (detail of the fruit, photo E. Vêla)*



### 8.3.2. Biological upwelling bio-indicator taxa

The phenomenon of biological upwelling, often associated with a pedological upwelling, corresponds to the resumption of a progressive dynamic series of vegetation/ecosystem dynamics following a disturbance (fire, storm, exceptional drought, cold spell, etc.), or the reduction or even disappearance of a stress/constraint (grazing, taking, etc.), or the reintroduction of a key element of the ecosystem (reforestation, reintroduction of a predator, etc.). The species taken into account here are very palatable shrub species, and can therefore only maintain/develop in the absence of grazing.

#### ***Malva subovata* (DC.) Molero & J.M. Monts.**

= *Lavatera maritima* Gouan

#### MALVACEAE

While this taxon is considered characteristic of cliffs, the presence on the site of *Malva subovata* in places accessible to sheep and goats can be interpreted as the result of a biological recovery following the disappearance of pastures.

*Malva subovata* is a woody, perennial, bushy, western Mediterranean taxon that flowers from February to May (Fig. 34). It grows on the rocks and scrub of the coastline, particularly on rocky slopes and limestone scree. It has been recorded in Kroumirie (Tabarka), in the North-East (Porto Farina, presently named Ghar el Melh) and in Cap bon (El Haouaria) (Pottier-Alapetite 1979).



Figure 34. *Malva subovata* (DC.) Molero & J.M. Monts. (Malvaceae), taxon bioindicator of biological upwellin

***Teucrium fruticans* L.**

LAMIACEAE

*Teucrium fruticans* was retained as an indicator of biological upwelling by deduction. Indeed, this species, which is quite rare in the Mediterranean and which only develops in areas with little grazing, was only observed on the site in the form of young individuals indicating a regeneration of the vegetation.

It is a shrub from the western Mediterranean basin that flowers from May to June. It grows in sunny or semi-shaded scrub and rocky outcrops (Fig. 35). It has been recorded in Tunisia in Kroumirie (between Tabarka and Bab-Ahrik), in the Mogods and in the North-East (Pottier-Alapetite1981).



Figure 35. *Teucrium fruticans* L. (Lamiaceae), taxon bioindicator of upwelling

**8.3.3. Overgrazing Bio-indicator taxa**

***Asphodelus ramosus* L. subsp. *Ramosus***

= *Asphodelus microcarpus* Viv.

XANTHORRHOEDACEAE

It is a Mediterranean taxon, herbaceous, perennial, with strongly tuberous roots. It flowers from February to May (Fig. 36). It is widespread and very common in Tunisia, found in uncultivated areas, on limestone soils, and can form abundant colonies in the event of overgrazing, being toxic to livestock



*Figure 36. Asphodelus ramosus L. subsp. ramosus (Xanthorrhoeaceae), taxon bioindicator of overgrazing*

### **Calicotome Villosa (Poir.) Link**

#### **FABACEAE**

This Mediterranean taxon is a very sturdy shrub widespread in Tunisia. It flowers from March to June and grows in scrub and on rocky outcrops (Fig. 37). It is very thorny, not eaten by cattle, and therefore becomes abundant in heavily grazed areas.





*Figure 37. Villosa (Poir.) Link calico. (Fabaceae), taxon bioindicator of overgrazing (right, photo E. Véla)*

### **Thymelaea hirsuta (L.)Endl.**

#### **THYMELEACEAE**

This Mediterranean taxon is a very sturdy shrub that is widespread in Tunisia from the Medjerda Valley to the South of the country. It flowers from January to May and grows in bushes and rocky pastures (**Fig. 38**). The plant, unappreciated by livestock because it is poisonous, becomes dominant in overgrazed areas ([Nabli 1989](#)).



*Figure 38. Thymelaea hirsuta (L.) Endl. (Thymeleaceae), taxon bioindicator of overgrazing*



#### 8.4. Invasive taxa

*Agave americana* L.

AGAVACEES

This taxon is native to Central America and Mexico. The plant is widespread in Tunisia where it is sub-spontaneous, cultivated and used as hedges. It is voluminous, with a thick stump, and flowers from May to July (Fig. 39).



Figure 39. *Agave americana* L. (Agavaceae), exotic and invasive taxon

*Carpobrotus edulis* (L.) N.E. Br. var. *edulis*  
= *Mesembryanthemum edule* L.

#### AIZOACEAE

This taxon, naturalized on the Mediterranean rim, is a remarkable slope fixative. It is a hardy perennial plant with flattened stems that can reach more than 1m in height. It flowers from March to September (Fig. 40).



Figure 40: *Carpobrotus edulis* (L.) N.E. Br. var. *edulis* (Aizoaceae), exotic and invasive taxon (photo E. Véla)

*Opuntia ficus-indica* (L.) Mill.

= *O. maxima*

#### CACTACEAE

It is a taxon native to Mexico, introduced in Tunisia by the Spanish (Pottier- Alpetite 1979). Nowadays it is sub-spontaneous, cultivated as a defensive hedge or as a summer fodder plant, its fruits are consumed and appreciated. It flowers from May to July (Fig. 41).



*Figure 41. Opuntia ficus-indica (L.) Mill. (Cactaceae), exotic and invasive taxon (photo E.Véla)*

***Opuntia stricta (Haw.) Haw.***

CACTACEAE

Naturalised in Tunisia, this taxon (Fig. 42) is native to the Gulf of Mexico (Caribbean, SE USA, Mexico). It is on the IUCN list of the 100 most invasive species in the world. It has been reported in the garrigue near the housing lots on the island of Zembra in 2007, and in Sidi Ali el Mekki garrigue in 2008 (Véla, 2013).



*Figure 42. Opuntia stricta (L.) Mill. (Cactaceae), exotic and invasive taxon*



*Oxalis pes-caprae* L.

= *O. cernua* Thunb.

#### OXALIDACEES

This taxon is native to Cape Town and was naturalized throughout the Mediterranean region. It is widespread in Tunisia, especially in the North and in the oases. It flowers from January to April and multiplies abundantly from bulbils (Fig. 43).

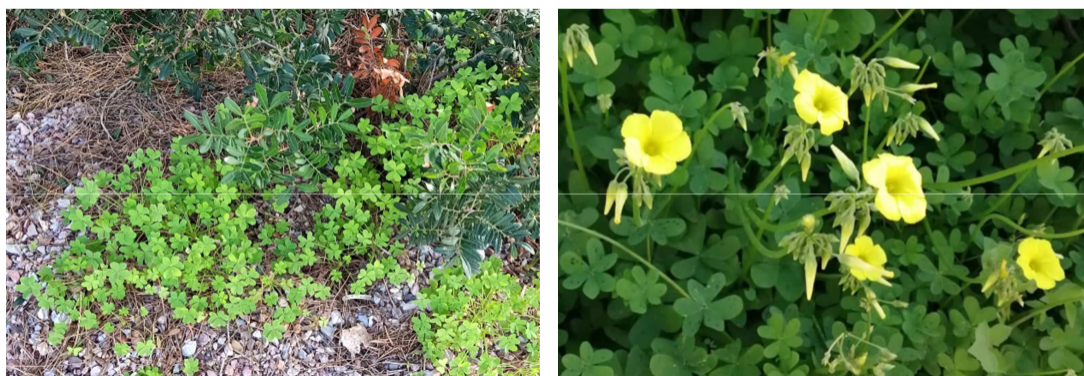


Figure 43. *Oxalis pes-caprae* L. (Oxalidaceae), exotic and invasive taxon

### 9. DISTRIBUTION OF NOTABLE TAXA AND ASSESSMENT OF THEIR POPULATIONS

The distribution of each notable taxon and the assessment of its populations have been delineated (Appendix 3). However, these data only take into account the observations made in the framework of this survey (June, July and November 2019). The information therefore remains incomplete for spring-flowering taxa: their range, population size and conservation status will have to be completed by spring surveys.

A distribution map of taxa with restricted locations is presented.

#### 9.1. Endemic taxa

##### 9.1.1. Endemic taxa Tunisia

*Limonium intricatum* Brullo & Erben

PLUMBAGINACEAE

During investigations carried out in the framework of this study, this species, which is endemic to Tunisia, was only found on the rocks of the coastal fringe, on the Eastern and



Southern slopes of Ras Ettarf, at the eastern end of Sidi Ali el Mekki, where it is quite abundant (Fig. 44). This is the station where the taxon had been collected and described by Brullo & Erben. It should be looked for on the northern side, where it had been observed by these same authors (Brullo & Erben 1989), and where it has recently been reviewed by E. Véla (E. Véla, pers. obs.).

The study site is the only known locality for this taxon. It should therefore be classified as CR (Critically Endangered) on the IUCN Red List. It would also be interesting to develop a programme to monitor its populations and its conservation *in-situ* and *ex-situ*.



Figure 44. Location of *Limonium intricatum* Brullo & Erben

### **Limonium pyramidatum Brullo & Erben**

#### *PLUMBAGINACEAE*

A few individuals of this taxon endemic to Tunisia, reported from only four sites (Cap Blanc, Île Plane, Île des Chiens and Sidi Ali el Mekki, (Brullo & Erben 1989), were observed on rocks at the bottom of the coastal fringe at Ras Ettarf, where the species had been reported by Brullo & Erben in 1989. Erben (1989), but also at several points on the rocky and calcareous crest of the southern slope of Sidi Ali el Mekki, which thus constitutes a new station (Fig. 45).

It is important to evaluate this taxon according to IUCN criteria, and to develop a monitoring programme for its small populations and its *in-situ* and *ex-situ* conservation.

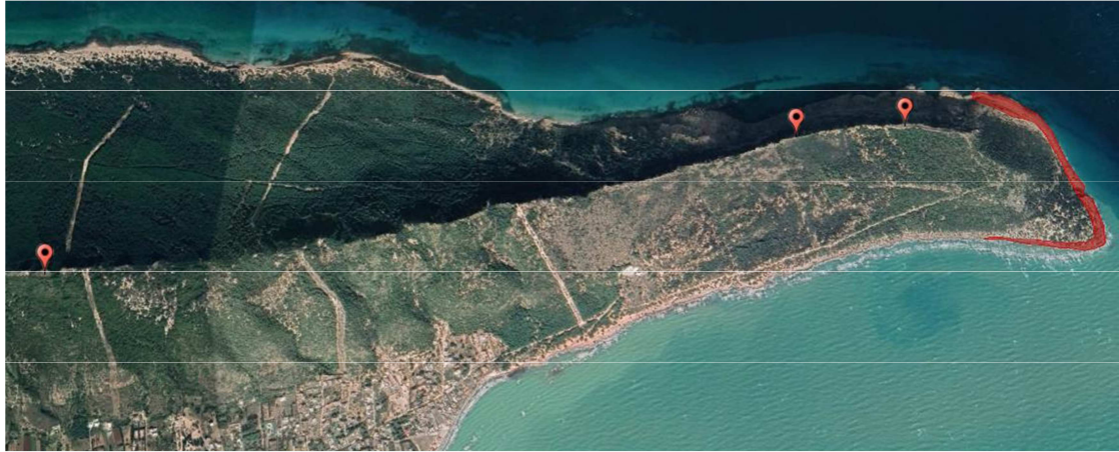


Figure 45. Location of *Limonium pyramidatum* Brullo & Erben

***Linaria heterophylla* Desf. var. *dichroa* Litard. & Maire**

**PLANTAGINACEAE**

This taxon is endemic to the dune complexes of Northeastern Tunisia, and is therefore rare and threatened on a global scale. On the study site, it remains on the mobile or loosely fixed dune remnants at several points on the southern slope, and is frequent east of Raf Raf beach. The dwellings built over its habitat constitute a major threat to this taxon: the populations observed are all very fragmented, more particularly around the anarchic constructions of Ghar el Melh beach (Sidi Ali el Mekki) where the taxon is in danger of extinction (Fig. 46).

It would be interesting to evaluate this taxon according to IUCN criteria, and to develop a monitoring programme for the populations, and for its *in-situ* and *ex-situ* conservation, as well as for the conservation of its habitat

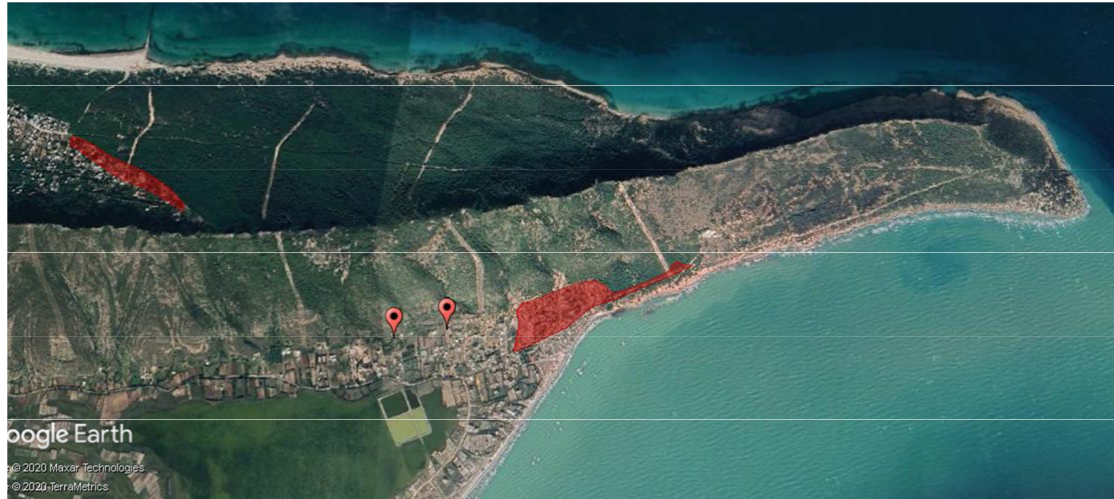


Figure 46. Location of *Linaria heterophylla* Desf. var. *dichroa* Litard. & Maire

### 9.1.2. Endemic taxa Algeria-Tunisia

*Allium maghrebinum* Brullo, Pavone & Salmeri

AMARYLLIDACEES

Several individuals of this endemic Algerian-Tunisian taxon were observed at different levels along the North-facing ridge around the semaphore (Fig. 47).

Spring surveys will make it possible to specify its distribution, the size of its population and its microhabitat.

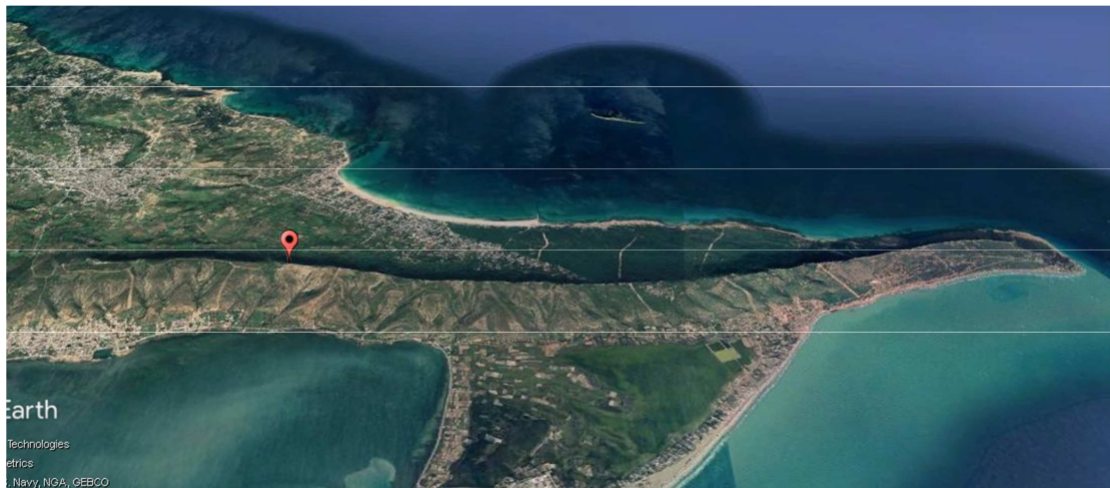


Figure.47. Location of *Allium maghrebinum* Brullo, Pavone & Salmeri, *Barnardia numidica* (Poir.) Speta and *Bunium crassifolium* Batt



***Bituminaria tunetana* C.Brullo, Brullo, Cambria, El Mokni & Giusso**

FABACEAE

Only a few individuals of this endemic Algerian-Tunisian taxon were observed at the foot of the southern slope above the town of Ghar el Melh (Fig. 48).

Spring surveys are essential to specify its distribution, population size and microhabitat.

It would be interesting to develop a monitoring programme for this population and its *in-situ* and *ex-situ* conservation.

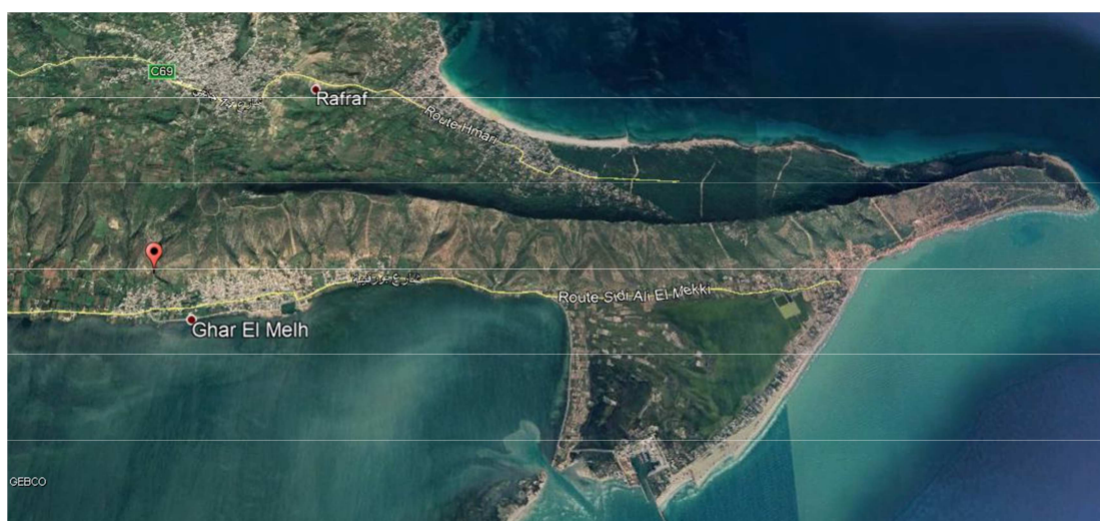


Figure 48. Location of *Bituminaria tunetana* C.Brullo, Brullo, Cambria, El Mokni & Giusso

***Bunium crassifolium* Batt.**

APIACEAE

The presence of this taxon, rare in Tunisia at the study site, where it was previously recorded in Korbous only (Cap Bon) (Cuénod 1954), is an interesting discovery: it is a new Tunisian station. A few are located on the exposed rocks North and South of the ridge, from the semaphore to Sidi Ali el Mekki (Fig. 47). However, spring surveys are essential to delimit the range of this taxon, which flowers between April and June, and to assess the importance and conservation status of its populations.

***Prospero pulchellum* (Munby) Speta**

ASPARAGACEAE



This taxon has been observed in all the overgrazed areas on the southern (J. Ennadhour and the western end of J. Eddmina) and northern slopes (above the Dar Hmouda douar), but its population is particularly abundant on the upper southern slopes, at the semaphore level

### *Sedum pubescens Vahl*

#### CRASSULACEAE

The study site is a station that was not referenced (Pottier-Alapetite 1979). Only a few individuals of this endemic Algerian-Tunisian species were observed on the rocky parts of the slope above the restaurant Le Pirate (Fig. 49).

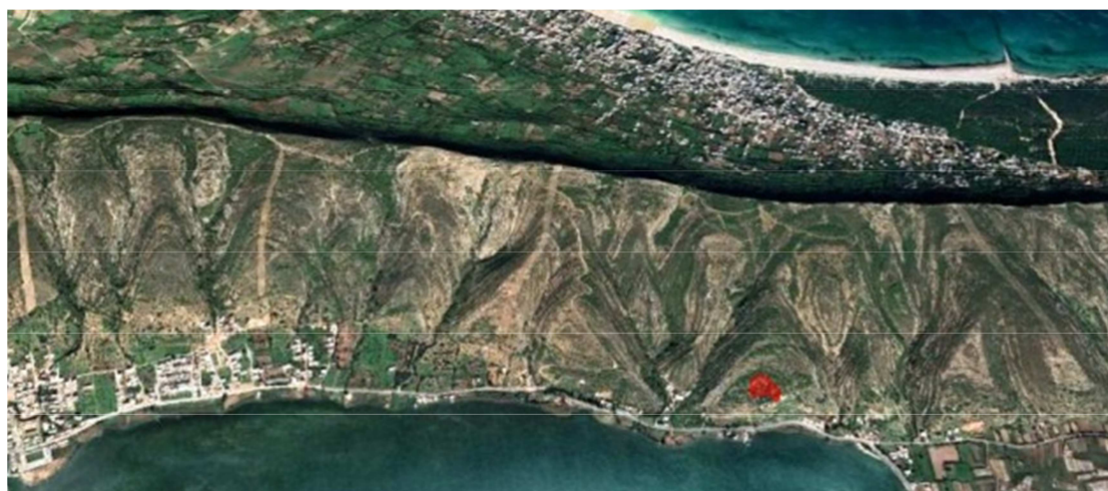


Figure 49. Location of *Sedum pubescens* Vahl.

### 9.1.3. Endemic taxa

#### *Tunisia-Libya*

#### *Malcolmia doumetiana (Coss.) Rouy*

#### BRASSICACEAE

In the context of this study, the surveys were carried out between June and November 2019, which corresponds to the end of the life cycle of this spring-flowering annual (April to June). Thus, only a few individuals of this taxon were observed on 06 June 2019 on the more or less fixed dunes on the southern slope of Sidi Ali Mekki (Fig. 50). However, it should be recalled that according to the work of Ghrabi-Gammar & V ela (2008), this species “abounds on both slopes, on bare veneered dunes or in woodlands with light undergrowth” in Sidi Ali El Mekki. Given its type of habitat, it is very likely that this species will also develop further west. Only spring surveys will be able to

provide the necessary information to delimit the distribution range of this notable taxon on the study site, and to assess the importance and conservation status of its populations

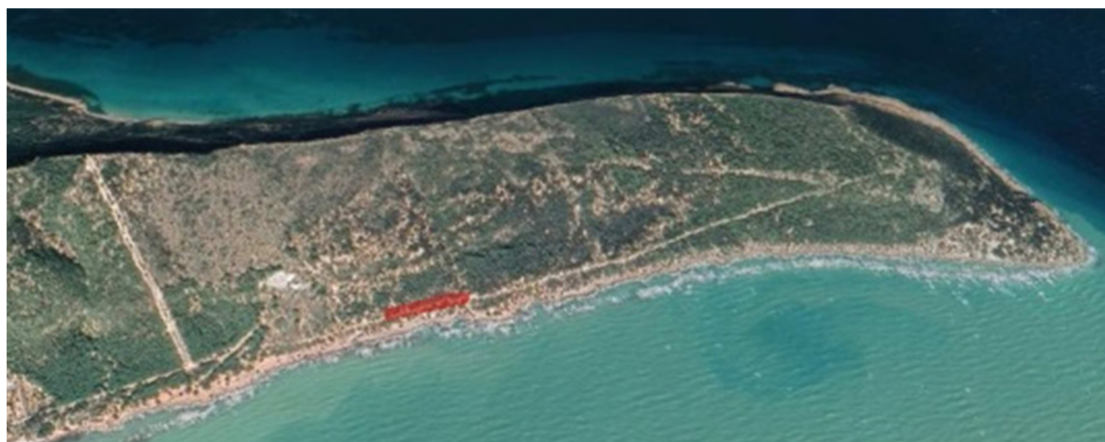


Figure 50. Location of *Malcolmia doumetiana* (Coss.) Rouy

### **Onopordum platylepis (Murb.) Murb.**

#### ASTERACEAE

Only a few individuals of this taxon were observed, on 8 June 2019, on the ridge near the semaphore, and on the roadside on the southern slope West of the village of Ghar el Melh.

Surveys later in the summer would probably allow to note other observation points for this summer-flowering taxon, to thus delimit its range in the study site, and to assess the importance and conservation status of its populations.

#### **9.1.4. Endemictaxon**

##### ***Algeria-Tunisia-Sicily***

*Genista aspalathoides* Lam.

#### FABACEAE

The study site is a station that was not referenced by Pottier-Alapetite (1979). This taxon is present throughout the study site. It is particularly abundant in all overgrazed areas over the heights of the southern slope (J. Ennadhour and the western end of J. Eddmina) and above the Dar Hmoudda douar on the northern slope. This species grows back after fire, resists rather well to grazing because of its more or less thorny ball shape, and is thus indicative of overgrazing. To date, few of its sites are likely to be affected by urbanisation (E. Véla, pers. obs.).

### 9.1.5. *Endemic taxon Ibiza-Algeria-Tunisia-Lybia?*

#### *Barnardia numidica (Poir.) Speta*

ASPARAGACEAE

Only a few feet of this Algerian-Tunisian endemic, with a limited range in northern Tunisia, were found along the north-facing ridge at semaphore level (Fig. 47). The study site constitutes a Tunisian station that was not previously referenced for this taxon (Cuénod 1954).

Surveys at the time of its growth and flowering (September-October) are necessary to detail its distribution, population size and micro-habitat.

### 9.2. Rare/threatened taxa

#### *Muscari maritimum Desf.*

ASPARAGACEAE

The studied massif constitutes a station, which was not previously referenced for this rare taxon in Tunisia. Here again, the choice of the survey period (June to November 2019) did not allow us to study these spring-flowering species (March to May): we did not observe any individuals over the entire study site.

According to Ghrabi-Gammar & Véla (2008), this species “abounds on the plated dunes on the northern slope (East of Raf Raf plage), but is rare on the southern slope.

Spring surveys are essential to delineate the range of this taxon and to evaluate the importance and conservation status of its populations.

No evaluation is available at this time for this taxon.

#### *Rosmarinus officinalis L. var. prostratus*

LAMIACEAE

A few feet were located on the rocky outcrops at several levels of the summit ridge and on the southern slope of the study site.

#### *Rouya polygama (Desf.) Coincy*

= *Thapsia polygama* Desf.

= *Daucus rouyi* Spalik & Reduron

APIACEAE

On the study site, this species abounds more particularly on the more or less fixed sands, all along the foot of the southern slope of Sidi Ali el Mekki, up to the eastern slope of Sidi Tarf. A few individuals were also observed in different sandy points of the southern

slope further to the west. It is also found in abundance on the sandy veneers of the summit ridge of the massif.

It has not been officially assessed for Tunisia, but it is considered Critically Endangered in France and Endangered in Europe. Further surveys are necessary to detail its range and population size.

***Satureja barceloi* (Willk.) Pau**

LAMIACEAE

The study site is the only Tunisian station of this taxon. The flora of Tunisia locates it only on “*the southern slope of the Cape of Ghar El Melh*” (Pottier-Alapetite 1981). Surveys carried out between June and November 2019 found it in abundance throughout the site, particularly in rocky open areas (garrigue).

**9.3. Bio-indicating taxa**

**9.3.1. Threatened ecosystems bio-indicating taxa**

***Juniperus phoenicea* L. subsp. *turbinata* (Guss.) Arcang. and *J. oxycedrus* L. subsp. *macrocarpa* (Sm.) Ball**

CUPRESSACEAE

On the study site, these two sub-species are particularly found on the southern slope of the mountain range, where they contribute to the forest maturation of the site. *Juniperus oxycedrus* subsp. *macrocarpa* is restricted only to the dunes in the process of fixation, where it does not form pure feet. This subspecies is infrequently present in the form of trees on the sandy coastal fringe and on the southern slope between the town of Ghar el Melh and Sidi Ali el Mekki. It is often associated with *Juniperus phoenicea* subsp. *turbinata*, most often in the form of shrubs. This species reaches a tree size in the natural forest of the peninsula of Sidi Ali el Mekki, as well as in some valleys of the southern slope. A regeneration of these two taxa can be observed in places, both in the coastal fringe and in the natural forest.

The monitoring and protection of the fragile habitats of these two taxa are necessary especially around the Marabout of Sidi Ali el Mekki, and near the anarchic constructions, which are dangerously altering the dune, and exposing the root system of several large juniper trees.

***Quercus coccifera* subsp. *Pseudococcifera***

FAGACEAE

The taxon is present throughout the site. It is particularly abundant as a shrub in the natural forest of Sidi Ali el Mekki, on the ridge of J. Ennadhour at the semaphore, and in



the valleys of the southern slope. It is more sparse in the garrigues on the slant of the northern and southern slopes.

Very large kermes oak trees, remnants of ancient forests that are now deeply degraded, can be seen at several points on the southern slope, near the dwellings and cultivated/grazing areas. It is also the case of the beautiful specimens, behind the beach of Sidi Ali el Mekki, some of which are partially uprooted, and thus strongly threatened by extinction nearby the constructions and anarchic seaside resorts that are constantly expanding.

Only an immediate halt to these constructions, combined with a re-silling will make it possible to save this ecological heritage.

### **9.3.2. Biological upwelling bioindicator Taxa**

*Malva subovata* (DC.) Molero & J. M. Monts.

= *Lavatera maritima* Gouan

MALVACEAE

A few individuals of this taxon have been found here and there on the rocky slopes of the southern slope up to the summit ridge. The presence of this edible species could indicate a biological recovery following the disappearance of the pasture.

*Teucrium fruticans* L.

LAMIACEAE

*Teucrium fruticans* are present from West to East, all the way down the southern slope and to the summit ridge. The presence of this taxon in the reforested areas of the study site is an indicator of the success of this reforestation, which generally favours a biological upwelling resulting in the appearance of taxa closely associated with the type of the trees planted.

### **9.3.3. Overgrazing bio-indicator taxa**

*Asphodelus ramosus* L. subsp. *Ramosus*

XANTHORRHOEDACEAE

This taxon is very abundant throughout the study site, particularly in open and rocky areas. Toxic to cattle, its abundance is indicative of overgrazing.

A good grazing management of the site may limit its spread.

*Villosa* (Poir.) Link calico.

FABACEAE

This taxon is present throughout the site. It is very thorny, and is particularly abundant in overgrazed areas, namely in the garrigue.

***Thymelaea hirsuta (L.) Endl***

THYMELEACEAE

This toxic taxon and overgrazing indicator is abundant on the rocky slopes of the southern slope garrigues. A sound grazing management of the site may limit its spread.

**9.4. Invasive taxa**

***Agave americana L.***

AGAVACEAE

This sub-spontaneous taxon in Tunisia constitutes, in the study site, hedges that delimit former cultivation plots. Several large specimens were also observed scattered along the southern slope of J. Ennadhour and the western part of J. Eddmina. On the other hand, a single individual can be observed on the Sidi Ali el Mekki massif. The voluminous feet multiply each year forming a high number of shoots. This taxon contributes to the modification of the natural landscape of the site.

***Carpobrotus edulis (L.) N.D. Br. var. edulis***

AIZOACEAE

This taxon, naturalized in Tunisia, is a remarkable slope fixer. On the study site, it is common in coastal dunes where it occupies large areas and prevents the development of any other species. This taxon was introduced in the site as an ornamental plant in the gardens around the houses or around the straw huts on the beach, and is now found as far as Ras Ettarf. This taxon represents a potential threat of invasion, but it is also a sign of anthropisation and “gardening” for the natural space (Ghrabi-Gammar & Véla 2008).

It is important to plan eradication actions for this taxon in order to safeguard the natural vegetation of the site’s coastal dunes.

***Opuntia ficus-indica (L.) Mill.***

CACTACEAE

This sub-spontaneous taxon, planted in the old defensive hedges delimiting the cultivation plots at the foot of the southern slope of Jbel Ennadhour, is found mixed with the natural vegetation, in several high and sometimes inaccessible and/or unfrequented points: the installation and propagation of the species is then probably ensured by the birds that eat the fruit, and thus allow the seeds to spread. This taxon, which can grow to large sizes, contributes to the modification of the natural landscape of the site.

It is important to plan actions to eradicate this taxon in order to safeguard the beauty of the natural landscape of the site.

***Opuntia stricta* (L.) Mill.**

CACTACEAE

A very large number of feet of this naturalized taxon invades all the natural vegetation of the southern slope of Sidi Ali el Mekki. It proliferates at the expense of native species and disfigures the landscape. It is important to take action to eradicate this taxon.

***Oxalis pes-caprae* L.**

XALIDACEAE

A ruderal taxon, naturalized in Tunisia.

Here again, the choice of the prospecting period (June to November 2019) was not favourable to the study of this herbaceous species which develops from January to April. We were able to observe a few feet in November, to the east of Raf Raf beach, on the site, near the Douar Dar Hmouda, and at several points on the southern slope, to the west of the site. According to [Ghrabi-Gammar & Véla \(2008\)](#), this species grows on the Jbel of Sidi Ali el Mekki “*at several points on the site, in a ruderal position colonising the pine plantations on the sands, as well as in an extreme position in the scrub at the foot of the cliffs. It seems impossible today to envisage getting rid of them.* »

## **10. THREATS**

All four habitat types identified in the study area host several notable taxa. The main threats to these habitats of high conservation value, are mainly due to direct or indirect anthropogenic action, namely uncontrolled urbanisation, uncontrolled tourism, past and present overgrazing, extension of agricultural activities, fires and invasion by exotic species ([Valderrabano et al. 2018](#); [IUCN 2019a](#)).

### **10.1. Urbanisation**

The entire foothill of the southern slope of the study site, up to the beginning of the peninsula of Sidi Ali el Mekki, is occupied by the town of Ghar el Melh, and by small properties consisting of dwellings and small plots of crops, or villas ([Fig. 51](#)). The installation of fences thus blocked access to the heights of a large part of this sector of the slope by local population, hikers, scientists, etc. ([Fig. 51](#)). This urbanisation, together with agro-pastoral activities, is responsible for the intense degradation of a forest, which was probably once remarkable, of which only a few large *Quercus coccifera* subsp. *pseudococcifera* and *Ceratonia siliqua* trees are left today



*Figure 51. Urbanisation and agro-pastoral activity on the foothills of the southern slope.*

This is also the case of the anarchic seaside constructions that constantly spread behind the beach of Sidi Ali el Mekki, destroying the dune and the associated vegetation, and threatening the few remaining specimen trees of kermes oaks with extinction (Fig. 52). To our knowledge, this station is the only one in Tunisia where this taxon reaches the tree size. This anthropic pressure, which destroys mobile dunes, also endangers the Tunisian endemic *Linaria heterophylla* var. *dichroa* in this sector.





Figure 52. Growing anarchic seaside urbanisation behind the beach of Sidi Ali el Mekki, which threatens the few remaining specimens of kermes oaks with extinction.

Seaside urbanisation is also continuing at an alarming rate at the expense of the natural forest on the Raf Raf beach side where the species *Quercus coccifera* subsp. *pseudococcifera* *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa* are becoming very rare. This anthropic pressure also endangers the psammophilic taxon, *Linaria heterophylla* Desf. var. *dichroa*.

## 10.2. Uncontrolled tourism

In Sidi Ali el Mekkihe sector, along with increasing anarchic urbanisation, the installation of straw huts nearby the “car park” and on the beach shores along the peninsula (Fig. 53), the considerable flow of summer visitors, especially on weekends, constitute the main threat to the extremely sensitive habitat of the sandy coastal fringe, but also to the whole natural space easily accessible to tourists, especially the area around the marabout Sidi Ali el Mekki. Moreover, today, there is no rational waste management on the site. Thus, the negligence of the inhabitants and users of the site, and the laxity of the authorities mean that all parts of the site invaded by bathers are unfortunately altered by waste of all kinds (Fig. 54).



Figure 53: Installation of straw huts along the coastal fringe of Sidi Ali el Mekki.



Figure 54. Waste of all kinds in areas invaded by bathers.

### 10.3. Overgrazing

The degradation of the natural forest, probably initially attributed to land clearing, but strongly accentuated by intense overgrazing, can be observed at almost every stage, from the high and dense shrubland to the grass, or even to the bare ground. This overgrazing has affected the whole site; only the peninsula of Sidi Ali el Mekki seems to have been nearly spared. Field observations argue that this activity has now probably ceased, or has greatly diminished in a large part of the site, which could, in the long term, allow at least partial ecological resilience of the ecosystem. However, at other levels, current grazing is adding to past overgrazing. This is the case of the ridge above the town of Ghar el Melh (close to the semaphore), but especially the northern slope above the Dar Hmouda douar, and the western end of the study site, where the habitat is transformed into a low bushy garrigue, mainly made up of plants that are not eaten by cattle, because they are thorny or poisonous : *Calicotome villosa*, *Genista aspalathoides*, *Asphodelus ramosus*, *Thymelaea hirsuta*, *Drimia numidica*, *Daphne gnidium*.

#### 10.4. Agriculture

When the slope of the hill and the nature of the soil allowed it, the inhabitants appropriated the natural habitat and converted it into agricultural land (market gardening or fruit tree plantations: olive trees, plum trees, mulberry trees, fig trees, etc.) (Fig. 55). This is the case of the entire southern piedmont, beyond Ghar el Melh peninsula, as well as the entire southern slope, West of the valley of the Oued El Fejja, the entire north-western slope, as far as the town of Raf Raf, and further East, the entire northern piedmont as far as the boundary with the huge plantation of *Pinus pinea*.



Figure 55. Conversion of natural habitat to agricultural land (northern piedmont at the level of the town of Raf Raf).

#### 10.5. Fire

Despite the creation of firebreaks all along the southern slope, and East of the northern slope, the study area has been affected by several fires: in July 2010, above and around the marabout Sidi Ali el Mekki, and since the revolution, nearby J. Bab Ziadi, and on the northern slope. Very vulnerable to fire outbreaks, the natural forest composed mainly of conifers, and therefore more particularly that of Sidi Ali el Mekki, is the most threatened sector. However, while a large part of the fauna is sensitive to fire (turtles, some snails...), the vast majority of the flora is not or very little sensitive to it. About half of the species germinate massively from seeds after the passage of the fire (as soon as the rains return), the other half germinate from stumps. However, remarkable trees such as *Quercus coccifera* subsp. *pseudococcifera* or *Juniperus oxycedrus* subsp. *macrocarpa*, if they were to burn, would take more than a century to regain their present imposing size,



and would probably never manage to do so because of the continuing degradation of the environment. On the other hand, at least one species is an exception, *Juniperus phoenicea* subsp. *turbinata*, which does not shed from its stump or germinate from its seeds after a fire. In the event of a fire, it will therefore have to patiently recolonise the site, step by step, thanks to the fruit-eating vertebrates (galbules). In this respect, its presence and especially that of old adults is an indicator of the absence of fires for a more or less long time.

## 10.6. Invasion by exotic species

Exotic species have been introduced by men in gardens (*Oxalis pes-capra*, *Carpobrotus edulis* var. *edulis* and *Opuntia stricta*), or to form hedges of former cultivation plots (*Agave americana* and *Opuntia ficus-indica*). They have now become sub-spontaneous, and invade all habitats (Fig. 56). Thus, by competing with spontaneous herbaceous vegetation, oxalis and witch claw are increasingly covering large areas, while the very large specimens of agave and prickly pears are changing the natural landscape of the site.



Figure 56: Invasion into all habitats of the site of exotic species introduced by man (left, *Carpobrotus edulis* var. *edulis*; right, *Opuntia stricta*).

The majority of endemic taxa growing on the study site, are not benefitting any regular monitoring programme or protection action. They also do not appear on the national red list and do not benefit any legal protection. The IUCN Global Red List contains 242 plants of taxa classified as CR, EN, VU whose range includes Tunisia, i.e. 9% of Tunisia's total flora (Valderrabano et al. 2018). This low percentage for Tunisian taxa is mainly due to the lack of updating of their data (taxonomy, habitat, population size, threats, etc.). An evaluation of the degree of threat to endemics in the study site based on IUCN criteria, will improve these statistics.



## 11. EVALUATION OF THE CONDITIONS OF SPECIFIC HABITATS CONSERVATION ON WHICH DEPEND NOTABLE TAXA

Our objective is to assess the current state of conservation of habitats by considering their relationship with the structure and floristic composition of plant communities, notable species and main threats, and to propose possible conservation and/or management actions.

### 11.1. Sandy coastal fringe

It is a habitat severely affected by human disturbance and therefore has a vulnerable conservation status. As already mentioned (IUCN 2019a), these disturbances are mainly reflected in heavy seaside urbanisation and extension of tourist infrastructures, leading to a reduction, even loss and fragmentation of the habitat. Thus, to the south and along the peninsula of Sidi Ali el Mekki, there are only shreds of beaches.

Moreover, pollution by garbage and solid waste dumping has accentuated the decline in the quality of this habitat; heavily altering the vegetation associated with it (psammophilic group at *Ammophila arenaria*, *Crucianella maritima* of the kermes oak series), which is endemic to Corsica-Sardinia and Numidia (from El Kala to Sousse) (Ghrabi-Gammar & Véla 2008), *Rouya polygama*, rare and endangered in Tunisia. It should be noted that this taxon, not yet assessed in Tunisia, is classified as Critically Endangered (CR) in France (Red List of Threatened Species in France 2012), and as Endangered (EN) in Europe (Bilz et al. 2011).

On the other hand, on the more or less fixed dunes, the shrub and tree formations of *Juniperus phoenicea* subsp. *turbinata*, *J. oxycedrus* subsp. *macrocarpa* and *Quercus coccifera* subsp. *pseudococcifera* are particularly exposed to the direct action of the winds, combined with sand smoothing activities pertaining to the development of access roads to the sea, and the installation of tourist and recreational infrastructures. This coastal erosion thus causes, concurrently with these developments, a destabilisation of the dune where several large juniper trees have had their roots uncovered, and are thus threatened by extinction. It should be noted that this vulnerable habitat, also shelters,, among the psammophilic herbaceous plants, the Tunisian-Lybian endemic *Malcolmia doumetiana*.

The introduction of non-native species, including *Acacia cyclops* and *Pinus pinea*, but also *A. saligna* (= *A. cyanophylla*) and *P. pinaster*, to fix the maritime dunes, has visibly led to an artificialization of the habitat by altering the natural succession of these dunes.

Furthermore, this habitat is threatened by the planting of *Carpobrotus edulis* on the beaches and near the houses. The presence of this exotic and invasive taxon constitutes a degradation in itself, growing to the detriment of the development of native species, even though contributing to the fixation of dunes.

Considering the importance of the sandy coastal fringe heritage, it is becoming urgent, on the one hand, to encourage decision-makers and managers to take an even greater interest in its conservation and the safeguarding of its biodiversity; and, on the other hand, to raise public awareness on the need to respect and protect this environment. It is also strongly recommended that a specific monitoring programme be established to assess the state of conservation of this habitat, and enable the monitoring of its extent and the distribution of notable populations species. Other actions are suggested, such as the permanent monitoring of the extension of *Carpobrotus edulis*, the control of anarchic constructions, as well as the monitoring of tourist activities in order to reduce human pressure on the site, more particularly the frequency of tourist visits during the summer season.

### **11.2. The rocky coastal fringe**

Situated at the extreme South-East of Ras Ettarf peninsula, this rocky habitat relief makes it difficult for men to access. Thus, in the absence of human disturbance, it poses very few direct threats and is well preserved. Moreover, it is of significant phytogeographic value, as it shelters chasmophyte species characteristic of the cliffs of the Mediterranean coasts, and constitutes a refuge for two endemic Tunisian statice *Limonium intricatum* and *L. pyramidatum*.

### **11.3. The semi-natural forest**

This is a forest that stretches along the southern and northern flanks of J. Eddmina. It consists mainly of *Pinus halepensis* associated with *Quercus coccifera* subsp. *pseudococcifera* *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa*. It is a habitat of patrimonial interest, sheltering endemic and rare species such as *Linaria heterophylla* var. *dichroa*, *Genista aspalathoides*, *Satureja barceloi*... Nevertheless, it is nowadays very fragile and threatened, being subject to different anthropic activities. These threats mainly concern reforestation with non-native species, fires, extension of agriculture, urbanisation and touristic developments (IUCN 2019a).

- Reforestation actions with non-native species, *Acacia saligna*, *A.cyclops*, *P. pinea* and *P. pinaster*, have led to an artificialization of the forest on several levels. On the ridge of the J. Eddmina and in the northeast of the peninsula, this degradation has even led to a biological homogenization, where plantations of *Acacia cyclops* and *Pinus pinea* respectively form monospecific feet. On the southern slope, the proliferation of *Opuntia stricta* at the expense of native species is also a serious threat, and has disfigured the landscape. This introduction of non-local genetic material has negative consequences on the natural habitat and its functions. Indeed, exotic species can affect the structure and diversity of communities in the long term, and more particularly the survival of heritage species.
- After a devastating fire in 2010, a large part of the forest above the marabout Sidi Ali el Mekki disappeared, leaving the place to a garrigue that is probably sustainable, due to the very slow regeneration of the indigenous species of the tree strata, *Quercus coccifera* subsp. *pseudococcifera* and *Juniperus oxycedrus* subsp. *macrocarpa*, which would take, if the degradation of the environment is halted, more than a century to reconstitute the ecosystem.
- The extension of crops at the expense of the forest, urbanisation and tourist developments are also potential threats that further highlight the trends of fragmentation, destruction and loss of this habitat. Thus, wherever the slope of the hill and the nature of the soil allowed it, the forest was converted into agricultural land, causing a very strong regression of its expanse.

Moreover, at several points on the foothills of the southern slope, the sporadic presence of some large *Quercus coccifera* subsp. *pseudococcifera* and *Ceratonia siliqua* trees, remnants of an ancient forest, testifies to the devastating effect of urbanisation.

The anarchic extension of tourist infrastructures has also had a significant impact on the quality of this habitat, which has become extremely vulnerable, and threatening to its biodiversity's state of conservation, including heritage species. In this case, behind the beach of Sidi Ali el Mekki, a local population of a few relict trees of *Quercus coccifera* subsp. *pseudococcifera*, some of which are partially uprooted, is severely threatened with extinction, and on the side of Raf Raf beach, the bioindicator taxa *Juniperus phoenice* subsp. *turbinata*, *J. oxycedrus* subsp. *macrocarpa* and *Q. coccifera* subsp. *pseudococcifera* become more sparse and tend to disappear.

On these sites, the endemic of the dune complexes of North-Eastern Tunisia *Linaria heterophylla* var. *dichroa* also develops. This taxon is rare and highly threatened by extinction due to the fragmentation of its populations, particularly near the constructions (Sidi Ali el Mekki, Raf-Raf-Plage).

Two other notable species are part of the woody procession of the undergrowth of this forest: the endemic Algerian-Tunisian-Sicilian *Genista aspalathoides*, abundant almost throughout the site, and the rare and endangered taxon *Satureja barceloi* on the side of the marabout Sidi Ali El Mekki, where its condition is relatively degraded, especially on the edges of the track leading to the marabout and the beach..

Apart from these cases of decline in the quality of this habitat, the part of the steep cliffs (on the northern flank of the massif, on Raf Raf side) is the best preserved, being difficult to access. On the other hand, the presence of young individuals within the native species *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa* (Sidi Ali el Mekki) indicates a kind of regular regeneration of the population, a sign of “biological recovery”.

The anthropic pressures that weigh heavily on this ecological heritage justify the need to undertake urgent actions for the conservation of the natural forest. The prioritisation of actions aims to:

- Raise awareness among decision-makers about the urgent need to stop anarchic construction;
- Pay particular attention to the conservation of the notable taxon *Quercus coccifera* subsp. *pseudo coccifera* (IUCN 2019b) on this site, which is probably the only one in Tunisia where the kermes oak reaches the tree line. Following a continuous degradation of its habitat, it now occupies a very limited area with only about twenty individuals. Consequently, a single event (extension of buildings, fire...) could cause this unique population to disappear completely. It indeed is becoming urgent to prohibit the uprooting of these trees, and to protect and restore its habitat;
- establish a management and monitoring plan by mapping the populations of the endemic *Linaria heterophylla* var. *dichroa* (IUCN 2019b), and plan its conservation *in situ* and *ex situ* ;
  - A permanent management and monitoring of the distribution/extent of exotic species, in particular *Acacia saligna*, and *A. cyclops*, and eradication of *Opuntia ficus-indica* and *O. stricta* ;
  - A monitoring and surveillance of the extent, fragmentation and distribution of this habitat (mapping), as well as its reforestation with native species;
  - A monitoring agricultural activities by a high-resolution aerial image mapping (IUCN 2019b);



- Raise awareness among managers and the local population of the heritage value and conservation of this habitat and its biodiversity.

#### 11.4. The garrigue

This forest ecosystem, degraded as a result of past and current human activities of land clearing and overgrazing (IUCN 2019a, 2019b), extends over a wide range of habitats including large areas of the site, and can be observed in almost all regressive stages, from high and dense garrigues to grass or even bare soil.

These intense disturbances of overgrazing indicate an impoverishment of the floral procession. Indeed, overgrazing is a selective pressure that tends to eliminate the local flora in favour of certain nonedible species that are often of little ecological interest. Among these species is also the endemic Algerian-Tunisian-Sicilian *Genista aspalathoides*. Being thorny, it resists well to grazing and is abundant almost across the whole study site.

Despite its state of degradation, this habitat is home to a wealth of notable species, five of which are endemic to Algeria-Tunisia (*Bunium crassifolium*, *Prospero pulchellum*, *Sedum pubescens*, *Allium maghrebinum* and *Barnardia numidica*), one endemic to Tunisia-Lybia (*Onopordum platylepis*), and two are rare/threatened (*Satureja barceloi* and *Rosmarinus officinalis* var. *prostratus*). Some of these taxa are particularly vulnerable due to their narrow range and relatively small population size. These include *Allium maghrebinum*, *Barnardia numidica*, *Bunium crassifolium*, *Prospero pulchellum* and *Sedum pubescens*. Without control of pastoral activities, the survival of the few individuals of these taxa could be seriously compromised.

Nevertheless, it should be noted that in a large part of the site, clearing and overgrazing seem to have ceased or strongly decreased (IUCN 2019a), this would allow, at least partial, ecological resilience of the ecosystem in the long term.

In addition to overgrazing, the landscape on the southern slope of this natural habitat is disturbed, particularly by the presence of several large specimens of *Agave americana*, *Opuntia ficus-indica* and *O. stricta*, exotic taxa, which have become sub-spontaneous.

Thus, in order to safeguard this habitat, urgent actions must be taken:

- Control grazing by drawing up a management plan (periods, duration, species and animal load, etc.).
- Establish a management and monitoring (mapping) plan for populations of vulnerable endemic taxa and a programme for their *in situ* and *ex situ* conservation.
- Control the spread of exotic species through regular monitoring;

- Raise awareness among managers and the local population about the heritage value and conservation of this habitat and its biodiversity.

## 12. TRENDS IN FLORISTIC DIVERSITY

A summary of the data collected in the surveys carried out in 2019 across the entire Jbel Ennadhou-J. Eddmina, and more particularly in the areas where the site's vegetation is best preserved, has allowed to have an overview of the flora and vegetation of the site, to identify the different types of terrestrial habitats, to locate them, and to assess their state of conservation, focusing in particular on the specific habitats on which depend notable taxa. It also made it possible to draw up an exhaustive list of notable taxa, to specify their distribution and assess their populations, and finally to identify the threats to habitats, vegetation and notable flora.

This new, accurate, up-to-date and relevant data is of paramount importance in improving knowledge on the site's vegetation and terrestrial flora. They represent a reference diagnosis on the basis of which future programmes and protocols for monitoring and follow-up of habitats and evaluation of changes in their vegetation and floristic diversity, can be carried out.

Furthermore, these data, compared with those in the literature, make it possible to identify certain information on the site's biodiversity trends. This information concerns:

- The floristic richness of the site ;
- The vegetation of the main habitat units identified;
- The group of heritage plants (endemic, rare or endangered in Tunisia), and bioindicators of the site's vegetation good health (biological upwelling)
- The group of bio inhibiting plants that cause the degradation of the site's vegetation (invasive species, indicators of overgrazing) or that modify the natural landscape (exotic plants).

### 12.1. Floral richness

Despite the absence of annual spring species (no spring surveys for this study), 260 taxa belonging to the vascular terrestrial flora were inventoried on the site ([Appendix 1](#)). They correspond to 69 families and 195 genera. The most represented families are the Asteraceae (31 taxa/26 genera), the Poaceae (26 taxa/21 genera) and the Fabaceae (19 taxa/13 genera). 32 families are represented on the study site by a single genus with a single species. 10 taxa are endemic (3 Tunisian, 5 Tunisian-Algerian, 2 Tunisian-Libyan, 1 Tunisian-Sicilian, 1 Ibiza-Algerian-Tunisian-Libyan), and 4 are rare and threatened in Tunisia. This floristic richness shows the conservation interest of the site.

However, comparing this list with that of the bibliographical data is a delicate operation, and above all inconclusive when it comes to drawing up a balance sheet to highlight trends in the site's floristic diversity. As the table shows, the floristic inventories published for the site prior to this study are incomplete, and were only carried out on the basis of two relatively recent survey campaigns (2003, 2008), irregular in time, non-seasonal, of short duration (1 to 4 days), and above all limited to one part of the site.

*Surveys and number of taxa inventoried at the study site between 2003 and 2019.*

Reference	Prospected area	Prospecting period	Number of taxa inventoried
APAL (2003)	Sidi Khelifa-Jbel Eddmina-Ras Ettarf Sidi Ali El Mekki	May 2001	81
Ghrabi-Gammar & Vêla (2008)	Northern and southern slopes of the entire peninsula of Sidi Ali el Mekki, East of a virtual line linking the Raf-Raf beach to Ghar el Melh beach	November 2007	about 230, but unpublished list
This study	The entire Jbel Ennadhour-J mountain range. Eddmina	6-9 June 2019 10-12 July 2019 5-7 November 2019	260

On the other hand, in the *flore de Tunisie* (Cuénod 1954; Pattier Alapetite 1979-1981), 40 taxa are recorded in the locality under the name “Ghar el Melh” or “Sidi Ali El Mekki” or “Porto Farina”, including the Tunisian-Algerian endemic *Galactites mutabilis* Durieu which we did not encounter during our surveys conducted in summer and autumn 2019.

On the other hand, the exhaustive inventory established in the framework of this study, as well as the location and assessment of the abundance of notable taxa, constitute the first basic reference for future work to monitor the site's floristic diversity. However, the information remains incomplete for taxa with spring flowering: their range, size and population status will have to be completed by spring surveys.

The analysis of this inventory, and by comparison with the natural groupings of the phytocological map drawn up by [Gounot & Schoenenberger \(1967\)](#), shows that the majority of the woody taxa of the natural vegetation, as well as their specific procession, are still present on the site. However, as a result of the many anthropogenic activities noted, their population size has probably decreased, while weed and ruderal species, toxic to livestock, have spread, especially at sites located near housing lots, and in areas of cultivation and grazing. Regular monitoring (seasonal and interannual) of the extent of these areas invaded by these species would make it possible to identify the most degraded sectors in order to take rapid action and decisions that would allow to regenerate natural vegetation and improve the floristic composition of the study site.

Finally, it should be noted that the notable species, and more particularly the endemics, were at the origin of the inscription of the study site on the list of IPAs and KBAs of Tunisia ([Valderrabano et al. 2018](#)); however, no conservatory action for these endemics *in situ* or *ex situ* has yet been undertaken.

## **12.2. Vegetation of the main habitat units identified**

The different types of vegetation characterising the main habitat units identified on the study site are: pioneer vegetation fixing the sand of the fringe sandy coastline, the pioneer vegetation of the rocky coastal fringe, the vegetation of the natural forest and the vegetation of the garrigue.

### **12.2.1. The pioneer vegetation of the sandy coastal fringe**

This vegetation develops particularly by (1) the beach shreds and the sharp dunes located at the foot of the southern slope, between Sidi Ali El Mekki beach and Ras Ettarf; it is made up of pioneer sand fixing species, including the rare and endangered species of Tunisian *Rouya polygama*, and (2) high dunes in the process of fixing with junipers in trees or shrubs associated with a dozen woody trees, several psammophilic herbaceous plants and the endemic *Malcolmia doumetiana* from Tunisia-Libya. The fixation of these dunes is consolidated by plantations of acacias and pines, and *Carpobrotus edulis* is often invasive. The proliferation of the exotic species *Opuntia stricta* is also noted.



This vegetation, rich in taxa, most of which have already been inventoried in previous studies, should be preserved, especially those that are highly fragile and made up of beautiful juniper specimens. Surveys and monitoring of the populations of the main species of pioneer sand-binding vegetation, should be developed all along the sandy coastal fringe, especially in areas marked by intense tourism in summer.

### **12.2.2. The pioneering vegetation of the rocky coastal fringe**

This vegetation is essentially made up of about twenty chasmophytic and/or aerhaline taxa with a scattered distribution, including the Tunisian endemics *Limonium intricatum* and *L. pyramidatum*, and the rare and endangered species in Tunisia *Rouya polygama*.

*In situ* and *ex situ* Monitoring and conservation actions for the two Tunisian endemic species and their habitat will have to be undertaken.

### **12.2.3. Natural forest vegetation**

At the study site, the forest vegetation is mainly located on the southern and northern flanks of J. Eddmina. It is natural or reinforced by reforestation with acacias (2 taxa) and/or pines (3 taxa), heterogeneous and rarely monospecific, largely sparse and fragmented, particularly West of Sidi Ali El Mekki peninsula.

The arborescent stratum of this forest vegetation consists mainly of Aleppo pine associated with Phoenician juniper and sometimes mixed with plantations of acacia and pine with foreign stumps from the site. Its undergrowth is made up, in addition to the kermes oak and the oxychedron juniper, of around twenty woody species including the endemic Algerian-Tunisian-Sicilian *Genista aspalathoides*, the overgrazing indicator species *Calicotome villosa*, and around twenty thermophilic species including the rare and threatened taxon *Saturera barceloi*, which is threatened on a Tunisian scale. A large number of the exotic *Opuntia stricta* infiltrates this entire habitat. The floristic composition of the undergrowth and the herbaceous stratum of the natural forest vegetation is the same throughout its range with a variation in its floristic richness and the size of its woody plants. This forest vegetation is rich and diversified on the study site. The evolutionary trends in its dynamics can be deduced by analysing the distribution of vegetation in its undergrowth and herbaceous stratum, based on the topography of the environment and the anthropic action exerted on it

- On Raf Raf side (on the heights of the northern slope), the natural forest is dense and well preserved, being difficult of access due to its relief, while further down, it is partially replaced by plots of land used for cultivation, resulting in the formation of a mosaic made up of a remnant of natural vegetation and crops.

- On the southern slope of Sidi Ali el Mekki, the forest is sparse, fragmented and less diversified; further West, the junipers and the kermes oak are more and more scattered, disappearing in certain places; the forest is then dominated by the pine of Aleppo.
- On the ridges, at the level of rocky outcrops, the forest vegetation is dominated by Aleppo pine associated with thermophiles, including *Rosarinus officinalis* var. *prostatus* and *Satureja barceloi*, on the sandy veneers, it is replaced by monospecific or heterogeneous acacia plantations with some woody trees, including the rare and endangered species on a Tunisian scale, *Rouya polygama*
- Near Sidi Ali el Mekki habitations, the forest has suffered a very old and intense degradation which still continues, compared to the data published in 1967 (Gounot & Schoenenberger 1967) and 2008 (Ghrabi-Gammar & Véla 2008). At present, only the remains of a few very large and beautiful kermes oak trees, more or less uprooted and suffering from the reduction or even destruction of their habitat, are left.
- At several points at the foothills of the southern slope, there are only degraded remnants of old forests with isolated carob and kermes oak trees, most of them located on private land.
- On a sector located above the marabout of Sidi Ali el Mekki, the dense forest burnt down in July 2010, is now replaced by a garrigue.

The analysis of the data from this study made it possible to identify and locate several types of forest vegetation, pertaining mainly to different micro-habitats and anthropogenic pressures. This demonstrates the need to carry out a large number of regular surveys (inventory, phytosociological surveys, etc.) in order to draw up an updated exhaustive inventory of this vegetation, to assess its diversity and richness in heritage plants, and to identify micro-habitats and the corresponding threats. There is an urgent need to protect the sites where the natural forest is dense, as well as the habitats where junipers and kermes oak are in a tree-like state. Regular monitoring of rare and/or endangered taxa, as well as those that represent a tool for assessing grazing intensity, will allow a sound management of the study site forest vegetation

#### **12.2.4. The garrigue's vegetation**

On the study site, the garrigue develops at the level of the entire southern slope of J. Ennadhour, on the ridge near the semaphore and also in several areas across the northern slope. It is characterised by a large number of taxa of the woody cortege of the undergrowth of the disappearing forest (thermophilous, heliophilous, herbaceous stratum). In this type of habitat we also find *Satureja barceloi* and a large number of

good forage species, especially non-spiny Poaceae and Fabaceae, as well as plants toxic to livestock. It is also in this type of habitat that the few feet of the Algerian-Tunisian endemic *Bituminaria tunetana*, as well as the Tunisian-Lybian endemic *Onopordum platylepis*, have been observed. Several feet of *Agave americana* and *Opuntia ficus-indica* are scattered in the garrigue, changing its natural landscape. Depending on the nature and topography of the soil, its exposure, its floristic composition and the intensity of the grazing, we observed the following on the study site :

- a dense garrigue with beautiful kermes oak shrubs, the Tunisian-Algerian-Sicilian endemic *Genista aspalathoides*, and rare and endangered taxa in Tunisia: *Satureja barceloi* and *Rosmarinus officinalis* var. *prostratus*;
- a low and sparse garrigue with, in addition to *Genista aspalathoides* and *Satureja barceloi*, two Tunisian-Algerian endemics: *Bunium crassifolium* and *Sedum pubescens*;
- a station, above Ghar el Melh, with about twenty feet of an endemic Mediterranean tree spurge, *Euphorbia dendroides*;
- In areas opened up by the clearing and overgrazing of the scrubland, the lawn is particularly rich in bulbous plants, including Tunisian-Algerian endemics: *Allium maghrebinum*, *Barnardia numidica*, *Bunium crassifolium* and *Prospero pulchellum*;
- a high and dense scrubland (northern slope), but which is becoming very degraded, above Douar Hammouda and near the village of Raf Raf, with the disappearance of junipers and kermes oak and the development of small heliophilic bushes and numerous species indicating overgrazing.

The data obtained indicate that the garrigue has been overgrazed for a long time. This has caused a significant degradation to its vegetation cover. At present this grazing has ceased in some areas, but it persists in others and is affecting the vegetation in an alarming way. Such is the case especially above Douar Hammouda and near the Raf Raf village. The defence of these areas, and regular monitoring of their indicator species will make it possible to preserve their floristic richness, more particularly the numerous endemic, rare or threatened plants. The station at *Euphorbia dendroides* will have to be protected

### **12.3. Heritage plants and vegetation health bio-indicators of the site**

The synthesis of the results of our surveys enabled us to select a group of plants composed of the heritage, endemic, rare or endangered species of Tunisia, as well as taxa that are bioindicators of a good vegetation health in the study site (biological upwelling). Their distribution and abundance can be considered as a key tool to assess the trends in the site's floristic biodiversity.

This group contains 12 taxa endemic to Tunisia (3); Algeria-Tunisia (5); Tunisia-Libya (2); Algeria-Tunisia-Sicily (1); Ibiza-Algeria-Tunisia-Libya? (1), and 4 rare and threatened taxa in Tunisia.

### 12.3.1. Tunisian endemics

The Tunisian endemic *Limonium intricatum*, considered restricted to this study site, was only located on the eastern and southern slopes of Ras Ettarf, at the eastern side of Sidi Ali el Mekki. It will have to be looked for on the northern side, where it had been observed by [Brullo & Erben \(1989\)](#); this will allow an assessment of all its populations.

On the other hand, *Limonium pyramidatum*, endemic to the North-East of Tunisia, has a wider distribution area in Tunisia (Cap Blanc, Sidi Ali el Mekki, Ile Plane and Ile des Chiens). On the study site, it was found at Ras Ettarf, but also at several points on the crest of the southern slope of Sidi Ali el Mekki, thus constituting a new station for this species. It is important to evaluate this taxon according to IUCN criteria.

A programme for monitoring populations and *in situ* and *ex situ* conservation actions need to be planned in the near future for these two *Limoniums*.

*Linaria heterophylla* var. *dichroa*, endemic to north-eastern Tunisia, has a fragmented distribution at the study site (a few feet on the southern slope, and several to the east of Raf Raf beach). This taxon is dependent on mobile or loosely fixed dunes, a habitat that is highly threatened by anarchic constructions throughout the site. Indeed, the proliferation of new dwellings displays a worrying decline of the taxon, which is getting rare and extremely threatened on the site, particularly around the constructions of Ghar el Melh and Raf-Raf plage, where it nears extinction. It would be interesting to evaluate this taxon according to IUCN criteria, and to develop a programme for its *in situ* and *ex situ* conservation, and for the protection of its habitat.

This wealth of rare and endangered Tunisian endemics demonstrates the conservation interest of the study site. Unfortunately, no action for monitoring or conservation of the fragile habitats (*in situ* and/or *ex situ*) of these three endemics has been undertaken. It is therefore urgent to act to safeguard them.

### 12.3.2. Tunisian-Algerian endemic species

Five Tunisian-Algerian endemic species are listed on the study site: *Allium maghrebinum*, *Bituminaria tunetana*, *Bunium crassifolium*, *Prospero pulchellum* and *Sedum pubescens*.



- *Allium maghrebinum*, recently described by [Brullo \(2015\)](#), has only been observed with a few individuals along the north-facing ridge around the semaphore. These data do not make it possible to assess its population trend or rarity status. Only surveys at the end of winter and in spring will make it possible to specify its distribution, the size of its population and its micro-habitat. It would be interesting to evaluate this taxon according to the IUCN criteria, and to develop a monitoring programme for its populations, *in situ* and *ex situ* conservation, as well as the conservation of its habitat.
- Only a few individuals of *Bituminaria tunetana*, a taxon recently described by [Brullo et al. \(2017\)](#), were observed at the foot of the southern slope above the town of Ghar el Melh. These data do not allow an assessment of its population trend or rarity status at the site. Spring surveys are essential to delimit its range, assess the size of its population, and precisely determine its micro-habitat. It is important to evaluate this taxon according to IUCN criteria, and to develop a monitoring programme for its populations, *in situ* and *ex situ* conservation, as well as the conservation of its habitat.
- *Bunium crassifolium*, a rare taxon in Tunisia (reported only at Cap Bon), was also newly discovered (a few feet) during our surveys at the study site, in the exposed rocks the north and south of the ridge, from the semaphore to Sidi Ali el Mekki. However, spring surveys are essential to delimit its range, assess the importance and state of conservation of its populations, and develop a monitoring and its *in situ* and *ex situ* conservation programme.
- *Prospero pulchellum*, possibly endemic to Algeria-Tunisia, generally grows in light bushes, lawns and sandy rocks that are rather shady and overgrazed. A few populations have been located on both sides of the study site. This species is more abundant on the southern slope at the semaphore level. It was assessed as *Data Deficient* ([Vela 2019](#)). Spring surveys are essential to delimit the distribution range of this taxon and assess the importance and conservation status of its populations on the study site.
- *Sedum pubescens*, a taxon with a wide distribution in Tunisia (North-East, Mogods, Medjerda Valley, Kroumirie, Cap Bon and Tunisian Dorsale), is limited to a few feet located on the rocky parts of the low and clear garrigue of the southern slope above Le Pirate restaurant. The study site constitutes a station that was not referenced for this taxon ([Pottier-Alapetite 1979](#)). Regular monitoring of the size and dynamics of populations of this taxon would make it possible to complete the missing data.

The mention of new endemic taxa on this site, constituting a new locality for Tunisia, is an important fact. It would be interesting to increase the number of surveys, in search of *Galactites mutabilis*, the Tunisian-Algerian endemic reported by [Pottier-Alapetite \(1981\)](#) on the site, and which has not been found.

### 12.3.3. Endemic Tunisia Libya

- The few feet of *Malcolmia doumetiana* observed mingle with the psammophilic herbaceous plants of the clear undergrowth of Sidi Ali el Mekki. In 2008, this species was abundant on both slopes (Ghrabi-Gammar & Véla 2008). Only spring surveys will provide the necessary information to define the distribution range of this notable taxon on the study site, and to assess the importance and conservation status of its populations.
- The presence of *Onopordum platylepis*, a species common in northern and central Tunisia ([Pottier-Alapetite 1981](#)), had already been noted in May 2001 ([APAL 2003](#)) and again in November 2007 (Ghrabi-Gammar, pers. obs.) at the site. Only a few feet, close to the semaphore, and on the roadside of the southern slope of Jbel Ennadhour, have been observed during this study.

### 12.3.4. Endemic Tunisia-Algeria-Sicily

*Genista aspalathoides*, a thorny non-edible species, was not referenced by [Pottier-Alapetite \(1979\)](#) at the study site. It is present in different places on the site, and becomes abundant in places accessible to cattle, strongly marked by intense current overgrazing, such as (1) the low, sparse garrigues on the southern slope, (2) the very scrubby, dense garrigue on the J. Ennadhour ridge above the village of Ghar el Melh, and (3) the relatively high, dense garrigue on the northern slope. A regular monitoring of the abundance of this thorny shrub will give information on the degree of degradation of the vegetation, more particularly, that based on kermes oak and junipers.

### 12.3.5. Endemic Ibiza-Algeria-Tunisia-Lybia?

*Barnardia numidica*, with a limited range in Northern Tunisia, was found for the first time on the site, which thus constitutes a new Tunisian locality ([Cuénod 1954](#)), where only a few feet were observed on the North-facing ridge. These data will have to be completed by surveys done in September-October, when the taxon is growing and flowering, in order to specify its distribution, population size, habitat, threats, etc. A programme of prospecting, monitoring and *in situ* and *ex situ* conservation of the population of this taxon on the site will have to be developed.

### 12.3.6. Rare and endangered taxa in Tunisia

Four taxa have been identified as rare and threatened in Tunisia. They are *Rouya polygama*, *Muscari maritimum*, *Rosmarinus officinalis* var. *prostratus* and *Satureja barceloi*.

- *Rouya polygama*, a pioneer sand-fixing species, is quite common on the study site (not referenced by Pottier-Alapetite 1979) which constitutes an extension of its towards the East. It is localised at the sandy and rocky coastal fringes, as well as on the sandy veneers of the ridge of the southern slope. The species is considered threatened in some countries in its distribution area. It has not yet been assessed in Tunisia where it is considered infrequent. The protection in the study site of the habitat of the Tunisian endemic *Limonium intricatum* and *L. pyramidatum* will allow it to be safeguarded.
- *Muscari maritimum*, a rare taxon in Tunisia, had not been listed in the *Flore de Tunisie* at the study site (Cuénod 1954), until it was observed by Ghrabi-Gammar & Vêla (2008) on the southern slope (rare) and on the northern slope, East of Raf Raf plage (abundant). However, surveys carried out in 2019 did not find this spring taxon. A programme of prospection, location, study and monitoring of the size and population dynamics of this taxon is to be developed. It will make it possible to define its conservation status and to evaluate its status based on IUCN criteria.
- *Rosmarinus officinalis* var. *prostratus* is a south-western Mediterranean variety found from the Gulf of Naples to the Strait of Gibraltar. A few feet have been located on rocky outcrops at several levels on the crest of the southern slope of the study site. Additional surveys would be necessary to complete the data concerning the distribution, abundance and ecology of this little known and little studied shrub.
- *Satureja barceloi*, a south-western Mediterranean species with a disjunct range, is in an isolated position in Sidi Ali el Mekki, the only Tunisian locality, and is therefore very rare in the country. It is part of the low thermophilic woody species associated with the Aleppo pine. Surveys carried out in 2019 have enabled it to be found in abundance throughout the site. A programme based on the morphology, ecology and genetics of this taxon throughout its range (Tunisia, Algeria and Spain) is currently underway. It will update and enrich the data relating to this taxon (phylogeny, habitat, population size and dynamism, threats, etc.). It will also make it possible to propose conservation measures and evaluate it according to IUCN criteria.

### 12.3.7. Bio-indicator taxa for the site's vegetation health

Five species were selected as bio-indicators of the site's vegetation health . These are *Quercus coccifera* subsp. *pseudococcifera*, *Juniperus phoenicea*

subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa*, and *Teucrium fruticans* and *Malva subovata* retained as indicators of biological recovery, which inform us of the trend towards regeneration of the environment and its natural vegetation.

- *Juniperus oxycedrus* subsp. *macrocarpa* and *J. phoenicea* subsp. *turbinata*: these two subspecies were located more particularly on the southern slope of the study site. The first is only adapted to dunes in the process of fixation (coastal fringe, and in the area between the town of Ghar el Melh and Sidi Ali el Mekki). It is generally in the form of a shrub frequently associated with *Juniperus phoenicea* subsp. *turbinata*, and rarely as a tree (natural forest of Sidi Ali el Mekki, certain valleys on the southern slope). A comparison of the data obtained in the framework of this study with those published by [Ghrabi-Gammar & Co. Véla \(2008\)](#) shows a trend that is both positive, marked by the regeneration of the populations of these two taxa (coastal fringe and natural forest), and negative, marked by the weakening, degradation or even disappearance of their habitat or the uncovering of the root system of several large trees, particularly east of the town of Ghar el Melh, following the development of illegal constructions, and on the side of the marabout of Sidi Ali el Mekki, due to heavy human frequentation. Monitoring and protection of all the fragile habitats of these two taxa is urgent.
- *Quercus coccifera* subsp. *pseudococcifera*: At the study site, this taxon is either abundant as a shrub in the natural forest of Sidi Ali el Mekki, on the ridge of J. Ennadhour at the semaphore, and in the valleys of the southern slope, or sparse on the slopes of the northern and southern slopes. The existence of beautiful specimens of kermes oak trees located behind the beach of Sidi Ali el Mekki represents vestiges of an ancient forest in the study site. Their habitat is now deeply degraded at several levels of the foothills of the southern slope, near the dwellings, and cultivated/grazed areas where some uprooted feet can be observed. This trend of degradation of the habitat and populations of this taxon, already recorded in 2008 ([Ghrabi-Gammar & Véla 2008](#)), is continuing to spread and could lead to their extinction. Only urgent conservation measures (immediate halt to illegal construction, re-sinking of the habitat) could save this ecological heritage.
- *Malva subovata*: this bushy, edible taxon is adapted to the rocky slopes and limestone scree of the coast. On the study site, it was located on this type of habitat on the southern slope with a reduced number of feet. The presence of this taxon in a given site indicates a halt to grazing in the area. Monitoring the abundance of this taxon in the habitats to which it is attached, is an effective tool for measuring their biological recovery following the disappearance of grazing.
- *Teucrium fruticans*: this shrub, which is dependent on shady bushes and rocky outcrops, has been found in several locations on the southern slope. Its presence in reforested areas is an indicator of the success of this reforestation. The monitoring of



its abundance in the reforested areas of the study site, is an effective tool for measuring the biological upwelling of each type of tree planted.

#### **12.4. Bio-indicating plants for the degradation of vegetation and the natural landscape**

In this group, three taxa are selected as indicators of overgrazing (*Asphodelus ramosus* subsp. *ramosus*, *Calicotome villosa* and *Thymelaea hirsuta*), two as invasive taxa (*Carpobrotus edulis* var. *edulis* and *Oxalis pes-caprae*), and three as exotic plants that modify the natural landscape (*Agave americana*, *Opuntia ficus-indica* and *O. stricta*).

##### ***11.1.1. Species indicative of overgrazing***

*Asphodelus ramosus* subsp. *ramosus*, *Thymelaea hirsuta* and *Calicotome villosa*: the first two taxa are poisonous to livestock, abundant especially in the open and rocky environment of the study site, while the last is very thorny, abundant especially in the heavily grazed garrigue. Monitoring the abundance of these taxa is a simple and effective tool for managing grazing on the study site, and thus limiting their spread

##### ***11.1.2. Invasive taxa***

*Carpobrotus edulis* var. *edulis* and *Oxalis pes-caprae*: Witch's Claw, introduced in Tunisia as an ornamental plant, is currently naturalized in the country. It is a remarkable fixative of slopes and coastal dunes, but it prevents the development of any other species. Currently, this taxon invades large areas on the coastal dunes of the study site, around houses and beach huts. It is important to programme actions for its management in order to safeguard the natural vegetation of the coastal dunes of the site. *Oxalis*, a ruderal taxon naturalized in Tunisia, colonized in 2008 the pine plantations on sand, the garrigue located at the foot of the cliffs. According to [Ghrabi-Gammar & Véla \(2008\)](#), it seems impossible today to envisage getting rid of it.

*Agave americana*, *Opuntia ficus-indica* and *O. stricta*: these three sub-spontaneous taxa in Tunisia constitute, along with other taxa such as lyciet, azarolier, bramble..., live hedges for the defence and delimitation of former cultivation plots, whose agronomic interest is recognised. Currently, wire netting, brick walls, etc. have replaced most of the live hedges on the study site, including those made up of agave and prickly pear. This substitution will lead to the disappearance of an ancient know-how acquired over decades by farmers and the local population. A large number of isolated specimens of these three taxa are scattered and mixed with the natural vegetation on the southern slope of J. Ennadhour, and on the western part of J. Eddmina for the agave, and on the northern and southern slopes for the prickly pear. The latter is sometimes found on the heights or in inaccessible and/or unfrequented areas. The birds probably ensure the spread of this taxon. These two taxa contribute to the modification of the natural landscape of the site. It is important to plan actions to reinforce their plantating in defensive hedges, and their

eradication from uncultivated areas in order to safeguard the beauty of the natural landscape of the site

## REFERENCES

- APAL-Agence de Protection et d'Aménagement du Littoral, 2003. Zone sensible littorale de Sidi Ali El Mekki. Rapport de Synthèse. KHRYS TAL Engineering.
- Bissardon M., Guibal L. & Rameau J.C., 1997. CORINE biotopes – Version originale – Type d'habitats français. Engref – ATEN. <http://www.espaces-naturels.fr/ATEN>.
- Bilz M., Kell S.P., Maxted N. & Lansdown R.V., 2011. European Red List of Vascular Plants. Luxembourg: Publications Office of the European Union.
- Bolòs O. & Vigo J., 1984-2001. Flora dels Països Catalans, Vol. 4. Editorial Barcino. Barcelona.
- Brullo S. & Erben M., 1989. The genus *Limonium* (Plumbaginaceae) in Tunisia, Mitt. Bot. Staatssamml. München, 28:484.
- Brullo S., Pavone P. & Salmeri C.W., 2015. Biosystematic researches on *Allium cupani* group (Amaryllidaceae) in the Mediterranean area. Fl. Medit. 25 (Special Issue): 209-244.
- Cuénod A., 1954. Flore analytique et synoptique de la Tunisie. Cryptogames vasculaires, gymnospermes et monocotylédones. Office de l'expérimentation et de la vulgarisation agricoles de Tunisie, Tunis: [1]-39 + 287 p.
- Dobignard A. & Chatelain C., 2010-2013. Index synonymique de la flore d'Afrique du Nord, volumes 1-5. Editions des Conservatoire et jardin botaniques de la ville de Genève, Genève.
- Feinbrun-Dothan N., 1986. Flora Palaestina, Vol. 4: Alismataceae to Orchidaceae.
- Fennane M., Ibn Tattou M., Mathez I., Ouyahya I. & El Oualidi I. (ed.) 1999. Flore Pratique du Maroc, 1. Trav. Inst. Sci., ser. Bot. 36, I-XIV, pp. 1-558.
- Garbari F., Greuter W. & Miceli P. 1979. The '*Allium cupanii*' group: a preliminary taxonomic, caryological and leaf anatomical study. *Webbia* 34 (1): 459-480.
- Ghrabi-Gammar Z. & Véla E., 2008 Expertise sur la flore terrestre du site littoral de Sidi Ali el Mekki (Ghar el Melh/Raf Raf, Tunisie). Institut National Agronomique de Tunisie, Tunis.
- Gigot G. & Juillet N., 2011. *Rouya polygama*. The IUCN Red List of Threatened Species 2011: e.T161807A5497967.

**Gounot M. & Schoenenberger A.**, 1967. Carte phytoécologique de la Tunisie septentrionale. Notice détaillée et carte au 1/200.000, Feuilles 2-3. **Annales de l'Institut National de la Recherche Agronomique de Tunisie**, 40.

**INRF**, 1975. Carte bioclimatique de la Tunisie selon la classification d'Emberger : étages et variantes (1/1 000 000). Ministère de l'Agriculture, République tunisienne.

**IUCN**, 2019a. Characterisation and conservation assessment of terrestrial habitats at Ghar el Melh. By Lansdown, R.V., Daoud-Bouattour, A., **Ghrabi-Gammar, Z., Ben Haj Jilani, I. and Véla, E.** Projet GEMWET, Malaga: 27 pages + annexes.

**IUCN**, 2019b. A monitoring program and protocols for wetland and terrestrial habitats at Ghar el Melh, Tunisia. By Lansdown, R.V. Projet **GEMWET**, Malaga: 27 pages + annexes.

**Lansdown R.V., Sawalha K.M.S., Semaan M., Fragman-Sapir O., Hamasha H. & Taifour H.**, 2017. *Leopoldia bicolor*. The IUCN Red List of Threatened Species: e.T13148105A18610869.

**Le Floch E., Boulos L. & Véla E.**, 2010. Catalogue synonymique commenté de la Flore de Tunisie. Edition 2. Ministère de l'Environnement et du Développement durable. Tunis, 500 p.

**Le Houérou H.-N.**, 1980. L'impact de l'homme et de ses animaux sur la forêt méditerranéenne (Première partie). Forêt méditerranéenne. t. II. (1) : 31-44.

**Maire R.**, 1932. Contribution à l'étude de la flore de l'Afrique du Nord, Fascicule 19.

**Bull. Soc. Hist. Nat. Afrique N.**, 23: 163-222.

**Maire R.**, 1958. Flore de l'Afrique du Nord (Maroc, Algérie, Tunisie, Tripolitaine, Cyrénaïque et Sahara), Vol. 5. Lechevalier Paris.

**Médail F. & Véla E.**, 2020. Flore et végétation vasculaires de l'archipel de Zembra (Tunisie nord-orientale). Note naturaliste PIM, Marseille : 67 p.

**Nabli M.A.**, 1989. Essai de Synthèse sur la Végétation et la Phyto-écologie Tunisienne. Faculté des Sciences, Tunis.

**Ozenda P.**, 1958. Flore du Sahara septentrional et central. CNRS, Paris. **Pignatti S.**, 1982. Flora d'Italia. Vol. 2. Edagricole, Bologna.

**Pottier-Alapetite G.**, 1979-1981. Flore de la Tunisie. Publications scientifiques tunisiennes. Programme flore et végétation tunisiennes, Tunis. Vol. 1, Dicotylédones (p.p.) : [Salicacées - Ombellifères] : [i]-xix + 1-651. Vol. 2, Dicotylédones (fin) : [Ericacées - Composées] : [i]-xiv +655-1190.

**Quézel P. & Santa S.**, 1962-1963. Nouvelle Flore de l'Algérie et des Régions désertiques méridionales, 2 vol. CNRS, Paris.



**Speta F.**, 1998. Systematische Analyse der Gattung *Scilla* L. s. l. (Hyacinthaceae).

Phyton (Horn) 38 (1): 1-224.

**Tison J.M. & De Foucault B.**, 2014. Flora Gallica – Flore de France. Éditions Biotope.

**Valderrabàno M., Gil T., Heywood V. & de Montmollin B.** (eds.), 2018. Conserving wild plants in the south and east Mediterranean region. Gland, Switzerland and Malaga, Spain: IUCN.

**Véla E.**, 2013. Notes sur les cactus du genre *Opuntia* s. l. en Algérie et en Tunisie. In: **A. Dobignard & C. Châtelain (Eds)**, Index synonymique de la flore d’Afrique du Nord, vol. 5, Editions des Conservatoire et jardin botaniques de la ville de Genève, Genève, pp. 377.

**Véla E.**, 2019. *Prospero pulchellum*. The IUCN Red List of Threatened Species: e.T136106211A136106213.

**Walter K.S. & Gillett H.J.** (ed.), 1998. 1997 IUCN Red List of Threatened Plants. IUCN, Gland, Switzerland and Cambridge, UK.

## Appendix 1: Exhaustive list of taxa encountered during the study.

In red, are indicated the exotic taxa of the Tunisian flora.

In green, are indicated the endemic taxa (Alg., Algeria; Ibi., Ibiza; Lyb., Libya; Tun., Tunisia; Sic., Sicily)

In bold, are indicated the rare and threatened taxa in Tunisia

KBA = Sidi Ali el Mekki KBA; IPA = Sidi Ali el Mekki IPA 1, presence; 0, absence; -, absence of information

IUCN Red List Status: DD, Data Deficient; NT, Near Threatened; VU, Vulnerable

Valid name	Synonym(s)	Family	IPA
<i>Acacia cyclops</i> A. Cunn. ex G. Don		Mimosoideae	1
<i>Acacia karroo</i> Hayne	<i>A. horrida</i> (L.) Willd.	Mimosoideae	0
<i>Acacia saligna</i> (Labill.) Wendl. f.	<i>A. cyanophylla</i> Lindl.	Mimosoideae	1
<i>Aeluropus littoralis</i> (Gouan) Parl.		Poaceae	1
<i>Agave americana</i> L.		Agavaceae	1
<i>Ajuga iva</i> (L.) Schreb.		Lamiaceae	1
<i>Allium</i> cf <i>polyanthum</i> Schult. & Schult.f.		Amaryllidaceae	1
<i>Allium chamaemoly</i> L. subsp. <i>chamaemoly</i>		Amaryllidaceae	0
<b><i>Allium magrebinum</i> Brullo, Pavone &amp; Salmeri</b>	<b><i>A. cupani</i> Rafin. [pro parte]</b>	<b>Amaryllidaceae</b>	<b>-</b>
<i>Allium roseum</i> L., sensu lato		Amaryllidaceae	0
<i>Allium subvillosum</i> Schultes & Schultes	<i>A. subhirsutum</i> subsp. <i>album</i> (Santi) Maire & Weiller	Amaryllidaceae	0
<i>Ambrosina bassii</i> L.		Araceae	1
<i>Ammophila arenaria</i> (L.) Link subsp. <i>arundinacea</i> H. Lindb.		Poaceae	1
<i>Ampelodesmos mauritanicus</i> (Poir.) T. Durand & Schinz		Poaceae	0

*Anagallis arvensis* L.

Primulaceae

1

*Anagyris foetida* L.

Fabaceae

0



Valid name	Synonym(s)	Family	K B A	IP A
<i>Andryala integrifolia</i> L.		Asteraceae	1	1
<i>Anthyllis tetraphylla</i> L.		Fabaceae	1	0
<i>Anthyllis vulneraria</i> L. subsp. <i>maura</i> Becker		Fabaceae	1	1
<i>Arisarum vulgare</i> Targ. Tozz.		Araceae	1	0
<i>Artemisia absinthium</i> L.		Asteraceae	1	0
<i>Arthrocnemum macrostachyum</i> (Moric.) K. Koch	<i>A. indicum</i> (Willd.) Moq.	Amaranthaceae	1	1
<i>Arundo micrantha</i> Lam.		Poaceae	1	0
<i>Asparagus acutifolius</i> L.		Asparagaceae	1	1
<i>Asparagus albus</i> L.		Asparagaceae	1	0
<i>Asperula aristata</i> L., sensu lato	<i>A. cynanchica</i> subsp. <i>aristata</i> (L. f.) Briq. & Cavillier	Rubiaceae	1	1
<i>Asphodelus ramosus</i> L. subsp. <i>ramosus</i>	<i>A. microcarpus</i> Viv.	Xanthorrhoeaceae	1	1
<i>Atractylis cancellata</i> L.		Asteraceae	1	1
<i>Atriplex portulacoides</i> L.	<i>Obione portulacoides</i> (L.) Moq.	Amaranthaceae	1	1
<b><i>Barnardia numidica</i> (Poir.) Speta</b>	<b><i>Scilla numidica</i> Poir.</b>	<b>Asparagaceae</b>	<b>1</b>	<b>-</b>
<i>Bellis annua</i> Pomel		Asteraceae	1	0
<i>Bituminaria tunetana</i> Brullo et al.	<i>Psoralea bituminosa</i> L. [pro parte]	Fabaceae	1	0
<i>Blackstonia perfoliata</i> subsp. <i>grandiflora</i> (Viv.) Maire	<i>B. grandiflora</i> (Viv.) Pau	Gentianaceae	1	1
<i>Brachypodium hybridum</i> Catalán, Joch.Müll., L.A.J.Mur & T.Langdon	<i>B. distachyon</i> var. <i>multiflorum</i> Willk.	Poaceae	1	1
<i>Brachypodium retusum</i> (Pers.) P. Beauv.	<i>B. ramosum</i> Roem. & Schult.	Poaceae	1	1
<i>Brachypodium rigidum</i> (Roth) Link	<i>B. stacei</i> Catalan et al, <i>B. distachyon</i> var. <i>asperum</i> (DC.) Speak.	Poaceae	1	1
<i>Briza maxima</i> L.		Poaceae	1	1
<i>Bromus diandrus</i> Roth		Poaceae	1	1

*Bunium crassifolium* Batt.

Apiaceae

1 1

*Bupleurum semicompositum* L.

Apiaceae

1 1

Valid name	Synonym(s)	Family	K B A	IP A
<i>Cakile maritima</i> Scop. subsp. <i>maritima</i>		Brassicaceae	1	1
<i>Villosa calico</i> (Poir.) Link		Fabaceae	1	1
<i>Campanula dichotoma</i> L.	<i>C. dichotoma</i> subsp. <i>eu-dichotoma</i>	Campanulaceae	1	
	Maire			
<i>Capparis spinosa</i> L.		Capparidaceae	1	
<i>Carex flacca</i> Schreb.		Cyperaceae	1	1
<i>Carpobrotus edulis</i> (L.) N.D. Br. var. <i>edulis</i>	<i>Mesembryanthemum edule</i> L.	Aizoaceae	1	1
<i>Centaurea sphaerocephala</i> L.		Asteraceae	1	1
<i>Centaurium erythraea</i> Raf. subsp. <i>grandiflorum</i> (Pers.) Melderis	<i>C. umbellatum</i> subsp. <i>grandiflorum</i> (Biv.) Maire	Gentianaceae	1	
<i>Ceratonia siliqua</i> L.		Caesalpinioideae	1	
<i>Chaenorhinum flexuosum</i> (Desf.) Lange subsp. <i>flexuosum</i>		Plantaginaceae	1	0
<i>Wall-mounted Chenopodium</i> L.		Amaranthaceae	1	1
<i>Cistus clusii</i> Dunal	<i>C. libanotis</i> L.	Cistaceae	1	1
<i>Cistus creticus</i> L. subsp. <i>eriocephalus</i> (Viv.) Greuter & Burdet	<i>C. villosus</i> L.	Cistaceae	1	
<i>Cistus salviifolius</i> L.		Cistaceae	1	
<i>Clematis flammula</i> L.		Ranunculaceae	1	1
<i>Convolvulus althaeoides</i> L.		Convolvulaceae	1	0
<i>Convolvulus cantabrica</i> L.		Convolvulaceae	1	0
<i>Convolvulus cf siculus</i> L.		Convolvulaceae	1	0
<i>Convolvulus lineatus</i> L.		Convolvulaceae	1	0
<i>Coris monspeliensis</i> L. subsp. <i>monspeliensis</i>		Primulaceae	1	1
<i>Coronilla juncea</i> L.		Fabaceae	1	1
<i>Crataegus monogyna</i> Jacquin		Rosaceae	1	0
<i>Crithmum maritimum</i> L.		Apiaceae	1	1

*Crucianella maritima* L.

Rubiaceae 1 1

*Cupressus sempervirens* L.

Cupressaceae 1 0

Valid name	Synonym(s)	Family	K B A	IP A
<i>Cuscuta epithymum</i> L., sensu lato		Cuscutaceae	1	1
<i>Cutandia divaricata</i> (Desf.) Asch. & Barbey		Poaceae	1	1
<i>Cutandia maritima</i> (L.) Barbey		Poaceae	1	1
<i>Cynodon dactylon</i> (L.) Pers.		Poaceae	1	1
<i>Cynomorium coccineum</i> L.		Cynomoriaceae	1	1
<i>Cynosurus echinatus</i> L.		Poaceae	1	0
<i>Cyperus capitatus</i> Vand.	<i>C. kalli</i> (Forssk.) Murb.	Cyperaceae	1	1
<i>Dactylis glomerata</i> subsp. <i>hispanica</i> (Roth) Nyman		Poaceae	1	1
<i>Daphne gnidium</i> L.		Thymelaeaceae	1	0
<i>Daucus carota</i> L. subsp. <i>maximus</i> (Desf.) Ball		Apiaceae	1	1
<i>Delphinium verdunense</i> Balb.	<i>D. peregrinum</i> subsp. <i>halteratum</i>	Ranunculaceae	1	
<i>Desmazeria sicula</i> (Jacq.) Dumort.	var. <i>cardiopetalum</i> (DC.) Lange	Poaceae	1	
<i>Dianthus sylvestris</i> Wulfen subsp. <i>siculus</i> (C. Presl) Tutin	<i>D. caryophyllus</i> subsp. <i>siculus</i> (C. Presl) Arcang, <i>D. siculus</i> C. Presl	Caryophyllaceae	1	
<i>Diplotaxis muralis</i> (L.) DC.		Brassicaceae	1	
<i>Dittrichia graveolens</i> (L.) Greuter	<i>Inula graveolens</i> (L.) Desf.	Asteraceae	1	0
<i>Dittrichia viscosa</i> (L.) Greuter	<i>Inula viscosa</i> (L.) Aiton	Asteraceae	1	0
<i>Drimia numidica</i> (Jord. & Fourr.) J.C.Manning & Goldblatt	<i>Urginea maritima</i> (L.) Baker	Asparagaceae	1	
<i>Drimia purpurascens</i> J.Jacq.	<i>Urginea undulata</i> (Desf.) Steinh.	Asparagaceae	1	
<i>Ecballium elaterium</i> (L.) A. Rich.		Cucurbitaceae	1	0
<i>Echinops spinosissimus</i> Turra	<i>E. spinosus</i> L.	Asteraceae	1	0
<i>Echium sabulicolum</i> Pomel		Boraginaceae	1	1
<i>Elymus farctus</i> (Viv.) Runemark ex Melderis subsp. <i>farctus</i>	<i>Agropyron junceum</i> subsp. <i>mediterraneum</i> Sim.	Poaceae	1	



<i>Emex spinosa</i> (L.) Campd.	Polygonaceae	1	
<i>Ephedra fragilis</i> Desf. subsp. <i>fragilis</i>	Ephedraceae	1	1
<i>Erica multiflora</i> L.	Ericaceae	1	1

Valid name	Synonym(s)	Family	K B A	IP A
<i>Eryngium maritimum</i> L.		Apiaceae	1	1
<i>Euphorbia bivonae</i> Steud.		Euphorbiaceae	1	0
<i>Euphorbia dendroides</i> L.		Euphorbiaceae	1	0
<i>Euphorbia paralias</i> L.		Euphorbiaceae	1	1
<i>Euphorbia terracina</i> L.		Euphorbiaceae	1	1
<i>Ficus carica</i> L.		Moraceae	1	0
<i>Fumana laevipes</i> (L.) Spach		Cistaceae	1	1
<i>Fumana scoparia</i> Pomel	<i>F. ericoides</i> var. <i>scoparia</i> (Pomel) Maire	Cistaceae	1	1
<i>Fumana thymifolia</i> (L.) Spach ex Webb	<i>F. thymifolia</i> var. <i>glutinosa</i> (L.) Burnat	Cistaceae	1	1
<i>Fumana viridis</i> (Ten.) Sennen	<i>Fumana laevis</i> (Cav.) Pau	Cistaceae	1	1
<i>Galactites tomentosa</i> Moench		Asteraceae	1	1
<i>Galium lucidum</i> All.	<i>G. mollugo</i> L. subsp. <i>corrudifolium</i> (Vill.) Briq.	Rubiaceae	1	1
<b><i>Genista aspalathoides</i> Lam.</b>		Fabaceae	<b>1</b>	<b>1</b>
<i>Geranium columbinum</i> L.		Geraniaceae	1	0
<i>Geranium robertianum</i> L. subsp. <i>purpureum</i> (Vill.) Nyman	<i>G. purpureum</i> Vill.	Geraniaceae	1	0
<i>Gladiolus dubius</i> Guss.	<i>G. byzantinus</i> Mill.	Iridaceae	1	0
<i>Glaucium flavum</i> Crantz		Papaveraceae	1	1
<i>Glebionis coronaria</i> (L.) Spach	<i>Chrysanthemum coronarium</i> L.	Asteraceae	1	1
<i>Globularia alypum</i> L.		Globulariaceae	1	1
<i>Hedysarum spinosissimum</i> L.		Fabaceae	1	0
<i>Hedysarum spinosissimum</i> L. subsp. <i>capitatum</i> (Rouy) Asch. & Graebn.		Fabaceae	1	1
<i>Helianthemum syriacum</i> (Jacq.) Dum. Cours. subsp.	<i>H. lavandulifolium</i> Mill.	Cistaceae	1	1

*thibaudii* (Pers.) Meikle

*Helichrysum conglobatum* (Viv.) Steud.

*H. stoechas*  
*brachyphyllum*

subsp. Asteraceae

1 1

Valid name	Synonym(s)	Family	K B A	IP A
	(Drink.) Murb.			
<i>Himantoglossum robertianum</i> (Loisel.) Delforge		Orchidaceae	1	-
<i>Hippocrepis ciliata</i> Willd.		Fabaceae	1	1
<i>Hippocrepis multisiliquosa</i> L.	<i>H. multisiliquosa</i> subsp. <i>confusa</i>	Fabaceae	1	0
	(Pau) Maire			
<i>Hirschfeldia incana</i> (L.) Lagrèze-Fossat subsp. <i>geniculata</i> (Desf.) Maire		Brassicaceae	1	0
<i>Hyacinthoides lingulata</i> (Poir.) Rothm.	<i>Scilla lingulata</i> Poir.	Asparagaceae	1	1
<i>Hyoseris radiata</i> L.		Asteraceae	1	0
<i>Hyparrhenia sinaica</i> (Delile) López González	<i>H. hirta</i> (L.) Stapf [pro parte]	Poaceae	1	0
<i>Hypochaeris laevigata</i> (L.) Cess. & al.		Asteraceae	1	0
<i>Juniperus oxycedrus</i> L. subsp. <i>macrocarpa</i> (Sm.) Ball		Cupressaceae	1	1
<i>Juniperus phoenicea</i> L. subsp. <i>turbinata</i> (Guss.) Arcang.		Cupressaceae	1	1
<i>Lagurus ovatus</i> L. subsp. <i>ovatus</i>		Poaceae	1	1
<i>Launaea fragilis</i> (Asso) Pau subsp. <i>fragilis</i>	<i>L. resedifolia</i>	Asteraceae	1	1
<i>Leontodon tuberosus</i> L.		Asteraceae	1	0
<i>Limbarda crithmoides</i> (L.) Dumort. subsp. <i>longifolia</i>	<i>Inula crithmoides</i> L.	Asteraceae	1	1
(Arcang.) Greuter				
<b><i>Limonium intricatum</i> Brullo &amp; Erben</b>		<b>Plumbaginaceae</b>	<b>1</b>	<b>1</b>
<b><i>Limonium pyramidatum</i> Brullo &amp; Erben</b>		<b>Plumbaginaceae</b>	<b>1</b>	<b>1</b>
<i>Limonium virgatum</i> (Willd.) Fur.		Plumbaginaceae	1	1
<b><i>Linaria heterophylla</i> Desf. var. <i>dichroa</i> Litard. &amp; Maire</b>	<b><i>L. multicaulis</i> (L.) Mill. subsp. <i>heterophylla</i> (Desf.) D.A.Sutton</b>	<b>Plantaginaceae</b>	<b>1</b>	<b>1</b>
	[pro parte]			

<i>Linum strictum</i> L. subsp. <i>spicatum</i> (Pers.) Nyman		Linaceae	1	1
<i>Linum trigynum</i> L.	<i>L. gallicum</i> L.	Linaceae	1	0
<i>Linum usitatissimum</i> subsp. <i>angustifolium</i> (Huds.) Thell.	<i>L. bienne</i> Mill.	Linaceae	1	1



Valid name	Synonym(s)	Family	K B A	IP A
<i>Lobularia maritima</i> (L.) Desv.		Brassicaceae	1	1
<i>Lonicera implexa</i> Aiton		Caprifoliaceae	1	0
<i>Lotus creticus</i> L.		Fabaceae	1	1
<i>Lotus cytisoides</i> L.		Fabaceae	1	0
<i>Lycium europaeum</i> L.		Solanaceae	1	1
<b><i>Malcolmia doumetiana</i> (Coss.) Rouy</b>	<b><i>Maresia doumetiana</i> (Coss.) Batt.</b>	<b>Brassicaceae</b>	<b>1</b>	<b>1</b>
<i>Malva subovata</i> (DC.) Molero & J. M. Monts.	<i>Lavatera maritima</i> Gouan	Malvaceae	1	0
<i>Malva sylvestris</i> L.		Malvaceae	1	1
<i>Mandragora autumnalis</i> Bertel.		Solanaceae	1	0
<i>Marrubium vulgare</i> L.		Lamiaceae	1	0
<i>Medicago marina</i> L.		Fabaceae	1	1
<i>Medicago polymorpha</i> L.	<i>Mr. hispida</i> Gaertn.	Fabaceae	1	1
<i>Mercurialis annua</i> L.		Euphorbiaceae	1	1
<i>Moraea sisyrinchium</i> (L.) Ker-Gawl.	<i>Iris sisyrinchium</i> L., <i>Gynandriris sisyrinchium</i> (L.) Parl.	Iridaceae	1	0
<b><i>Muscari maritimum</i> Desf.</b>		<b>Asparagaceae</b>	-	-
<i>Nigella arvensis</i> L. subsp. <i>glaucescens</i> (Guss.) Greuter & Burdet	<i>N. arvensis</i> subsp. <i>eu-arvensis</i> var. <i>glaucescens</i> (Guss.) Drink.	Ranunculaceae	1	1
<i>Olea europaea</i> L. subsp. <i>europaea</i> var. <i>europaea</i>		Oleaceae	1	0
<i>Olea europaea</i> L. subsp. <i>europaea</i> var. <i>sylvestris</i> (Mill.) Lehr	<i>O. europaea</i> var. <i>oleaster</i> (Hoffmanns. & Link) DC.	Oleaceae	1	0
<i>Oncostema elongata</i> (Parl.) Speta		Asparagaceae	1	0
<i>Ononis hispanica</i> L. subsp. <i>ramosissima</i> (Desf.) Förhter & Podl.	<i>O. natrix</i> subsp. <i>ramosissima</i> (Desf.) Batt. var. <i>adglutinans</i> (Presl.) Sirj.	Fabaceae	1	1
<b><i>Onopordum platylepis</i> (Murb.) Murb.</b>	<b><i>O. nervosum</i> subsp. <i>platylepis</i> Murb.</b>	<b>Asteraceae</b>	<b>1</b>	<b>0</b>

*Opuntia ficus-indica* (L.) Mill.

Cactaceae

1 1

*Opuntia stricta* (Haw.) Haw.

Cactaceae

1 1

Valid name	Synonym(s)	Family	K B A	IP A
<i>Orobanche</i> sp.		Orobanchaceae	1	1
<i>Oryzopsis miliacea</i> (L.) Benth. & Hook. f. ex Asch. & Schweinf.		Poaceae	1	
<i>Osyris alba</i> L.		Santalaceae	1	
<i>Oxalis pes-caprae</i> L.	<i>O. cernua</i> Thunb.	Oxalidaceae	1	1
<i>Pallenis maritima</i> (L.) Greuter	<i>Asteriscus maritimus</i> (L.) Less.	Asteraceae	1	1
<i>Pallenis spinosa</i> (L.) Cass. subsp. <i>spinosa</i>	<i>P. spinosa</i> subsp. <i>eu-spinosa</i> Maire	Asteraceae	1	1
<i>Pancratium maritimum</i> L.		Amaryllidaceae	1	1
<i>Panicum repens</i> L.		Poaceae	1	1
<i>Parietaria judaica</i> L. subsp. <i>judaica</i>	<i>P. officinalis</i> L. subsp. <i>judaica</i> (L.) Bég.	Urticaceae	1	
<i>Parietaria lusitanica</i> L.		Urticaceae	1	
<i>Paspalum distichum</i> L.		Poaceae	1	0
Rock <i>Phagnalon</i> (L.) DC.		Asteraceae	1	1
Saxon <i>Phagnalon</i> (L.) Cass.		Asteraceae	1	0
<i>Phagnalon sordidum</i> (L.) Rchb.		Asteraceae	1	0
<i>Phillyrea media</i> L.	<i>P. angustifolia</i> subsp. <i>media</i> (L.) Rouy.	Oleaceae	1	
<i>Pinus halepensis</i> Mill.		Pinaceae	1	
<i>Pinus pinaster</i> Aiton		Pinaceae	1	1
<i>Pinus pinea</i> L.		Pinaceae	1	1
<i>Pistacia lentiscus</i> L.		Anacardiaceae	1	1
<i>Plantago afra</i> L.	<i>P. psyllium</i> L.	Plantaginaceae	1	1
<i>Plantago albicans</i> L.		Plantaginaceae	1	1
<i>Plantago lagopus</i> L.		Plantaginaceae	1	1
<i>Plantago macrorhiza</i> Pear.	<i>P. coronopus</i> subsp. <i>macrorhiza</i> (Pear.) Arcang.	Plantaginaceae	1	

*Plantago weldenii* Rchb.

Plantaginaceae

1

*Plumbago europaea* L.

Plumbaginaceae

1

0

Valid name	Synonym(s)	Family	K B A	IP A
<i>Polycarpon polycarpoides</i> (Biv.) Zodda subsp. <i>catalaunicum</i> O. Bolós & Vigo	<i>P. peploides</i> DC.	Caryophyllaceae	1	1
<i>Polygonum maritimum</i> L.		Polygonaceae	1	1
<i>Portulaca oleracea</i> L., sensu lato		Portulacaceae	1	1
<i>Prasium majus</i> L.		Lamiaceae	1	1
<b><i>Prospero pulchellum</i> (Munby) Speta</b>	<b><i>Scilla pulchella</i> Munby, <i>S. autumnalis</i> var. <i>gracillima</i> Batt.</b>	<b>Asparagaceae</b>	<b>1</b>	<b>1</b>
<i>Prunus amygdalus</i> Batsch		Rosaceae	1	0
<i>Pseudorlaya pumila</i> (L.) Large var. <i>pumila</i>	<i>Orlaya maritima</i> (Gouan) W.D.J. Koch	Apiaceae	1	1
<i>Quercus coccifera</i> L. subsp. <i>pseudococcifera</i> (Desf.) Arcang.		Fagaceae	1	1
<i>Ranunculus bullatus</i> L.		Ranunculaceae	1	0
<i>Reichardia picroides</i> (L.) Roth		Asteraceae	1	0
<i>Reseda alba</i> L. subsp. <i>alba</i>		Resedaceae	1	1
<i>Retama raetam</i> (Forssk.) Webb subsp. <i>bovei</i> (Spach) Talavera & Gibbs		Fabaceae	1	1
<i>Rhamnus alaternus</i> L.		Rhamnaceae	1	0
<i>Rhamnus lycioides</i> L. subsp. <i>oleoides</i> (L.) Jahand. & Maire		Rhamnaceae	1	1
<i>Rhodalsin geniculata</i> (Poir.) F.N. Williams	<i>Minuartia geniculata</i> (Poir.) Thell.	Caryophyllaceae	1	1
<i>Rosmarinus officinalis</i> L. var. <i>offinalis</i>		Lamiaceae	1	1
<b><i>Rosmarinus officinalis</i> L. var. <i>prostratus</i></b>		<b>Lamiaceae</b>	<b>1</b>	<b>1</b>
<i>Rostraria cristata</i> (L.) Tzvelev	<i>Koeleria phleoides</i> (Vill.) Pers.	Poaceae	1	1
<i>Rostraria litorea</i> (All.) Holub	<i>Koeleria pubescens</i> (Lam.) P.	Poaceae	1	1



	Beauv.			
<i>Rouya polygama</i> (Desf.) Coincy	<i>Thapsia polygama</i> Desf.	Apiaceae	1	1
<i>Rubia peregrina</i> L.		Rubiaceae	1	1
<i>Rubus ulmifolius</i> Schott		Rosaceae	1	0

Valid name	Synonym(s)	Family	K B A	IP A
<i>Rumex bucephalophorus</i> L.		Polygonaceae	1	1
<i>Rumex roseus</i> L.	<i>R. tingitanus</i> L.	Polygonaceae	1	1
<i>Ruscus hypophyllus</i> L.		Asparagaceae	1	0
<i>Ruta chalepensis</i> L. subsp. <i>chalepensis</i>		Rutaceae	1	1
<i>Salsola kali</i> L.		Amaranthaceae	1	1
<i>Salvia verbenaca</i> L.		Lamiaceae	1	0
<b><i>Satureja barceloi</i> (Willk.) Pau</b>	<b><i>S. fontanesii</i> Briq.</b>	<b>Lamiaceae</b>	<b>1</b>	<b>1</b>
<i>Satureja graeca</i> L.	<i>Micromeria graeca</i> (L.) Rchb.	Lamiaceae	1	0
<i>Satureja nervosa</i> Desf.		Lamiaceae	1	0
<i>Scabiosa atropurpurea</i> L. subsp. <i>maritima</i> (L.) Arcang.		Dipsacaceae	1	1
<i>Schoenus nigricans</i> L.		Cyperaceae	1	1
<i>Scirpoides holoschoenus</i> (L. f.) Soják subsp. <i>holoschoenus</i>	<i>Scirpus holoschoenus</i> L. subsp. <i>eu-holoschoenus</i> Briq.	Cyperaceae	1	1
<i>Scolymus grandiflorus</i> Desf.		Asteraceae	1	0
<i>Scolymus hispanicus</i> L.		Asteraceae	1	0
<i>Scorzonera undulata</i> Vahl		Asteraceae	1	0
<i>Scrophularia sambucifolia</i> L. subsp. <i>mellifera</i> (L'Hér. ex Aiton) Maire		Scrophulariaceae	1	1
<i>Sedum album</i> L. subsp. <i>micranthum</i> (Bast.) Syme		Crassulaceae	1	0
<b><i>Sedum pubescens</i> Vahl</b>		<b>Crassulaceae</b>	<b>1</b>	<b>0</b>
<i>Sedum sediform</i> (Jacq.) Pau		Crassulaceae	1	1
<i>Selaginella denticulata</i> (L.) Spring		Selaginellaceae	1	0
<i>Sherardia arvensis</i> L.		Caryophyllaceae	1	0
<i>Silene arenarioides</i> Desf.		Caryophyllaceae	1	1
<i>Silene coelirosa</i> (L.) Godr.		Caryophyllaceae	1	0
<i>Silene colorata</i> Poir.		Caryophyllaceae	1	1

*Silene succulenta* Forssk.

Caryophyllaceae 1 1

*Silene villosa* Forssk.

Caryophyllaceae 1 1

Valid name	Synonym(s)	Family	K B A	IP A
<i>Smilax aspera</i> L.		Smilacaceae	1	1
<i>Solanum linneanum</i> Hepper & Jaeger		Solanaceae	1	0
<i>Solanum nigrum</i> L. subsp. <i>nigrum</i>		Solanaceae	1	0
<i>Sonchus bulbosus</i> (L.) N. Killian & Greuter	<i>Crepis bulbosa</i> (L.) Tausch	Asteraceae	1	0
<i>Spergularia marina</i> (L.) Besser	<i>S. salina</i> J. & C. Presl,	Caryophyllaceae	1	1
<i>Stipa tenacissima</i> L., sensu lato		Poaceae	1	1
<i>Symphotrichum squamatum</i> (Spreng.) Nesom	<i>Aster squamatus</i> (Spreng.) Hieron	Asteraceae	1	0
<i>Tamarix</i> sp.		Tamaricaceae	1	0
<i>Teucrium flavum</i> L. subsp. <i>flavum</i>		Lamiaceae	1	0
<i>Teucrium fruticans</i> L.		Lamiaceae	1	1
<i>Teucrium capitatum</i> L.		Lamiaceae	1	1
<i>Thapsia garganica</i> L.		Apiaceae	1	0
<i>Thymbra capitata</i> (L.) Cav.	<i>Thymus capitatus</i> (L.) Hoffmanns. & Link	Lamiaceae	1	1
<i>Thymelaea hirsuta</i> (L.) Endl.		Thymelaeaceae	1	1
<i>Thymus algeriensis</i> Boiss. & Reut.	<i>T. hirtus</i> subsp. <i>algeriensis</i> (Boiss. & Reut.) Murb. var. <i>cinerescens</i> Murb.	Lamiaceae	1	1
<i>Tolpis virgata</i> (Desf.) Bertol.		Asteraceae	1	1
<i>Trifolium scabrum</i> L.		Fabaceae	1	0
<i>Trifolium stellatum</i> L.		Fabaceae	1	0
<i>Umbilicus horizontalis</i> (Guss.) DC.	<i>Cotyledon umbilicus-veneris</i> L.	Crassulaceae	1	0
<i>Urginea fugax</i> (Moris) Steinh.		Asparagaceae	1	1
<i>Urospermum dalechampii</i> (L.) Scop. ex F.W. Schmidt		Asteraceae	1	1
<i>Urtica urens</i> L.		Urticaceae	1	1
<i>Urtica pilulifera</i> L.		Urticaceae	1	1

*Verbascum sinuatum* L.

Scrophulariaceae 1 0  
e

*Vitis vinifera* L.

Vitaceae 1 0





**Appendix 2: List and status of the 26 notable taxa identified in the Study Area**

Valid name	Synonym(s)	Family
<b>ENDEMIC TAXA</b>		
<i>Limonium intricatum</i> Brullo & Erben		Plumbaginaceae
<i>Limonium pyramidatum</i> Brullo & Erben		Plumbaginaceae
<i>Linaria heterophylla</i> Desf. var. <i>dichroa</i> Litard. & Maire	<i>L. multicaulis</i> (L.) Mill. subsp. <i>heterophylla</i> (Desf.) D.A.Sutton [pro parte]	Plantaginaceae
<i>Allium maghrebinum</i> Brullo, Pavone & Salmeri	<i>A. cupani</i> Rafin. [pro parte]	Amaryllidaceae
<i>Bituminaria tunetana</i> Brullo et al.	<i>Psoralea bituminosa</i> L. [pro parte]	Fabaceae
<i>Bunium crassifolium</i> Batt.		Apiaceae
<i>Prospero pulchellum</i> (Munby) Speta	<i>Scilla pulchella</i> Munby, <i>S. autumnalis</i> var. <i>gracillima</i> Batt.	Asparagaceae
<i>Sedum pubescens</i> Vahl.		Crassulaceae
<i>Malcolmia doumetiana</i> (Coss.) Rouy	<i>Maresia doumetiana</i> (Coss.) Batt.	Brassicaceae
<i>Onopordum platylepis</i> (Murb.) Murb.	<i>O. nervosum</i> subsp. <i>platylepis</i> Murb.	Asteraceae
<i>Barnardia numidica</i> (Poir.) Speta	<i>Scilla numidica</i> Poir.	Asparagaceae
<i>Genista aspalathoides</i> Lam.		Fabaceae

Valid name	Synonym(s)	Family
<b>RARE/THREATENED TAXA</b>		
<i>Muscari maritimum</i> Desf.	<i>Leopoldia maritima</i> (Desf.) Parl.	Asparagaceae
<i>Rosmarinus officinalis</i> L. var. <i>prostratus</i>		Lamiaceae
<i>Rouya polygama</i> (Desf.) Coincy	<i>Thapsia polygama</i> Desf.	Apiaceae
<i>Satureja barceloi</i> (Willk.) Pau	<i>S. fontanesii</i> Briq.	Lamiaceae
<b>BIOINDICATOR TAXA</b>		
<i>Juniperus oxycedrus</i> L. subsp. <i>macrocarpa</i> (Sm.) Ball	<i>J. macrocarpa</i>	Cupressaceae Cupressaceae
<i>Juniperus phoenicea</i> L. subsp. <i>turbinata</i> (Guss.) Arcang.	<i>J. phoenicea</i> var. <i>turbinata</i>	Fagaceae Malvaceae Lamiaceae
<i>Quercus coccifera</i> L. subsp. <i>pseudococcifera</i> (Desf.) Arcang.		Xanthorrhoeaceae Fabaceae
<i>Malva subovata</i> (DC.) Molero & J. M. Monts.	<i>Lavatera maritima</i> Gouan	
<i>Teucrium fruticans</i> L.		
<i>Asphodelus ramosus</i> L. subsp. <i>ramosus</i> <i>Calicotome villosa</i> (Poir.) Link		
	<i>A. microcarpus</i> Viv.	
<i>Thymelaea hirsuta</i> (L.) Endl.		Thymelaeaceae

Valid name	Synonym(s)	Family
<b>INVASIVE TAXA</b>		
<i>Carpobrotus edulis</i> (L.) N.D. Br. var. <i>edulis</i>	<i>Mesembryanthemum edule</i> L.	Aizoaceae
<i>Oxalis pes-caprae</i> L.	<i>O. cernua</i> Thunb.	Oxalidaceae
<i>Agave americana</i> L.		Agavaceae
<i>Opuntia ficus-indica</i> (L.) Mill.	<i>O. maxima</i>	Cactaceae
<i>Opuntia stricta</i> (L.) Mill.		Cactaceae

\*\* / \*\*\* see text concerning the taxon

### Annex 3. Assessment of notable taxa populations by habitat type.

3, abundant; 2, fairly abundant; 1, sparse; 0, taxon absent; -, lack of information Endemism: Algeria, Algeria; Ibi, Ibiza; Libya, Libya; Tunisia, Tunisia; Sicily, Sicily

Valid name	Endemism	Sandy coastal fringe	Rocky coastal fringe	Natural forest	Garrigue
<b>Endemic</b>					
<i>Allium magrebinum</i>	Algeria-Tun. Ibi-Alg.-Tun.-	-	-	-	2
<i>Barnardia numidica</i>	Lyb. ?	-	-	-	1
<i>Bituminaria tunetana</i>	Algeria-Tun.	0	0	0	1
<i>Bunium crassifolium</i>	Algeria-Tun.	-	-	-	1
<i>Genista aspalathoides</i>	Algeria-Tunavia-Sic.	1	1	3	3
<i>Limonium intricatum</i>	Tun.	0	3	0	0
<i>Limonium pyramidatum</i>	Tun.	1	1	0	1
<i>Linaria heterophylla</i> var. <i>dichroa</i>	Tun.	2	0	1	1
<i>Malcolmia doumetiana</i>	Tun.-Lib.	1	0	1	0
<i>Prospero pulchellum</i>	Algeria-Tun. ?	-	-	-	2
<i>Onopordum platylepis</i>	Tun.-Lyb.	0	0	0	1
<i>Sedum pubescens</i>	Algeria-Tun.	0	0	0	1
<b>Rarely threatened</b>					
<i>Muscari maritimum</i>		-	-	-	-
<i>Rosmarinus officinalis</i> var. <i>prostratus</i>		0	1	1	2
<i>Rouya polygama</i>		3	3	0	1
<i>Satureja barceloi</i>		0	2	3	3
<b>Threatened ecosystems</b>					
<b>Bioindicators</b>					
<i>Juniperus oxycedrus</i> -Trees		1	0	1	0
<i>Juniperus oxycedrus</i> -Arbustes		2	2	2	1
<i>Juniperus oxycedrus</i> -Regeneration		1	-	1	1

<i>Juniperus phoenicea</i> -Trees	2	0	2	1
<i>Juniperus phoenicea</i> -Arbutes	3	3	3	2
<i>Juniperus phoenicea</i> -Regeneration	1	-	1	1
<i>Quercus coccifera</i> -Trees	0	0	1	1
<i>Quercus coccifera</i> -Arbustes	1	1	3	2
<i>Quercus coccifera</i> -Regeneration	0	-	1	1
<hr/>				
<b>Upwelling bioindicators</b>				
<i>Malva subovata</i>	0	0	1	1
<i>Teucrium fruticans</i>	0	1	2	2
<hr/>				
<b>Overgrazing bioindicators</b>				
<i>Asphodelus ramosus</i> subsp. <i>ramosus</i>	2	2	2	3
<i>Villosa calico</i>	2	2	2	3
<i>Thymelaea hirsuta</i>	1	1	1	2
<hr/>				
<b>Invasive Exotics</b>				
<i>Carpobrotus edulis</i> var. <i>edulis</i>	3	2	1	1
<i>Oxalis pes-caprae</i>	-	-	-	2
<i>Agave americana</i>	0	1	1	1
<i>Opuntia ficus-indica</i>	0	0	0	1
<i>Opuntia stricta</i>	1	2	2	2



