



Characterisation and conservation assessment of terrestrial biodiversity in the Ghar El Melh area [Report]

IUCN Centre for Mediterranean Cooperation
WWF North Africa



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An introduction and interactive web version of this report is available at:

<https://digital.iucn.org/water/ghar-el-melh-lagoon/> (English)

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Beach Sidi Ali El Mekki. Photo: ©Ugo Mellone

Executive summary

This report presents a conservation assessment of the vegetation, habitats and herpetile fauna within the area covered by Jebel Nadhour and Ghar El Melh KBA and Sidi Ali el Mekki KBA in northeastern Tunisia. The area includes a range of habitats from forest grading through maquis to low over-grazed scrub with sand deposits and rocky habitat on the peninsula, as well as a range of habitats of varying salinity on the plain, from saltmarsh through dunes to agricultural land and a small number of water bodies. Apart from the tip of Jebel Nadhour from Sidi El Haj Embarek to Ras Ettarf and parts of the saltmarsh and coastal dunes south of Ghar El Melh Lagoon, all habitats in the area have been dramatically modified and are degraded. All of the plain on which the soils are not too saline has been converted to agriculture or settlements.

The area supports more than 230 vascular plant species, including *Allium duriaeanum* and *Daucus rouyi* that are globally classed as Endangered and *Stipa tenacissima* which is Vulnerable, as well as *Desmazeria sicula* which is classed as Near Threatened. In addition, a species of *Linaria* has been recorded in the area which appears to be new and requires formal description. There is a need to collect more data on the vegetation of the saltmarsh and dunes to complement data on Jebel Nadhour and provide a comprehensive assessment of the plant conservation of the two KBAs.

Of the 7 species of Amphibians in Tunisia, 5 are found in this area. Among these species reported with certainty, only the Berber toad, *Sclerophrys mauritanicus*, is common and even abundant in the studied area. All other species are rare and some of them are threatened with extinction globally such as *Pleurodeles nebulosus* which is Vulnerable. The reptile population of Ghar El Melh is rich and diverse, with 16 of 17 species confirmed; the total species richness present in this area represents about 28% of the total number of species in Tunisia.

The most significant threat to natural habitats throughout the area is the decline in water quality which ultimately affects most habitats but is particularly important for surface water systems, including the lagoons. Dam construction is also having a significant effect on the quantity of fresh water flowing into the lagoons. The combined effects of reduced freshwater inflow from the catchment and increasing wastewater discharge into the lagoon have potential to tip the ecology of the lagoon beyond its capacity to recover. The second most significant threat to natural resources is construction. In the area, the most damaging current construction project is the development of the new road between Tunis and Aousja via Kalaat el Andaluus. Other construction threats to the natural habitats in the area arise from the poorly controlled construction of

facilities, including houses, recreation facilities and accommodation associated with tourism east of Ghar El Melh and around Sidi Ali el Mekki which are affecting the woodland and scrub, as well as the rocky coast on Jebel Nadhour.

The increase in tourist pressure, linked to the development of both temporary and permanent facilities will have a significant effect on much of the coast. Not only is there already damage and degradation of rocky coastal habitats and the upper margins of sandy beaches, but many subsidiary effects are taking place, such as increases in wastewater discharge into the lagoons and coastal waters, loss of mature trees along the base of Jebel Nadhour to make way for buildings, degradation of both fixed and mobile sand dunes and planting of invasive non-native plants such as *Opuntia ficus-indica* as hedges. Other threats such as the expansion of small-scale agriculture, the increasing spread of non-native species and over-grazing are less important than the direct impacts of human activities, however they too are contributing to the degradation of natural habitats. It is also highly likely that the impacts of many of these threats will be exacerbated by climate change.

The wetland area (paralic environments) as well as the border of the lagoon are the most impacted habitats for herpetiles. Road killings of amphibians during its breeding season, filling the lagoon claiming new areas for agriculture and water pollution are the main threats for the herpetiles in the area.

The most effective method of achieving most, if not all, of the conservation actions needed within the area is to prepare a conservation management plan. This must include a hydrological assessment to provide alternative long-term water supplies to replace those currently provided by dams on rivers and streams. This should be combined with restoration of meanders to the channels of flowing watercourses in the plain and buffer zones along all flowing water courses to reduce pollution. In addition, there is a need for a review of existing wastewater collection, treatment and disposal to inform upgrades and installation of new facilities toward considerable reduction in water pollution in the lagoons and other coastal waters. Innovative alternatives to reduce mortality of animals by road traffic will be also a cost-effective measure to conserve the rich diversity of terrestrial animals such as herpetiles.



Lagoon of Ghar El Melh. Photo by Astiosaurus - CC BY-SA (<https://creativecommons.org/licenses/by-sa/4.0>)

Collaborators

Coordinators

Khouloud Ben Charfi

WWF North Africa

Catherine Numa

IUCN Centre for Mediterranean Cooperation

Authors

Chapter 1

Richard V. Lansdown

Ardeola Environmental Services

Amina Daoud-Bouattour University of Tunis El Manar, Tunis, Tunisia

Zeineb Ghrabi-Gammar Institut national agronomique de Tunisie (INAT)

Imtinen Ben Haj Jilani Institut national agronomique de Tunisie (INAT)

Errol Véla

University of Montpellier

Chapter 2

Ridha Ouni

Department of Biology, University of Tunis El Manar, Tunis,
Tunisia

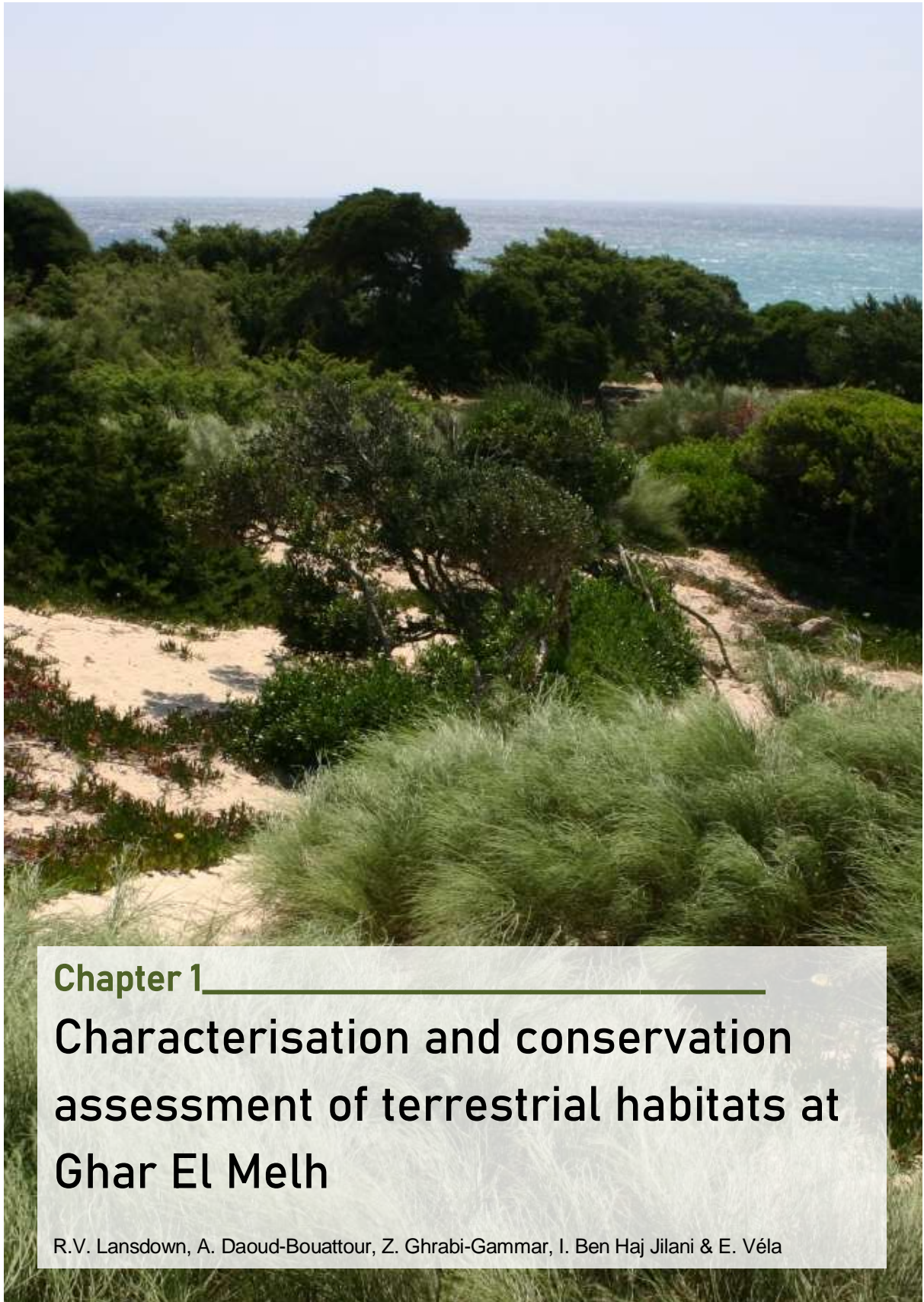
Translation

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Khouloud Ben Charfi [English]

Lay out

Cecilia Saura Drago



Chapter 1 _____
**Characterisation and conservation
assessment of terrestrial habitats at
Ghar El Melh**

R.V. Lansdown, A. Daoud-Bouattour, Z. Ghrabi-Gammar, I. Ben Haj Jilani & E. Véla

Dunes in Sidi Ali el Mekki. Photo: © E. Véla

1.1 Introduction

This report presents the results of surveys of the habitats around Ghar El Melh Lagoon, combined with data from the literature to characterise the vegetation of the lagoon and its surroundings. The area covered by this report extends from the outskirts of Tunis in the south, north to Raf Raf and east to the settlement and peninsula of Sidi Ali el Mekki, mainly following the C69 from Tunis through Utique and Aousja toward Raf Raf in the west (Figure 1). The report forms part of a series of documents supporting work toward the conservation of the Ramsar Site: Lagune de Ghar El Melh et Delta de la Mejerda (see <https://rsis Ramsar.org/ris/1706>), Jebel Nadhour and Ghar El Melh KBA and Sidi Ali el Mekki KBA. The lagoon is located in north-eastern Tunisia, approximately 50 kilometres north of the capital, Tunis (see Figure 1) and 40 kilometres east of the town of Bizerte.

Data were collected by walked surveys of all different habitat types, noting general characteristics of the vegetation, as well as any notable plant species. The aim was to collect reasonably comprehensive data on the occurrence and distribution of vascular plants, with notes on lower plants where practical. Surveys were carried out between the 10th-12th July and 5th-7th November 2019 by the authors of this report.



Figure 1 Location of the study area

The area supports more than 230 vascular plant species (Ghrabi-Grammar and Véla 2008, Appendix B), including the following threatened species (IUCN 2019):

Table 1 IUCN Red List categories for some plant taxa found in Ghar El Melh

Taxon	IUCN Red List		
	Global	EU	Mediterranean
<i>Allium duriaeanum</i>	EN		

<i>Daucus rouyi</i> Spalik & Reduron	EN	
<i>Stipa tenacissima</i> L. s.L.	VU	VU
<i>Desmazeria sicula</i> (cf.) (Jacq.) Dumort.	NT	
<i>Ammophila arenaria</i> (L.) Link subsp. <i>arundinacea</i> H. Lindb.*	DD	
<i>Olea europaea</i> L.		DD
<i>Prospero pulchellum</i> (Munby) Speta	DD	

* - unpublished draft assessment

In addition, a species of *Linaria* has been recorded and is classed as a “trigger species” for the Sidi Ali el Mekki KBA, which was originally recorded as *L. cossonii*, a name recognised by Le Floch, Boulos and Vela 2010 but not by Plants of the World Online (<http://www.plantsoftheworldonline.org>) (PoWo) but it has subsequently been re-determined as *Linaria heterophylla* Desf. var. *dichroa* Litard. & Maire (which is recognised by few published sources). For the purposes of this report, it is recorded as *L. heterophylla* var. *dichroa* but recognising that this identity will almost certainly change.

Habitat and threat codes referred to in this document are reproduced as Appendices C and D respectively. They are derived from the Mediterranean Important Plant Areas project (IPA-MED) and are largely comparable with the classifications used for IUCN Red List assessments.

Names follow Plants of the World Online except in the case of *Rosmarinus officinalis* var. *prostratus* (*R. officinalis* is recognized as *Salvia rosmarinus* Spenn. by PoWo which does not even list var. *prostratus* Pasq.) and *Satureja barceloi* (Willk.) Pau which is recognized as *Micromeria inodora* (Desf.) Benth. by PoWo.

1.2 Habitat description and conservation assessment

1.2.1 General characteristics

The habitats represented within the area can be divided into three groups (see also the habitat map reproduced as Appendix A).

- Areas heavily influenced by salt which extend from the base of Jebel Nadhour around the lagoon margin and the coastal fringe to the south.
- Low-lying agricultural land which occupies the less heavily salt-influenced areas of the plains.
- Forest and scrub with associated habitats on higher ground, mainly on Jebel Nadhour.

Almost all of the habitats within the area have been heavily and extensively modified by humans, to the extent that the only remaining natural habitats are on the eastern extreme of Jebel Nadhour between Sidi Ali el Mekki and Ras Ettarf and some lagoon habitats around Sebkhet el Ouafi Lagoon, Sidi Ali el Mekki Lagoon and the coastal fringe south of Sebkhet el Ouafi Lagoon. Apart from some areas of saltmarsh (presumably on very saline soils), the entire plain has been converted to agriculture, with remnant areas of semi-natural habitat now restricted to the margins of ditches and oxbows. On Jebel Nadhour the woodland has been degraded through, fire clearance and grazing or has been converted to agriculture around settlements such that there is a gradation from low forest on the tip of the peninsula, grading through tall scrub to low over-grazed scrub with scattered arable fields on the slopes above the settlements of Ghar El Melh and Raf Raf.

1.2.2 Lagoons (Habitat 13.4)

Ghar El Melh Lagoon is shallow (<1.9 m deep) and quite strongly saline (37-42 ‰) due to the broad connection to the sea (El Boughaz), with a muddy, anoxic sediment (Scapani *et al.* 2008). Sidi Ali el Mekki Lagoon is lower (< 0.55 m deep) and more strongly saline (40-60 ‰) with a sandier substrate. The vegetation of Ghar El Melh Lagoon can be divided into three zones (Scapani *et al.* 2008):

- The northern area is dominated by the alga *Ulva rigida* and appears more eutrophic, presumably due to wastewater discharge from the village of Ghar El Melh.
- The Central and western parts are relatively species-poor, dominated by *Ruppia cirrhosa* and *Cladophora* sp(p).

- The area around El Boughaz supports a greater diversity with 18 species (Shili et al. 2002) recorded, including *Cymodocea nodosa* and small plants of *Posidonia oceanica*, as well as the invasive alga *Caulerpa racemosa*.

Figure 2 Ghar El Melh Lagoon from the south, with Jebel Nadhour in the background. Photo: © E. Véla



Figure 3 Sidi Ali el Mekki Lagoon from the firebreak above the village. Photo: © R. Lansdown

Table 2 Plant taxa recorded in Ghar El Melh Lagoon (Shili *et al.* 2002)

Taxonomic group	Species	
Green algae (Chlorophyceae)	<i>Acetabularia acetabulum</i>	<i>Codium bursa</i>
	<i>Bryopsis hypnoides</i>	<i>Enteromorpha torta</i>
	<i>Caulerpa prolifera</i>	<i>Enteromorpha intestinalis</i>
	<i>Chaetomorpha linum</i>	<i>Enteromorpha linza</i>
	<i>Derbesia</i> sp.	<i>Ulothrix</i> sp.
	<i>Cladophora rupestris</i>	<i>Rhizoclonium</i> sp.
	<i>Cladophora</i> spp.	<i>Ulva rigida</i>
Red algae (Rhodophyceae)	<i>Ceranium</i> sp.	<i>Herposiphonia secunda forma tenella</i>
	<i>Dasya</i> sp.	<i>Polysiphonia setularoides</i>
	<i>Gracilaria gracilis</i>	<i>Sphaerococcus coronipifolius</i>
	<i>Hypnea musciformis</i>	
Brown algae (<i>Phaeophyceae</i>)	<i>Dictyopteris membranacea</i>	<i>Halopteris filicina</i>
Vascular plants (Angiosperms)	<i>Cymodocea nondosa</i>	<i>Ruppia cirrhosa</i>
	<i>Nanozostera noltii</i>	<i>Ruppia maritima</i>
	<i>Posidonia oceanica</i>	<i>Zostera marina</i>

Notable Taxa

No notable plant taxa have been recorded in the lagoons; however, seagrass beds are of high conservation value.

Threats

The lagoon is already somewhat degraded as a consequence of development pressures such as along the road from the village of Ghar El Melh to Sidi Ali el Mekki, construction of the fishing port of Ghar El Melh (Daoud-Bouattour 2007) (Threats 1.3, 6.1) and other increasing pressure from tourism, combined with domestic wastewater discharge from the village of Ghar El Melh and other settlements around the margin, industrial effluent discharge from the complex at Utique and inflow of water polluted by pesticides and fertilisers through the drainage network (Threats 7.2, 9.1, 9.2, 9.4). The quantity of water reaching the lagoons and even coastal waters is critical for the maintenance of the existing ecology, particularly in the light of potential increases in extreme weather events including droughts due to climate change. Construction of dams (Threats 7.2.4, 7.2.9) on inflow streams such as those flowing off Jebel Nadhour and rivers such as the Mejerda leads to increase salinity levels. The combined effects of reduced freshwater inflow from the catchment and increasing discharge of wastewater and pollutants into the lagoon have potential to tip the ecology of the lagoon beyond its capacity to recover.

Conservation Action

- A review of existing facilities for wastewater collection and treatment, combined with identification of potential for installation of additional facilities for Ghar El Melh and Sidi Ali el Mekki, as well as for houses along the road between the two, as well as upgrading the existing facilities at Aousja and Kalaat el Andalus would go a long way toward reducing eutrophication in the lagoons. Such a review should include potential for use of vegetative water-treatment systems wherever possible.
- Imposition of a requirement for adequate wastewater treatment for all new buildings would also contribute to reducing the pollution of the lagoons and coastal waters.
- There is also a need for a hydrological assessment of the area, combined with a review of current and predicted water requirements to identify alternatives to dams for provision of water for the area and for Tunis.

1.2.3 Saltmarsh and other halophyte communities (Habitats 5.16, 5.17)



Figure 4 Saltmarsh on the south-western margin of Ghar El Melh Lagoon. Photo: © R. Lansdown

The influence of salt on the vegetation can be seen from the coastal fringe inland, at least along water courses, as far as Utique. The margins of all the lagoons support a broad fringe of saltmarsh grading from vegetation dominated by *Sarcocornia fruticosa*, through *Arthrocnemum macrostachyum* to *Halocnemum strobilaceum*, then to *Juncus maritimus* and *J. subulatus*, through *Phragmites australis* or *Bolboschoenus glaucus* to oxbows supporting species such as *Typha domingensis* and *Ruppia* sp. (Daoud-Bouattour *in litt.* 2019). South of Ghar El Melh Lagoon, there is a gradation from the bare sand of the beach, through mobile dunes (see 2.2.5 below) to a zone of seasonal and large, permanent water bodies and saltmarsh. This zone is characterised by shrubby species such as *Atriplex halimus*, *Halocnemum strobilaceum*, *Juncus acutus*, *Limbarda crithmoides*, *Obione portulacoides*, *Suaeda vermiculata* and *S. maritima*, with patchy occurrence of *Limoniastrum monopetalum*, *Limonium virgatum*, *Plantago coronopus* and *Salicornia patula* (*S. europaea* agg.). In less saline habitats, particularly around the small-holder cultivation on the eastern side of Sidi Ali el Mekki Lagoon and along the northern margin of both this and Ghar El Melh lagoon, there is a range of typically coastal or salt-tolerant species such as *Hordeum marinum*, *Parapholis filiformis*, *Silene*

coeli-rosa and *Torilis nodosa* f. *bratiosa*, as well as fringing stands of *Phragmites australis* and *Juncus* species (Daoud-Bouattour *in litt.* 2019).

Notable Taxa

No notable plant taxa have been recorded in the saltmarsh and associated halophile vegetation in the area. However, whilst there is good information on the perennial vegetation, there has yet to be a thorough survey of annual plants or vegetation. It is likely that such a survey would find notable species in these habitats.

Threats

Much of the saltmarsh habitat is relatively intact and appears to be in good condition, mainly because it has not been possible to convert it to other uses. There are areas where it is degraded, such as around the port of Ghar El Melh, wherever settlements are located on the margin of the lagoons such as to the east of Aousja, around seasonal pools in the plains and along creeks and ditches. The ongoing construction of the road from Tunis to Aousja via Kalaat el Andalus has already affected some saline habitats and is likely to have an increasing effect as the hydrology of the plain will be significantly disrupted (Threat 4.1).

Conservation Action

- There is a need for a thorough survey of the annual vegetation of the saltmarsh (and of the coastal dunes) to complement data on perennial plants.
- There is a need to document the settlements which are located in the saltmarsh, including waste treatment and other potentially harmful effects on the habitat.
- There is a need to develop a detailed map of the distribution of saltmarsh, agriculture and development (settlements and industry) on the plains. This should serve as a baseline for monitoring trends.

1.2.4 Agricultural land (Habitats 14.1, 14.2, 14.3, 14.4)

There are three main types of agricultural land within the area surveyed:

- Intensive arable with some orchards on the level ground of the plain.
- Small fields and orchards on the slopes of Jebel Nadhour above Raf Raf and the village of Ghar El Melh.
- Small allotments (a.k.a potagers, culture ramli or guettayas) around the settlement of Sidi Ali el Mekki.



Figure 5 Agricultural land with seasonally flooded areas of remnant saltmarsh east of Utique. Photo: © R. Lansdown

Intensive agriculture occupies most of the plain between the saltmarsh and the hills to the west. Cereals, pumpkin and a few other crops, together with scattered orchards are separated by hedges, ditches or lines of trees and scrub along the lines of former streams and rivers.

Small fields on Jebel Nadhour typically occupy the gentler slopes with easy access from the settlements of Raf Raf and Ghar El Melh. They support no notable plants species but appear to suffer less herbicide and other pesticide application than the more intensive agricultural land and consequently allow a reasonable species diversity to persist in the margins and between fields. The allotments occur wherever there is sufficient depth of soil and a layer of freshwater over the groundwater to enable cultivation and where soils are sufficiently saline to preclude cultivation by other methods. They are not subject to pesticide or other chemical treatment and consequently support a wide range of native species., grading on their margins into the less halophyte-dominated saltmarsh communities.

Notable Taxa

No notable taxa are associated with agricultural land in the area.

Threats

Intensive agricultural habitats and the small fields on the hills are not threatened except by the expansions of settlements and industrial complexes (Threats 1.1, 1.2) but may themselves pose a threat to other habitats and species. Areas of traditional, extensive agriculture are threatened by intensification and industrialisation of agricultural processes.

The allotments are extremely vulnerable to the effects of climate change as well as other factors which may affect the hydrology of the lagoons. They are also critically dependent upon the balance of fresh to saline water and consequently could become unsustainable as a consequence of the construction of dams on streams flowing into the lagoon from Jebel Nadhour. There is also a risk that if no measures are put in place

to treat wastewater from new buildings in Sidi Ali el Mekki, the groundwater will become contaminated which could increase the risk of diseases among people using vegetables produced from the allotments.

Conservation Action

The allotments represent an ancient traditional cultivation method which is un-intensive and therefore enables the persistence of a wide range of native plant species, it also has potential to contribute to cultural aspects of tourism. It is important to ensure that this practice is allowed to continue. Areas need to be identified and designated for this use, particularly in the face of increasing development pressure in the area.



Figure 6 Traditionally grown Pumpkins drying in the sun south of Kalaat el Andalus. Photo: © R. Lansdown

1.2.5 Ditches and other freshwater wetlands (Habitats 15.1, 15.2, 15.7, 15.8, 15.9)



Figure 7 Heavily overgrown and shaded canalised channel south of Aousja. Photo: © R. Lansdown

A range of wetland types occurs within the area:

- Two arms of the Mejerda River which flow from the hills in the west, to the sea south of Ghar El Melh lagoon. Both of these water courses have been heavily modified, with trapezoid channels and engineered flood relief bunds. They support very little marginal vegetation and even less channel vegetation., all of which appears to be very species-poor. The former floodplains have been converted to arable and support no vegetation of note.
- A number of small seasonal streams flowing off Jebel Nadhour south into Ghar El Melh and Sidi Ali el Mekki Lagoons. These small streams are generally reasonably intact, although small dams are being constructed on an increasing number for water supply to houses in Ghar El Melh and the ribbon development to the east. Apart from dams, these streams are typically modified only as far as the adjacent habitats have been degraded through clearance and grazing. In many areas they are quite deeply incised into the bedrock of the hills, creating gorge-like conditions which support diverse bryophyte communities.
- A number of large linear water bodies cross the plain, which resemble the river channels except that flow is slow or lacking. As is the case with the river, these canals support little or no aquatic or wetland-dependent vegetation.
- There are ditches throughout the area, ranging from narrow channels designed to carry excess flow off arable fields and away from settlements on the hills, to road drains and the multitude of field drains crossing the plain. Most of these ditches carry or hold water only for hours or at most a few days and

support few wetland-dependent plants, apart from occasional *Cyperus* species and the non-native *Symphyotrichum subulatum*. Those ditches which do hold water for longer are mainly in arable areas of the plain and are dominated by *Phragmites australis*.

- There are a few small standing water bodies in the plains. Most of those which still have a natural structure and hydrology are situated in remnant patches of saltmarsh or *Juncus* stands around settlements. They are typically polluted, eutrophic and otherwise degraded, supporting only low plant species diversity and no notable taxa. In a few areas, particularly in the southern part of the plain around the new road, there are extensive seasonally inundated areas in fields where the crop has failed due to inundation. Most of these are largely bare, supporting only a few scattered halophytes, but one immediately adjacent to a junction on the road supported a good stand of *Damasonium bourgaei*.



Figure 8 Saline canal confluence south of Aousja. Photo: © R. Lansdown



Figure 9 Saline seasonal pool east of Utique. Photo: © R. Lansdown

- In a few places, large oxbow lakes occur, remnants of the former dynamic hydrology of the plain. Most of these are overgrown by dense scrub and or polluted and support no species of note, although one area along a former river channel is shaded by trees supported extensive carpets of acrocarpous mosses such as *Aloina*, *Barbula* and *Didymodon* species, with liverworts of the genus *Fossombronia*. One oxbow just outside Utique, although much degraded in parts, supports a wide range of wetland-dependent plants dominated by beds of *Phragmites australis*, *Schoenoplectus tabernaemontani* and *Typha domingensis*, with *Chara connivens*, *Ruppia* sp., *Ulva flexuosa* and *Vaucheria* species in the water and the banks covered with *Tamarix* sp. supporting a large stand of *Cynanchum acutum*.
- There are a few water storage small reservoirs on the plain.

Notable Taxa

No globally threatened species have been recorded in association with non-lagoon wetlands in the area. However, *Chara connivens* and *Damasonium bourgaei* are remnants of what may have been important wetland vegetation in the past and it is possible that restoration of freshwater wetlands could restore species from the seed or spore bank. The main conservation value of freshwater and less saline wetlands in the area is as habitat for animals, apart from the oxbow at Utique which could support other species, particularly charophytes, of note and some of the small streams on the hills which could support notable bryophytes.



Figure 10 Construction of the crossing of the River Mejerda by the new road from Tunis to Kalaat el Andalus. Photo: Google Earth

Threats

Apart from a few of the small seasonal streams flowing south off Jebel Nadhour, all water bodies in the area suffer from some level of water quality decline (Threats 7.2, 9.1, 9.2, 9.4). This is caused by a range of factors, including:

- Sediment mobilisation and run-off due to increased erosion as a consequence of actions such as grazing, use of unmetalled roads, arable farming without adequate buffer zones and development. The degree of sediment mobilisation from the new road from Tunis to Aousja is striking with all flowing water extremely turbid and deposits of silt throughout when the site was visited in October 2019. This will have significant effects on streams, rivers, lagoons and coastal waters.
- Un-treated or inadequately treated domestic waste water discharge. This is a particular risk with new development along the road east of Ghar El Melh and around Sidi Ali el Mekki where the space available for wastewater treatment is very limited and will become increasingly constrained with ongoing development. It also appears highly unlikely that any of the small settlements on the margins of the lagoons will have adequate wastewater treatment facilities. There is a need for formal planning and provision of water collection and treatment facilities for all settlements, linking in small and isolated settlements with systems installed for the larger villages and towns.
- Water abstraction, either directly from springs, from underground sources or by construction of dams, affects all flowing water bodies in the area. This abstraction causes a reduction in flow with secondary effects, such as reduced hydroperiod, reduction of the humidity profile, leading to declines in bryophyte populations and reduced of dilution of pollutants.
- In general, development throughout the area is adding pressure to the level and extent of degradation of flowing freshwater habitats (e.g. the crossing of the River Mejerda by the road from Tunis to Kalaat el Andalus), either by constraining channels or by increasing the artificialisation of channels.

Conservation Action

The degree of degradation of almost all non-lagoon wetlands in the area is such that these have little or no conservation value, except as habitat for a fairly impoverished fauna. Only through extensive restoration work can this be remedied. Actions are needed such as:

- Restoration of a meanders to the channels of flowing water courses in the plain, including use of seasonal wetlands to provide flood storage capacity and possibly water pollution attenuation.
- Establishment of buffer zones along all flowing water courses, as well as along ditches.
- Hydrological assessment to provide long-term water supplies to replace those currently provided by dams on rivers and streams.

1.2.6 Sandy habitats (fixed and mobile dunes) (Habitat 13.3 and unclassified)



Figure 11 *Daucus rouyi* (*Thapsia polygama*). . Photo: © R. Lansdown

Psammophilous (sand-loving) vegetation occurs in three main places in the survey area:

- Fixed dunes and sand deposits on Jebel Nadhour. Most of this habitat on the north face of Jebel Nadhour east of Raf Raf is planted with *Pinus pinea*, along the crest of the hill, throughout much of the peninsula, there are extensive areas where *Acacia cyclops* is dominant or actually forms monospecific stands. It is not clear whether these have replaced former areas of indigenous forest or whether these areas were formerly bare. This area supports little natural vegetation apart from the planted trees on most of the slopes but along the lower part of the hill, above the sea there is a reasonably diverse band of vegetation, including species such as *Linaria heterophylla* var. *dichroa*.
- The beach and narrow fringe of dunes below Sidi El Haj Embarek and extending almost to Ras Ettarf support sparse vegetation including: *Aeluropus litoralis*, *Arthrocnemum macrostachyum*, *Atriplex portulacoides*, *Cakile maritima*, *Elymus farctus* subsp. *farctus*, *Eryngium maritimum*, *Euphorbia paralias*, *Limonium* spp., *Lotus creticus*, *Polygonum maritimum* and *Salsola kali*. Similar sandy areas along the coast support other species such as *Cyperus capitatus* and *Eryngium maritimum*.

- Between the beach and the saltmarsh, south of Ghar El Melh Lagoon there is a band of mobile dunes supporting species such as *Cakile maritima*, *Crucianella maritima*, *Eryngium maritimum*, *Euphorbia paralias*, *Plantago coronopus* and *Rumex bucephalophorus*.

Notable Taxa

Psammophilous habitats on Jebel Nadhour support a range of notable taxa, particularly *Daucus rouyi* which occurs in large, dense populations in sandy areas both on the crest and above the rocky coast, as well as patchy *Linaria heterophylla* var. *dichroa* among the planted pines near Sidi Ali el Mekki. No notable taxa have been recorded in the beach and mobile dune but there has been no comprehensive survey of the coastal dunes in the southern part of the KBA.

Threats

In addition to the extensive *Pinus pinea* plantation on fixed dunes and the apparent preferential colonisation of open areas on sand by *Acacia cyclops* on the crest of Jebel Nadhour, the main threat to the vegetation of these habitats is from increasing tourism (Threats 1.3, 6.1). This is particularly apparent along tracks over sandy ground between Sidi Ali el Mekki beach and Ras Ettarf, where casual use of the tracks has caused them to spread to a width of up to 10 m of bare sand. Equally, the mobile dunes south of Ghar El Melh Lagoon are vulnerable to uncontrolled vehicle access, as well as destabilisation as a result of the many people walking over them. Improved access to this area and Sidi Ali el Mekki beach provided by the new road from Tunis through Kalaat el Andalus to Aousja will almost certainly increase pressure on these habitats.

Conservation Action

- It is difficult to see how the beach between Sidi El haj Embarek and Ras Ettarf can be protected from tourism, given that it is the focus of intensive establishment of tourist facilities. Much could be achieved to reduce the impact of tourism on the fixed dunes on Jebel Nadhour and the mobile dunes along the beach south of Ghar El Melh by providing defined and marked access routes. These could be installed in a way which encourages people to follow them and discourages casual access away from these routes.
- If *Pinus pinea* plantations are harvested, this needs to be done in a way which minimises damage to the soil structure and mobilisation of the sand. If they are not to be harvested then they should be selectively felled out in small groups, allowing re-establishment of natural regeneration of native species progressively as the plantations are cleared.
- There is a need for a survey of the vegetation of the coastal dunes south of Ghar El Melh Lagoon to document species diversity and locate any populations of notable taxa.

1.2.7 Rocky coast (Habitat 13.1 and unclassified)

This is a zone either grading from bare, very rocky cliffs above intertidal bedrock exposures or from the beach into the downhill margins of the indigenous woodland. It is characterised by species such as *Crithmum maritimum*, *Cyperus capitatus*, *Daucus rouyi*, *Limbarda crithmoides* subsp. *longifolia*, *Limonium intricatum*, *L. pyramidatum*, *Medicago marina*, *Pancratium maritimum*, *Thymelaea hirsuta* and *Zygophyllum album*. In a few areas north of Raf Ettarf, there are patches of *Schoenus nigricans* and *Carex flacca*, presumably where there is seepage of fresh water. At the upper edge of this zone, the vegetation grades into the lower shrubby elements of the indigenous woodland.



Figure 2 Casual construction of wooden tourist facilities along Ghar El Melh beach. Photo: © R. Lansdown

Notable Taxa

Many of the species which are widespread on the slopes and crest of the peninsula extend onto the rocky coast. In particular *Daucus rouyi* and *Rosmarinus officinalis* var. *prostratus* are widespread along the upper margin of this habitat, while *Limonium intricatum* and *L. pyramidatum* are particularly strongly associated with this habitat.



Figure 11 The coastal zone and Ghar El Melh Beach, showing the gradation from the marine fringe through bare sand to scrubby juniper-dominated vegetation. Photo: © R. Lansdown



Figure 12 Building construction on the base of the hill, along the coastal fringe. Photo: © R. Lansdown

Threats

The rocky coast between Sidi Ali el Mekki beach and Ras Ettarf is already becoming degraded both by intentional actions associated with the construction of tourist facilities and by increasing casual access by tourists moving out from the beach (Threats 1.3, 6.1). The ongoing installation of facilities supporting beach recreation, such as wooden shelters, buildings which often have electricity through generators and formal construction of steps, ramps and platforms, as well as planting of non-native *Opuntia ficus-indica* as hedges, are all adversely affecting the vegetation of the coast. This is likely to continue and increase significantly as more affluent tourists are ferried by boat to the more remote areas.

Conservation Action

It is difficult to see how development of tourist infrastructure along this coast can be controlled except by designation and enforcement of zones within which no infrastructure is allowed, including temporary structures.

1.2.8 Indigenous woodland and scrub (Habitats 1.4.4, 3.8.1, 3.8.2, 3.8.3)

Indigenous woodland extends from the fire break west of Sidi Ali el Mekki to the tip of the peninsula at Ras Ettarf (see Figure 13). The upper canopy is characterised by *Pinus halepensis* and *Juniperus phoenicea* subsp. *turbinata*, with *Quercus coccifera* subsp. *pseudococcifera* and *Juniperus oxycedrus* subsp. *macrocarpa* over lower shrubs or bushes of *Pistacia lentiscus* and *Phillyrea* species. Gaps in the vegetation support shrubby *Cistus salvifolius*, *Erica multiflora*, *Genista aspalathoides*, *Retama raetam* subsp. *bovei*, *Rosmarinus officinalis* subsp. *officinalis* and *Thymbra capitata*, over a diverse ground flora. On the east-facing slope from Ras Ettarf north the woodland is lower and shrubbier.

The woodland is more species-rich and varied in the eastern part of the peninsula from Sidi Ali el Mekki eastward, west of which it is more impoverished with fewer *Juniperus oxycedrus*, *J. phoenicea* and *Quercus*

coccifera and the canopy in places is almost entirely dominated by *Pinus halepensis*. Fire breaks typically support species which elsewhere form the shrub layer and provide an indication of the vegetation which develops when trees are cleared, including *Acacia cyclops*, *Brachypodium ramosum*, *Cistus salvifolius*, *Dittrichia viscosa*, *Ephedra fragilis*, *Fumana scoparia*, *Genista aspalathoides*, *Globularia alypum*, *Hippocrepis multisiliquosa*, *Phagnalum rupestre*, *Retama raetam* subsp. *bovei*, *Rhamnus myrtifolia*, *Rosmarinus officinalis* var. *prostratus*, *Satureja barceloi*, *Sedum sediforme*, *Stipa tenacissima* and *Thymbra capitata*.



Figure 13 The southern face of t Jebel Nadhour looking west from Sidi El Haj Embarek, showing the gradation from diverse woodland in the east to species-poor *Pinus halepensis*-dominated woodland in the west. Photo: © R. Lansdown



Figure 14 Scrubby habitat characteristic of past over-grazing immediately above the coastal road. Photo: © R. Lansdown



Figure 15 Mature *Quercus coccifera* subsp. *pseudococcifera* on level ground among recent buildings. Photo: © E. Véla

At the base of the hill along the road to the village of Ghar El Melh, between the lagoon and the hill there are the remains of a band of taller woodland, involving large, mature *Ceratonia siliqua* and *Quercus coccifera* subsp. *pseudococcifera* trees. This band of taller woodland apparently formerly occupied much of the level ground between the halophytic vegetation on the lagoon margin and the base of the slopes. Most of this band of taller woodland has been lost to uncontrolled ribbon-development along the road and this process continues. There are occasional taller *Q. coccifera* subsp. *pseudococcifera* trees in some of the shallow valleys running down the hill and it is possible that these represent remnants of more widespread high forest, although it is clear that this would not have extended to the tip of the peninsula.

Where the trees have been removed or damaged, the indigenous woodland is replaced by low scrub (garrigue) which is characterised by species typical of the understorey of the indigenous woodland. This includes species such as *Genista aspalathoides*, *Retama raetam* subsp. *bovei*, *Rosmarinus officinalis* var. *officinalis* and *Thymbra capitata*, as well as a number of other species typical of over-grazed habitats, such as *Asphodelus ramosus*, *Calicotome villosa* and *Thymelaea hirsuta*. This vegetation is well-developed on the southern slope of the hill above the two lagoons and in particular, near the masts above the village of Ghar El Melh, there are the remains of terraces and the scrub shows very strong evidence of past over-grazing with some evidence of renewed grazing. This habitat is characterised by very scrubby vegetation dominated by *Calicotome villosa*, *Rosmarinus officinalis* var. *officinalis* and *Thymelaea hirsuta*, with *Ampelodesmos mauritanicus*, *Asphodelus ramosus*, *Brachypodium ramosum*, *Carlina lanata*, *Centaurea* sp., *Cistus salviifolius*, *Cutandia divaricata*, *Daucus carota*, *Dittrichia viscosa*, *Genista aspalathoides*, *Marrubium vulgare*, *Onopordon platylepis*, *Quercus coccifera* subsp. *pseudococcifera* (bushes), *Rhamnus lycioides* subsp. *oleoides*, *Satureja barceloi*, *Scolymus hispanicus*, *Stipa tenacissima*, *Teucrium fruticans* and *Thymbra capitata*.

An area to the east, just below the crest, is characterised by bare ground with scattered low, shrubby plants, showing evidence of past over-grazing with current heavy grazing pressure and extensive exposures of karstic limestone. In this area *Brachypodium ramosum*, *Calicotome villosa*, *Genista aspalathoides* and *Rosmarinus officinalis* var. *officinalis* are dominant with *Ampelodesmos mauritanicus*, *Blackstonia perfoliata*, *Capparis spinosa*, *Carlina lanata*, *Convolvulus lineatus*, *Dittrichia viscosa*, *Erica multiflora*, *Malva subovata*, *Marrubium vulgare*, *Pistacia lentiscus*, *Ruta chalepensis*, *Satureja barceloi*, *Thymbra capitata* and *Thymelaea hirsuta*, with occasional local patches of *Pinus halapensis* and *Pinus pinea*. Acrocarpous mosses were very abundant in soil-filled hollows in limestone exposures.



Figure 16 Scrubby habitat typical of past and ongoing over-grazing near the television masts. Photo: © R. Lansdown

An additional habitat which has completely replaced the natural vegetation include extensive *Pinus pinea* plantations, a small one on the southern flank of Jebel Nadhour and an extensive plantation covering the lower slopes of the northern flank of Jebel Nadhour.

Notable Taxa

The woodland and scrub, grading into garrigue and phrygana, support most of the notable plant species recorded from the area. In particular *Allium duriaeanum*, *Daucus rouyi*, *Genista aspalathoides*, *Muscari maritima*, *Rosmarinus officinalis* var. *prostratus*, *Satureja barceloi* and *Stipa tenacissima* all occur wherever habitat is suitable. Ironically, past over-grazing throughout all but the eastern extreme of Jebel Nadhour with some continued lighter grazing has led to conditions which are particularly favourable for many of these species, with extensive bare or open ground among scrubby bushes and patches of scrub with occasionally trees. This open habitat favours many of the bulb-forming species and other notable taxa which currently occur in some abundance.

Threats

- Most of the habitat degradation due to over-grazing (Threat 2.3.3) or fire (Threat 7.1.1) continues to be a threat, in spite of recent work to control fires, leaving extensive areas which support scrubby vegetation which would, presumably, if left alone, eventually revert to indigenous woodland. However, there is an area above the town of Ghar El Melh where the influence of past overgrazing is becoming exacerbated by current grazing. The effects of over-grazing can most effectively be monitored through use of aerial imagery to map the extent of extant woodland, compared to scrub and open habitats. Degradation causing modification of the indigenous semi-natural woodland, may

also be a consequence of past selective felling of mature trees, particularly of *Juniperus oxycedrus* subsp. *macrocarpa*, *J. phoenicea* subsp. *turbinata* and *Quercus coccifera* subsp. *pseudococcifera*. The woodland and scrub on Jebel Nadhour continue to be threatened. The natural woodland and scrub are also threatened by expansion of small-holder agriculture on level ground near the villages of Ghar El Melh and Raf Raf (Threat 2.1.2).

- Loss of tall, mature trees is occurring at the base of the hill due to construction of buildings along the road (Threats 1.1, 1.3, 6.1). This construction is apparently occurring under permits issued by the Ghar El Melh municipality. However, there is an urgent need to bring this development under control as it is threatening many of the most mature trees remaining in the area as well as threatening significant areas of the coastal fringe. The effects of this construction can most effectively be monitored through use of aerial imagery to map the extent of a) construction and b) clearance of vegetation. In some cases, mature trees are actually protected by their inclusion within gardens or around houses, however these represent exceptions to the normal situation.
- There is also quite a lot of uncontrolled clearance of native vegetation among and around houses. This needs to be quantified and controlled. Some habitat is also being lost to expansion of small-scale agriculture.
- Non-native species such as *Acacia cyclops*, *A. karoo*, *A. saligna*, *Agave americana*, *Carpobrotus edulis* and *Opuntia ficus-indica* are widespread and increasing, colonising open habitats as well as displacing native species. This spread is exacerbated by planting of some of these species for ornament and as hedges.

Conservation Action

Apart from the ongoing loss of mature trees along the base of the hill, most of the woodland and scrub on Jebel Nadhour appears either to be in good condition, to be providing temporarily suitable habitat for notable herbs or to be recovering toward good condition. There is therefore a need to monitor the condition of different elements of this habitat, particularly in relation to development and the expansion of small-scale agriculture, but also as the suitability of the habitat for notable species changes. The most effective way to do this is to use remote tools, supported by infrequent ground truthing.

There is also a need to monitor the condition of the mature trees along the base of the hill. This could best be done by tagging all of the trees in combination with remote methods for monitoring construction.

1.2.9 Cliffs and other rock exposures (Habitat 6.2)

Cliffs and rock outcrops occur throughout Jebel Nadhour. These vary from a discontinuous line of outcrops along the northern face of the crest, mirrored by other more broken lines on the slopes above Raf Raf, to isolated boulders and bedrock exposures in gorges and the predominantly rock slope above Ras Ettarf.

Notable Taxa

In many places shelves and hollows in the rock faces have filled with soil and these support a wide range of plants, including *Allium duriaeanum* and *Satureja barceloi*. However, no specific saxicolous taxa of note have been recorded.

Threats

No threats specific to this habitat have been recorded. Where vegetation is cleared away from rock faces, this leads to a decline in humidity and ultimately loss of the bryophyte flora and where goats have access to these rock exposures, they will often graze and trample the pockets of soil, leading to the loss of all vegetation. However, these threats are not yet widespread.

Conservation Action

There is no need for specific action to conserve these habitats for their vegetation, as they are rarely threatened. However, they are likely to be extremely important both for bat roosts (in caves) and for reptiles. It is therefore important that the condition of these outcrops is monitored.



Figure 17 Rock outcrops along a valley above the village of Ghar El Melh. Photo: © R. Lansdown

1.2.10 Settlements and other anthropogenic habitats (Habitats 14.4, 14,5)

There are settlements throughout the survey area. The largest of these are Kalaat al Andalus, Aousja, Raf Raf, Ghar El Melh and Sidi Ali el Mekki. These areas include a wide range of habitats, from hedges and gardens to open, waste ground between housing plots. In addition to planted species, these areas generally support a diverse range of ruderals and many non-native species such as *Arundo donax* and *Symphotrichum squamatum*. These habitats are generally of very low conservation value but occasionally

where they have suffered little damage, they may support notable species. Some of these areas from Sidi Ali el Mekki to Ghar El Melh, including gardens and areas between housing plots are now important for the remaining mature *Quercus coccifera* and *Ceratonia siliqua* trees.

Notable Taxa

The only notable taxon recorded in settlements in the area is the as yet taxonomically unclear *Linaria heterophylla* var. *dichroa*, which occurred alongside a track on the western edge of Sidi Ali el Mekki and around houses to the east of Raf Raf beach.

Threats

The only threats to habitats in and around settlements arise from increased urbanisation, the spread of industrial units leading to a loss of open and green spaces in settlements and the “tidying” of areas around buildings which will lead to a loss of notable ruderal species.

Conservation Action

There is no need for specific action to conserve these habitats for their vegetation or the species which they support.

1.3 Threats

Table 3 presents a summary of the threats identified as potentially affecting the features of note and importance associated with the Jebel Nadhour and Ghar El Melh KBA and the Sidi Ali el Mekki KBA and IPA. The level of importance is based on a three-point scale, based on the following criteria:

Timing	Scope	Severity	Importance
Ongoing	whole (> 90 %)	Rapid decline	High
Future	majority (50-90 %)	Slow decline	Medium
Past	minority (< 50 %)	Negligible decline	Low

The level of importance given in the table is then based on the highest level of threat identified.

Table 3 Threats potentially affecting habitats or species in Ghar El Melh

Feature (Habitat or species)	Threat	Importance	Recommended response
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Lagoon	Development	High	Planning controls
	Tourism	High	Planning controls
	Wastewater discharge	High	Installation of treatment facilities
	Water abstraction	Medium	Hydrological assessment
Saltmarsh	Habitat degradation	Medium	Planning assessment and controls
	Development	High	Planning controls
Agricultural habitats	Intensification	Medium	Unknown
	Development	Medium	Planning controls
Freshwater wetlands	Sediment mobilisation	High	Buffer zones, good practice guidance
	Wastewater discharge	High	Installation of treatment facilities
	Canalisation	Medium	Habitat restoration
	Water abstraction	Medium	Hydrological assessment
Sandy habitats	Pine plantation	Medium	Felling and restoration
	Invasive alien species	High	Planning controls, eradication
	Tourism	High	Planning controls, good practice
Rocky coast	Tourism	High	Planning controls, good practice
	Invasive alien species	High	Planning controls, eradication
Woodland and scrub	Over-grazing	Low	Managed stocking levels
	Development	High	Planning controls
	Domestic clearance	Medium	Good practice
	Invasive alien species	High	Planning controls, eradication
Cliffs and rock exposures	Decline in shading	Medium	Good practice
Settlement	Urbanisation	Low	Planning controls

The most significant threat to natural habitats throughout the area is the decline in water quality. This arises through a range of influences, from untreated or inadequately treated domestic and industrial waste water discharge into water bodies, discharge of industrial effluent into water bodies and sediment mobilisation and run-off from erosion resulting from poor management of agriculture and unmetalled roads. Most habitats throughout the area are affected by the decline in water quality, but the most severely affected are the lagoons and coastal waters which are the last stage of dispersal of pollutants and sediment.

Dam construction on streams flowing off Jebel Nadhour is also having a significant effect on the quantity of fresh water flowing into the lagoons from the north, as is construction of dams on the upstream reaches of the rivers flowing into the lagoons from the west. The combined effects of reduced freshwater inflow from the catchment and increasing wastewater discharge into the lagoon have potential to tip the ecology of the lagoon beyond its capacity to recover.

The second most significant threat to natural resources is construction. In the area the most damaging current construction project is the development of the new road between Tunis and Aousja via Kalaat el Andalus. This road is already disrupting the hydrology of the plain and causing mobilisation of large quantities of sediment into water courses but will have dramatic impacts on natural species and habitat for years to come through increased access to vulnerable areas and particularly the increase in tourism associated with Sidi Ali el Mekki. Other construction threats to the natural habitats in the area arise from the poorly controlled construction of facilities, including houses, recreation facilities and accommodation associated with tourism east of Ghar El Melh and around Sidi Ali el Mekki which are affecting the woodland and scrub, as well as the rocky coast on Jebel Nadhour. Expansion of other settlements, including development of industrial facilities in the plain are also damaging natural habitats.

The increase in tourist pressure, linked to the development of both temporary and permanent facilities will have a significant effect on much of the coast. Not only is there already damage and degradation of rocky coastal habitats and the upper margins of sandy beaches, but many subsidiary effects are taking place, such as increases in wastewater discharge into the lagoons and coastal waters, loss of mature trees along the base of Jebel Nadhour to make way for buildings, degradation of both fixed and mobile sand dunes and planting of invasive non-native plants such as *Opuntia ficus-indica* as hedges.



Figure 18 Hillside between the village of Ghar El Melh and Sidi Ali el Mekki dominated by the non-native *Opuntia ficus-indica* with *Agave americana*. Photo: © R. Lansdown

Other threats such as the expansion of small-scale agriculture, the increasing spread of non-native species and over-grazing are less important than the direct impacts of human activities, however they too are contributing to the degradation of natural habitats. It is also highly likely that the impacts of many of these threats will be exacerbated by climate change.

1.4 Conservation

Three plans have been produced to inform management of parts of the area (APAL 2010, WWF-DGF 2011, WWF-DGF 2012). None of these have been designed for the long-term and none have developed a set of

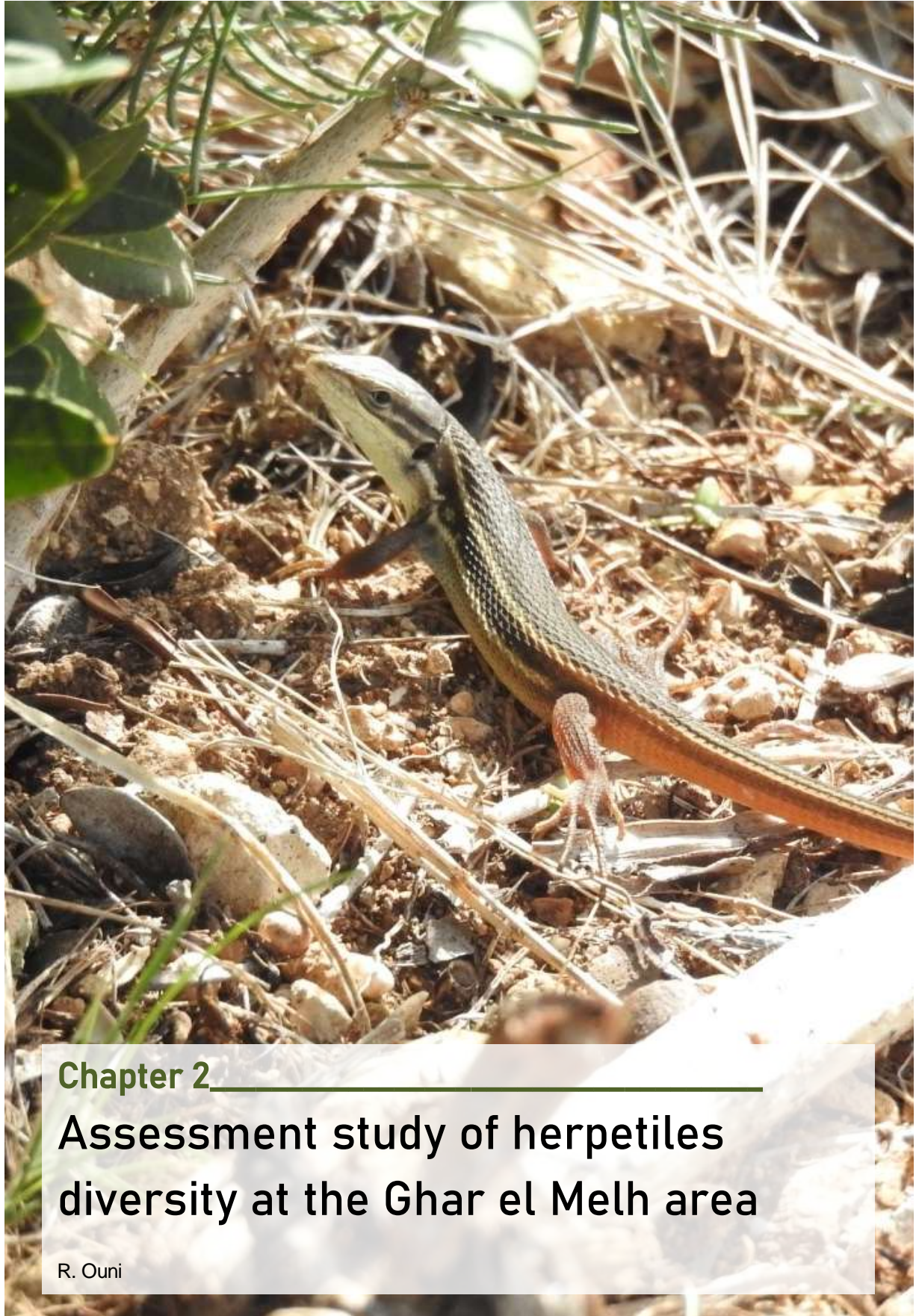
targets for habitat conservation throughout the zone of influence of the lagoons. There is a need to develop a conservation management plan for the area of influence of both KBAs. This would necessarily include both faces of Jebel Nadhour, both lagoons and the coastal strip south beyond Kalaat al Andalus, possibly as far as Mariana on the northern border of Tunisia, as well as the plain and aspects of the Mejerda catchment. This must include a hydrological assessment to provide long-term water supplies to replace those currently provided by dams on rivers and streams.

The management plan must include a review of all wastewater treatment and disposal within this area, particularly the capacity of existing facilities, as well as all disposal and quality of treated water. It must also include identification of locations for installation of wastewater collection and treatment facilities for the villages of Aousja, Ghar El Melh, Sidi Ail el Mekki, Kalaat el Andalus and Sidi Ali el Mekki, as well as imposition of a requirement for installation of facilities to deal with wastewater on all new developments. This work should include a review of isolated dwellings, particularly along the margins of the lagoons and should be linked to mapping of the distribution of saltmarsh, agriculture and development (settlements and industry) on the plains. This provision of services will contribute to reducing water pollution both in small standing water bodies, streams and rivers and more significantly in the lagoons. Reinstatement of meanders to the Mejerda could include creation of areas of vegetation within the channel through which the water would be allowed to flow and which would improve water quality. Similarly, upgrading of wastewater treatment should include consideration of potential to use vegetative treatment systems to improve water quality before discharge.

The boundary of the Sidi Ali el Mekki Important Plant Area (Valderrábano, Heywood and de Montmollin 2018) should be modified to include the known distribution of all the notable plant species documented in the area to-date and based on a detail habitat map. This should involve extension of the boundary to include the entire Jebel, as far west as the road from Aousja to Raf Raf. The boundary of the Sidi Ali

There is a clear need for local action to address the causes of habitat degradation in the area, including provision of defined and marked access routes on the beach, the rocky coast between Sidi El haj Embarek and Ras Ettarf and the coastal dunes, ensuring that methods for harvesting *Pinus pinea* plantations minimises damage to the soil structure and mobilisation of the sand and designation and enforcement of zones within which no infrastructure is allowed.

Data collected on the distribution and abundance of aquatic plants in the lagoons will also serve to inform habitat and species conservation action. However, data are not currently adequate to assess the conservation value and species diversity of the saltmarsh and coastal dunes. There is therefore a need for thorough survey of these habitats.



Chapter 2

Assessment study of herpetiles diversity at the Ghar el Melh area

R. Ouni

Psammodromus algirus. Photo: © R. Ouni

2.1 Introduction

The herpetofauna of Tunisia has a total of 68 species: 7 Amphibians and 61 species of Reptiles without counting sea turtles (Nouira, 1996 and 1998). The latter are represented by 3 chelonians (two freshwater turtles is one terrestrial), 1 amphisbaena, 34 saurians (lizards) and 23 ophidians (snakes: snakes and vipers). Among the latter, a certain number is found in the region of Ghar El Melh.

The purpose of this work is to identify the species, draw up the taxonomic list of herpetofauna and analyze its importance in relation to that of the country. Particular attention is to the biotopes and the spatial occupation of Amphibians and Reptiles in the studied sector while indicating the threats and pressures exerted on this fauna.

2.2 Study area

The study site includes the entire Sidi Ali el Mekki peninsula, a natural extension of Jebel Ennadhour. This area is an agricultural sector adjoining the northern part of the Gulf of Tunis, between "Cap Farina" and the estuary of the Medjerda river. Much of this region (almost 34 km²) is occupied by a lagoon that is 7 km long and about 4.5 km wide (Figure 19).

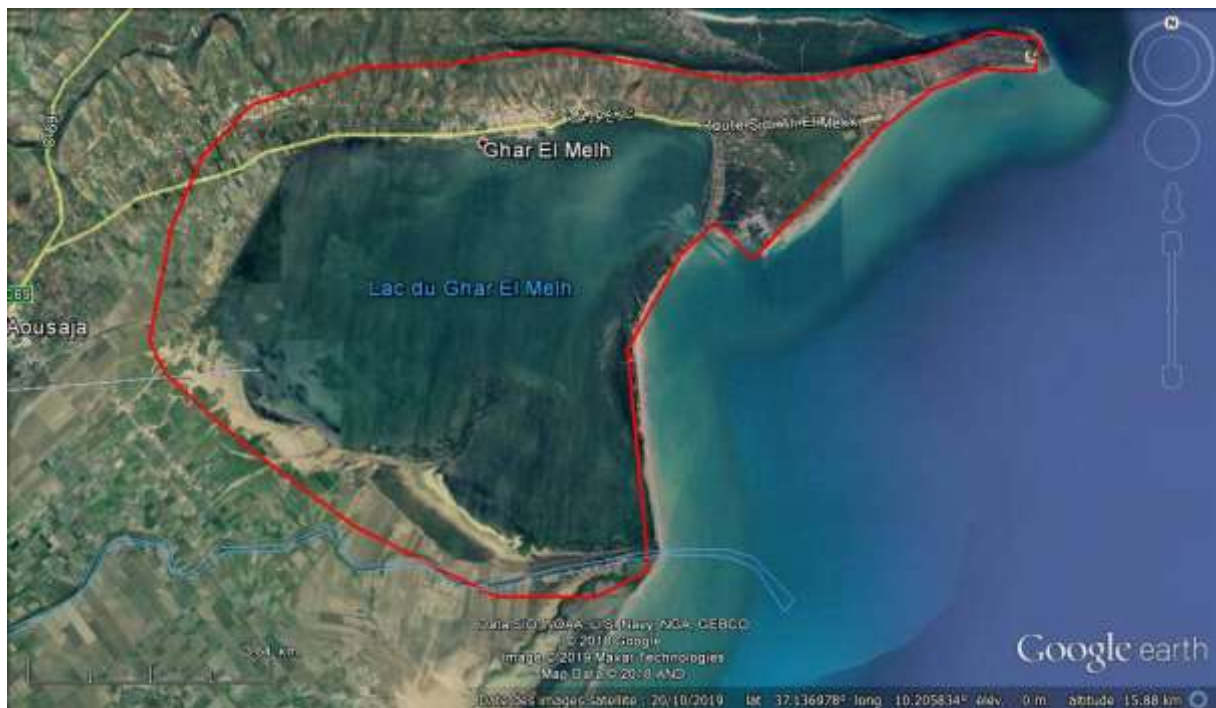


Figure 19 Delimitation of the Ghar El Melh study area

2.3 Methodology

This investigations aim to assess the state of populations and biotopes, particularly the distribution of notable amphibian and reptile species on the site and the habitats on which they depend by analyzing the site's biodiversity and ecological characteristics. In order to achieve these objectives and as the study concerns coastal regions, the transect method was adopted, often going from the sea to the continental limits of each habitat. The herpetofauna associated with the various plant formations and various environments was determined by direct observation and indices of the presence or recognition of species based on the traces of reptiles, in particular on sandy soils, burrows, or even the sound in the case of Amphibians.

Due to the time allocated to this work, the hibernation season of the animals and the climatic conditions during our field investigations, several techniques could not be applied to determine the density of the populations. Its assessment is therefore expressed in terms of abundance according to expert's experience and by comparison of populations of the same species studied at the same time in other sectors of Tunisia. The frequency of a specie is assessed indirectly by the type and number of habitats that are likely to harbor the species in relation to the total of habitats surveyed.

The specific composition of the herpetofauna was determined based on field observations and available literature data. The results obtained during this study are analyzed and interpreted; the status of the species is defined and the peculiarities and ecological interest are identified.

2.4 Taxonomic Structure Of Ghar El Melh Herpetofauna

The population of Amphibians is very rich in species: five out of the seven species in Tunisia are found in the study sector; this presence is due to the existence of wetlands and water points favorable to these animals. Reptiles, more adapted to arid areas, are less numerous in humid and sub-humid climates; only the species with Palaearctic affinity that characterize northern Tunisia are present. The following is a complete taxonomic list of the Herpetofauna of the Ghar El Meh region.

2.4.1 Amphibians: Analysis and status of taxa

- A. Order: Urodela
 - Family: Salamandroidea
 - *Pleurodeles nebulosus*
- B. Order : Anura
 - Family Alytidae
 - *Discoglossus pictus*

Family Bufonidae

- *Sclerophrys mauritanicus*
- *Bufotes boulengeri*

Family Ranidae

- *Pelophylax saharicus*

Of the 7 species of Amphibians in Tunisia, 5 are found in the study area. Among these species reported with certainty, only the Berber toad, *Sclerophrys mauritanicus*, is common and even abundant in the studied area. All other species are rare and / or vulnerable, particularly the *Pleurodeles nebulosus*.

Table 4 Diversity and status of amphibian species in Tunisia and in Ghar EL Melh

	In Tunisia	In Ghar el Melh
Total number of species	7	5
Endemic species	0	0
Introduced species	0	0
Rare to very rare species	3	4
Threatened species	1	0
Vulnerable species	2	1
Species traded	1	1

Table 5 Ecological status and biotopes of Amphibians of Ghar EL Melh

Species	Habitats	Status of species and habitats
<i>Pleurodeles nebulosus</i>	<ul style="list-style-type: none"> • Drainage pits • Puddles 	Very localized species, uncommon, very low densities.
<i>Discoglossus pictus</i>	- Lagoon habitat	Dispersed populations, uncommon, scarce in various habitats

<i>Pelophylax saharicus</i>	<ul style="list-style-type: none"> - Micro-island habitats: lagoon islets. - Cultivated areas - Fresh water points: springs, ponds, proximity to wells, temporary puddles. - <i>P. saharicus</i> is more attached to permanent water points and to wetter and more waterlogged areas. 	<p>-Scattered and infrequent populations</p> <p>-More common at water sources and ponds.</p>
<i>Sclerophrys mauritanicus</i>	<ul style="list-style-type: none"> • Lagoon and micro-island habitat: the islets • Cultivated areas • Fresh water points: springs, ponds, proximity to wells, temporary puddles 	<p>Common and abundant in all habitats, particularly in wells, ponds and water sources.</p>
<i>Bufotes boulengeri</i>	<ul style="list-style-type: none"> • Borders and limits of the lagoons 	<p>Rare and scarce in all habitats</p>

2.4.2 Reptiles: Population analysis and taxa status

A. Order Testudines

a. Family Emydidae

- *Mauremys leprosa*
- *Emys orbicularis*

b. Family Testudinidae

- *Testudo graeca*

B. Order Squamata

a. Family Lacertidae

- *Timon pater*
- *Acanthodactylus blanci*
- *Psammmodromus algirus*
- *Psammmodromus blanci*

b. Family Gekkonidae

- *Tarentola mauritanica*
- *Hemidactylus turcicus*

c. Family Scincidae

- *Chalcides chalcides*
- *Chalcides ocellatus*

d. Family Chamaeleonidae

- *Chameleo chamaelon*
- e. Family Colubridae
 - *Natrix maura*
 - *Hemorrhois hippocrepis*
 - *Macroprotodon mauritanicus*
 - *Malpolon insignitus*
- f. Family Viperidae
 - *Macrovipera lebetina*

The reptile population of Ghar El Melh is rich and diverse, it is composed of species of Palearctic and Mediterranean origin and the total species richness represents about 28% of the total number of species in Tunisia; about half of the families and 1/3 of the genera are represented in this group. In fact, the 17 species belong to 15 genera and 8 families (Table 6), which reflects an important and taxonomic composition.

Table 6: Comparison of the taxonomic composition of Reptiles

	Tunisia	Ghar el Melh	%
Number of species	61	17	27,86
Number of genera	42	15	35.71
Number of familia	19	8	42,15

The status of the different species was defined based on data from the literature and experts' observations.

Table 7: Ecological status of Reptiles in the Ghar El Melh region

Known and localized species	14	2 turtles (1 land and 1 freshwater), 7 lizards and 5 snakes
Introduced species	0	
Species endemic to Tunisia	0	
Relict species	1	<i>Psammodromus blanci</i>
Rare to very rare localized species	2	<i>Emys orbicularis</i> et <i>Psammodromus blanci</i>
Infrequent species	5	<i>Chamaeleo chamaelon</i> , <i>Chalcides chalcides</i> , <i>Acanthodactylus blanci</i> , <i>Macroprotodon mauritanicus</i> et <i>Malpolon insignitus</i> .
Species threatened by various anthropogenic factors	6	<i>Chamaeleo chamaeleon</i> , <i>Natrix maura</i> , <i>Hemorrhois hippocrepis</i> , <i>Macroprotodon mauritanicus</i> , <i>Malpolon insignitus</i> et <i>Macrovipera lebetina</i>
Sensitive species		<i>Chamaeleo chamaeleo</i> , <i>Testudo graeca</i>
Commercialized species	2 à 4	<i>Testudo graeca</i> , <i>Chamaeleo chamaeleon</i> et parfois certaines couleuvres (<i>Hemorrhois hippocrepis</i> , <i>Malpolon insignitus</i>)
Common, frequent and ubiquitous species	7	<i>Timon pater</i> , <i>Psammodromus algirus</i> , <i>Chalcides ocellatus</i> , <i>Hemidactylus turcicus</i> , <i>Tarentola mauritanica</i> , <i>Natrix maura</i> , <i>Hemorrhois hippocrepis</i> .

2.5 Biotopes and occupation of space

2.5.1 Habitat diversity and spatial occupation by herpetofauna

The habitats in the study area are very diverse. Although they are often limited or even reduced in surface area, are terrestrial or aquatic, dry or wet, low or medium altitude, sandy or clay soils, with dense or sparse vegetation, etc., they constitute a mosaic of favorable biotopes for the various species that colonize them according to their adaptations, preferences and ecological requirements. Some of these species are found in very specific environments; others, which are more tolerant and opportunistic, are found in various types of habitats, which allows the stand to structure and organize itself differently from one environment to another. Some biotopes are thus richer in species than others, and some species form metapopulations often composed of small, spatially fragmented, isolated populations with low numbers. These elements constitute the particularity and even the singularity of the local herpetofauna, which is both continental and insular in the ecological sense of the term. In this context, the study of this population is of paramount importance both in fundamental and applied terms for the management and conservation of biodiversity.

2.5.2 The paralic environment

The topography of the area marked by the mouth of the rivers that flow into the lowest areas, its proximity to the sea and its relationship with the lagoon, the large expanses of low marshy areas... make the area a special and unique environment that is home to a great diversity of flora and fauna.

All these natural wetlands are grouped together under the name of the paralic environment, which is made up of a mass of water in transition between marine and continental environments, as well as the mouths of the rivers, marshes, mudflats and drainage channels, water sources and wells, small ponds and perennial or temporary puddles.

In the southern part between the lagoon and the old course of the Medjerda river, there are mudflats and drainage channels and in the agricultural area there are several springs and wells.

The southern marshy area is home to some of the rarest species, including *Discoglossus pictus*, *Pleurodeles poireti* and *Emys orbicularis*. The Mauritania toad *Sclerophrys mauritanicus* is more dependent on wells, pits and drainage and irrigation channels. This species is unfortunately massacred by road accidents during the breeding period when the animals cross roads and move between water points favorable for egg laying.

The more water-dependent green frog *Pelophylax saharicus* is found in permanent ponds.

In total, 8 species can be found in this mosaic of wet biotopes: the two freshwater turtles: *Emys orbicularis* and *Mauremys leprosa*; the five amphibians: *Pleurodeles poireti*, *Discoglossus pictus*, *Pelophylax saharicus*, *Bufo boulengeri* and *Sclerophrys mauritanicus*, and the viperine snake *Natrix maura*.

2.5.3 Lagoon borders

Closely linked to the previous environment, the lagoon's coastal edges and borders, about 20 km long, represents a wetland covered with hygro-halophilic vegetation mainly composed of *Salicornia fruticosa* and *Arthrocnemum sp.*, *Juncus maritimus*, *Scipoides holoschoemus* and common marsh reed (*Phragmites*). This wetland is a very favorable environment for herpetofauna.

It is home to several species of reptiles (Table 8), particularly the Saurians: *Chalcides calcides*, *Timon pater* and *Tarentola mauritanica* and some snakes that use it as a hunting, exhibition and resting area.



Figure 20 Lagoon borders. Photo: © R. Ouni

The southern shore of the lagoon is much wilder and less anthropized than the northern shore, which is cultivated and highly exploited by farmers, fishermen, residents and visitors.

Currently, the site is more or well conserved than by traditional users, farmers and fishermen; however, many of the farmers are destroying habitats suitable for reptiles, either directly by filling in the lagoon areas to make them suitable for cultivated areas, or indirectly through the excessive use of chemical products (pesticides, insecticides, fertilizers ...). In addition, the construction of new houses on the edge of the lagoon and on the way to the beach reduces the natural areas and transforms the landscape. These multiple aggressions fragment the biotope and reduce the surfaces favorable to wildlife. The decrease in Reptile numbers in these areas does not favor the maintenance of

the ecological balance of this small, peculiar and fragile ecosystem. Preliminary studies prior to each filling operation are essential to reduce impacts and minimize the destruction of reptile habitats.

2.5.4 Micro-island habitat: the lagoon islets



Figure 21 Micro-island habitat. Photo: © R. Ouni

The microhabitats in the form of islets dispersed in the lagoon are often used for agricultural purposes, especially for vegetable gardening (potato, pepper, tomato ... and legumes), shelter some lizards and amphibians species whose populations are often very low. The most common are Saurians: *Chalcides chalcides*, *C. ocellatus*, *Timon pater* and *Psammotromus algirus*. Among the Amphibians, we find the two toads *Bufo boulengeri* and *Sclerophrys mauritanicus* and the discoglossus *Discoglossus pictus*. The intensive use of chemicals (pesticides and others) threatens the local herpetofauna populations.

2.5.5 Coastal Dunes and the backshore

The locally narrow dune barrier shelters sparse and scattered vegetation of thorny plants such as dune thistle (*Eryngium maritimum*) and tall clumps of white broom, *Retama monosperma*.

Only *Acanthodactylus blanci* is found on these coastal dunes, while the backshore is home to three species of *Acanthodactylus blanci* and in places *Chalcides ocellatus* and the *insignitus Malpolon* snake. Further east, and on the way to the Sidi Ali El Makki marabout, the sandy dunes become wider and higher. This very special environment is an artificial pine forest (Pinewood, Aleppo pine and maritime pine) with dense undergrowth in places but very poor in Reptiles species; it only shelters the chameleon *Chamaeleo chamaelon* and probably *Psammotromus blanci*.

2.5.6 The rocky coast



Figure 22 Rocky coast. Photo: © R. Ouni

The rocky coastal part between the beach of Sidi Ali El Maki and the beach of Rafraf is a very poor habitat in terms of species; it only shelters the two rupicolous geckos *Tarentola mauritanica* and *Hemidactylus turcicus*.

2.5.7 The Garrigues and Maquis

In addition to the paralic environment, the terrestrial and less humid landscape is marked by an important dominant matorral, garrigues and maquis, which characterize the study area. Similar plant formations are found throughout the area (eastern flank of Ennadhour Mountain, particularly between the forest of Sidi Ali El Mekki and the village of Bejou); they consist mainly of mastic grass, kermes oak, oleaster, oxychedron and Phoenician juniper, filaria, calico, rosemary ... and in places, the carob tree and agaves. The spontaneous vegetation is denser and the environment is more closed at the level of the river beds and ravines. The mountainside is sometimes more sparse, especially at the level of firebreaks and burnt areas. This habitat is rich in species, especially in their sectors bordering the rivers and fields, where at least 9 species are found: *Psammodromus algirus*, *Timon pater*, the two most common species; the land turtle *Testudo graeca*; the lizards *Chalcides ocellatus*, *Tarentola mauritanica* and 4 ophidians *Hemorrhoids hippocrepis*, *Macroprotodon mauritanicus*, *Malpolon insignitus* and *Macrovipera lebetina*. The latter viper is strictly dependent on this type of biotope; it can descend as far as cultivated fields, plains of grazing areas and even dwellings located at the foot of the mountain.



Figure 23 The garigue. Photo: © R. Ouni

The sparse low maquis

The sparse low scrub is generally formed by a low tree stratum, due to the substrate and the nature of the soil, the influence of the prevailing wind or overgrazing. This type of sub-habitat practically shelters the 9 species reported above. Many of them prefer open environments that are favorable for hunting and sun exposure.



Figure 24 The sparse low maquis. Photo: © R. Ouni



Figure 25 Dense maquis and garrigue. Photo: © R. Ouni

Dense scrubland and scrubland

This habitat subtype characterizes the forest periphery, the edge of adjacent cultivated fields and riverbeds where the generally shrubby vegetation is associated with a dense and closed bushy stratum. At this level, the stand is less rich, only the less discrete species are inferred *Testudo graeca*, *Hemorrhois hippocrepis*, *Macroprotodon mauritanicus* and *Malpolon insignitus*.

2.5.8 Forest Habitat

In addition to the oxychedron and the maritime pine, the environment is home to other species planted for reforestation and soil fixation, particularly the gable pine, Aleppo pine, Acacia and Eucalyptus in places. This environment is very poor in Reptiles; the two main species present are *Chameleo chamaelon* and *Psammodromus blanci*.



Figure 26 The forest of Sidi Ali El Meki (pine nuts, Aleppo pines and maritime pines). Photo: © R. Ouni

2.5.9 Grazing Areas and Agricultural Fields

The grazing areas, olive and fruit tree fields and small traditional orchards located between the foot of the mountain and the lagoon

constitute a very favorable environment for the animals seeking the edges where biotopes are often more diversified, trophic resources are more abundant (insects, rodents, birds...) and ecological and climatic conditions are more clement. At least 14 species depend on this habitat: *Psammodromus algirus*, *Chalcides chalcides*, *Chalcides ocellatus*, *Timon pater*, *Tarentola mauritanica*, *Hemidactylus turcicus*, *Hemorrhais hippocrepis*, *Malpolon insignitus*, *Natrix maura*, *Testudo graeca*, *Discoglossus pictus*, *Sclerophrys mauritanicus* and *Bufo boulengeri*. To these species we must add the *Macrovipera lebetina* viper which descends to the plains bordering the mountains in case of drought and lack of prey or even in case of floods or torrential rains at the beginning of the rainy season.

2.5.10 The Urban Habitat

The urban environment corresponds exclusively to the agglomerations (cities of Ghar El Melh and Raf-raf, or other small villages in the region). The other human dwellings in rural areas are part of the other natural biotopes described: agricultural fields, orchards, etc. The urban environment is poor in animal species; only two species of geckos are frequently found: *Tarentola mauritanica* and *Hemidactylus turcicus* and rarely reptiles with anthropophilic tendencies: the horseshoe snake *Hemorrhais hippocrepis* and *Seps Chalcides ocellatus*.



Figure 27 Urban habitat. Photo: © R. Ouni

2.6 Spatial Distribution of species

Table 8: Diversity and distribution by habitat of the herpetofauna of Ghar El Melh

The Paralic/ paralytic Environment	Lagoon Borders	Micro-island habitat: the lagoon islets	Coastal Dunes and the backshore	The rocky coast	Garrigues and Maquis		Forest Habitat	Grazing Areas and Agricultural Fields	Urban Habitat
					The sparse low maquis	The dense maquis			
<i>Sclerophrys mauritanicus</i>	<i>Psammodromus algirus</i>	<i>Psammodromus algirus</i>	<i>Acanthodactylus blanci</i>	<i>Tarentola mauritanica</i>	<i>Psammodromus algirus</i>	<i>Testudo graeca</i>	<i>Chamaeleo chamaeleon</i>	<i>Testudo graeca</i>	<i>Tarentola mauritanica</i>
<i>Bufotes boulengeri</i>	<i>Timon pater</i>	<i>Timon pater</i>	<i>Psammodromus blanci</i>	<i>Hemidactylus turcicus</i>	<i>Timon pater</i>	<i>Hemorrhois hippocrepis</i>	<i>Psammodromus blanci</i>	<i>Psammodromus algirus</i>	<i>Hemidactylus turcicus</i>
<i>Pelophylax saharicus</i>	<i>Chalcides chalcides</i>	<i>Chalcides chalcides</i>	<i>Malpolon insignitus</i>		<i>Chalcides ocellatus</i>	<i>Macroprotodon mauritanicus</i>		<i>Timon pater</i>	
<i>Discoglossus pictus</i>	<i>Chalcides ocellatus</i>	<i>Chalcides ocellatus</i>	<i>Chamaeleo chamaeleon</i>		<i>Hemorrhois hippocrepis</i>	<i>Malpolon insignitus</i>		<i>Chalcides chalcides</i>	
<i>Mauremys leprosa</i>	<i>Natrix maura</i>	<i>Sclerophrys mauritanicus</i>	<i>Chalcides ocellatus</i>		<i>Macroprotodon mauritanicus</i>			<i>Chalcides ocellatus</i>	
<i>Pleurodeles nebulosus</i>	<i>Tarentola mauritanica</i>	<i>Bufotes boulengeri</i>			<i>Malpolon insignitus</i>			<i>Natrix maura</i>	
<i>Emys orbicularis</i>	<i>Hemidactylus turcicus</i>	<i>Discoglossus pictus</i>			<i>Tarentola mauritanica</i>			<i>Hemorrhois hippocrepis</i>	
<i>Natrix maura</i>	<i>Sclerophrys mauritanicus</i>				<i>Macrovipera lebetina</i>			<i>Malpolon insignitus</i>	
	<i>Bufotes boulengeri</i>				<i>Testudo graeca</i>			<i>Tarentola mauritanica</i>	
	<i>Discoglossus pictus</i>							<i>Hemidactylus turcicus</i>	
	<i>Pelophylax saharicus</i>							<i>Sclerophrys mauritanicus</i>	
								<i>Bufotes boulengeri</i>	
								<i>Discoglossus pictus</i>	
								<i>Macrovipera lebetina</i>	
8	11	7	5	2	9	4	2	14	2

Table 9 Threats to the habitats that may act directly or indirectly on the species of the herpetofauna of Ghar el Melh

HABITAT	REPTILES	Threats to habitats
The Paralic/ paralytic Environment	<i>Natrix maura</i>	Pollution and intensification of agriculture
	<i>Sclerophrys mauritanicus</i>	Modification of water courses
	<i>Bufoetes boulengeri</i>	Urbanisation
	<i>Pelophylax saharicus</i>	Port and industrial facilities
	<i>Discoglossus pictus</i>	Hydroelectric development
	<i>Mauremys leprosa</i>	Backfilling
	<i>Pleurodeles nebulosus</i>	Pollution and intensification of agriculture
	<i>Emys orbicularis</i>	Backfilling, Pollution and intensification of agriculture
Lagoon borders	<i>Psammmodromus algirus</i>	Pollution and intensification of agriculture: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Timon pater</i>	Pollution and intensification of agriculture: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Chalcides chalcides</i>	Pollution and discharges
	<i>Chalcides ocellatus</i>	Pollution and discharges
	<i>Natrix maura</i>	Introduction of exotic species, Modification of rivers
	<i>Tarentola mauritanica</i>	Biological invasion
	<i>Hemidactylus turcicus</i>	Biological invasion
	<i>Sclerophrys mauritanicus</i>	Modification of watercourses
	<i>Bufoetes boulengeri</i>	Pollution and intensification of agriculture: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides); modification of watercourses
	<i>Discoglossus pictus</i>	Pollution and intensification of agriculture: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides); modification of watercourses
	<i>Pelophylax saharicus</i>	Pollution and intensification of agriculture: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides); modification of watercourses; Commerce
Micro-island habitat: the lagoon islets	<i>Psammmodromus algirus</i>	Fragmentation of habitats; Pollution and intensification of agriculture: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Timon pater</i>	Fragmentation of habitats; Pollution and intensification of agriculture: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Chalcides chalcides</i>	Fragmentation of habitats; Pollution and intensification of agriculture: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Chalcides ocellatus</i>	Fragmentation of habitats; Pollution and intensification of agriculture: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Sclerophrys mauritanicus</i>	Backfill, Pollution and intensification of agriculture
	<i>Bufoetes boulengeri</i>	Backfill, Pollution and intensification of agriculture
	<i>Discoglossus pictus</i>	Backfill, Pollution and intensification of agriculture
	<i>Acanthodactylus blanci</i>	Fragmentation of habitats; Leisure: bivouacs and wild camping

Coastal Dunes and the backshore	<i>Psammmodromus blanci</i>	Fragmentation of habitats; Leisure: bivouacs and wild camping
	<i>Malpolon insignitus</i>	Habitat fragmentation
	<i>Chamaeleo chamaeleon</i>	Leisure: bivouacs and wild camping
	<i>Chalcides ocellatus</i>	Leisure: bivouacs and wild camping
The rocky coast	<i>Tarentola mauritanica</i>	Leisure: bivouacs and wild camping
	<i>Hemidactylus turcicus</i>	Erosion
The sparse low maquis	<i>Psammmodromus algirus</i>	Fragmentation of habitats; Overgrazing; Erosion
	The dense maquis	Habitat fragmentation
	<i>Chalcides ocellatus</i>	Habitat fragmentation
	<i>Hemorrhhois hippocrepis</i>	Habitat fragmentation
	<i>Macroprotodon mauritanicus</i>	Habitat fragmentation
	<i>Malpolon insignitus</i>	Habitat fragmentation
	<i>Tarentola mauritanica</i>	Habitat fragmentation
	<i>Macrovipera lebetina</i>	Habitat fragmentation
The dense maquis	<i>Testudo graeca</i>	Commerce
	<i>Testudo graeca</i>	Fragmentation of habitats : fires, reforestation, etc.
	<i>Hemorrhhois hippocrepis</i>	Fragmentation of habitats : fires, reforestation, etc.
	<i>Macroprotodon mauritanicus</i>	Fragmentation of habitats: fires, reforestation, etc.; Commerce
The Forest Habitat	<i>Malpolon insignitus</i>	Fragmentation of habitats: fires, reforestation, etc.
	<i>Chamaeleo chamaeleon</i>	Fragmentation of habitats: fires, reforestation, etc. ; commerce
Grazing areas and agricultural fields	<i>Psammmodromus blanci</i>	Fragmentation of habitats: fires, reforestation, etc.
	<i>Testudo graeca</i>	Commerce
	<i>Psammmodromus algirus</i>	Biological invasion
	<i>Timon pater</i>	Pollution: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Chalcides chalcides</i>	
	<i>Chalcides ocellatus</i>	Pollution: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Natrix maura</i>	modification of watercourses
	<i>Hemorrhhois hippocrepis</i>	Pollution: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Malpolon insignitus</i>	Pollution: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Tarentola mauritanica</i>	Pollution: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Hemidactylus turcicus</i>	Pollution: intensive use of phytosanitary products (chemical fertilizers, pesticides, poisons and herbicides)
	<i>Sclerophrys mauritanicus</i>	Pollution and intensification: the intensive use of phytosanitary products against mosquito control (pesticides)
	<i>Bufotes boulengeri</i>	Pollution and intensification: the intensive use of phytosanitary products against mosquito control (pesticides)
	<i>Discoglosse pictus</i>	Pollution and intensification: the intensive use of phytosanitary products against mosquito control (pesticides)
Urban Housing	<i>Macrovipera lebetina</i>	Habitat fragmentation: fires
	<i>Tarentola mauritanica</i>	Pollution: Plant protection products (pesticides, etc.)
	<i>Hemidactylus turcicus</i>	Pollution: Plant protection products (pesticides, etc.)

2.7 Conclusions

In light of the results of the Amphibian Inventory:

- The species richness in Amphibians varies from 3 to 5 species per habitat, especially in the 4 habitats (the Paralic environment, the lagoon borders, the micro insular habitat: lagoon islands & grazing areas and agricultural fields) sharing typical ecological features (watercourse, wetland and soil moisture).
- The Paralic Environment is a very favorable habitat for Amphibians. At least 5 species out of the seven in Tunisia are inferred to this environment.
- In terms of Abundance and Frequency, the composition of this population locally reflects that of the whole Tunisian batrachofauna. Indeed, and at the scale of the region, the most common and abundant species is the North African green frog (*Pelophylax saharicus*). The Painted Discoglossus (*Discoglossus pictus*), a species considered invasive, and the Berber Toad (*Sclerophrys mauritanica*), are very frequent, common, ubiquitous and widely distributed, but always in low numbers. The green toad (*Bufoetes boulengeri*), on the other hand, is increasingly rare in Tunisia, both in presence and in numbers. Finally, the oyster mushroom (*Pleurodeles nebulosus*) is a very rare species, limited to northern Tunisia.
- This rich and diversified population deserves to be further studied from an ecological point of view (population dynamics and organization of the population), especially in the areas that shelter it.
- Surveys beyond the limits of the sector are also necessary to look for rare and discrete species likely to exist in the region.

And about the Reptile result, we conclude :

- That the specific richness of the Reptile population in the region of Sidi ali El Meki is at least 16 species identified with certainty; 1 other whose presence is highly probable remains to be sought, the *Psammodromus blanci*. This number represents a little more than the ¼ of the biodiversity of the Tunisian terrestrial herpetofauna.

2.8 References

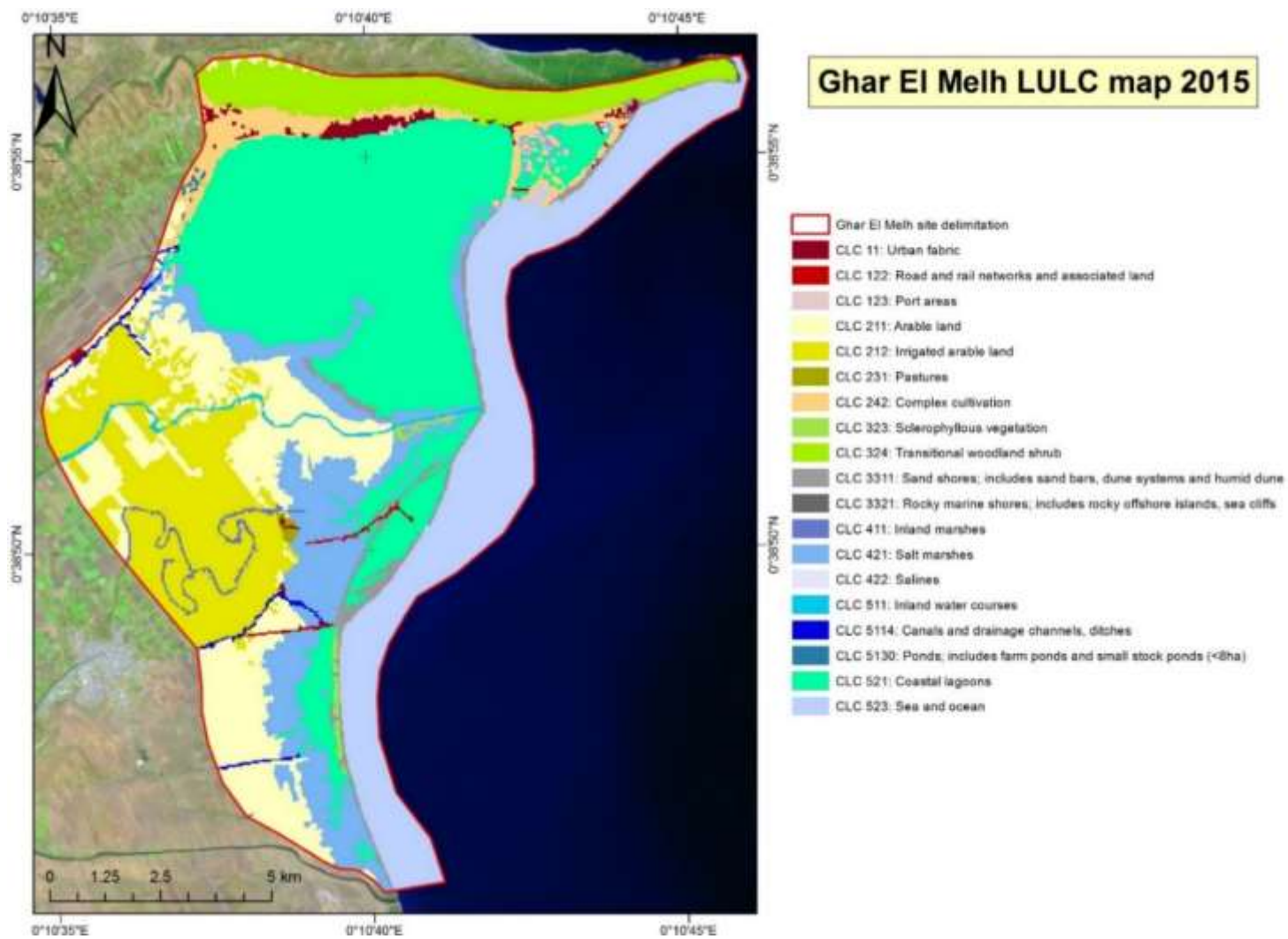
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Annexes

Ghar El Melh lagoon. Photo: © Ugo Mellone

Appendix A - Map of the main habitats represented within the study area



An introduction and a more complete version of this map is available at:
<https://bit.ly/3guvOsh>

Source: [Mediterranean Wetlands Observatory](#) (A. Guelmami, unpublished data)

Appendix B - Plant species recorded in the study area

Taxa which are classed as endemic by Le Flocc'h *et al.* (2010) are listed in green.

Taxa which are known to be non-native to the area are listed in red.

TAXON	JBEL NADHOUR AND GHAR EL MELH KBA	SIDI ALI EL MEKKI IPA	ENDEMIC TO TUNISIA (LE FLOCC'H <i>et al.</i> (2010))
ALGAE			
<i>Caulerpa racemosa</i>	1	0	
<i>Chara connivens</i>	1	0	
<i>Chara vulgaris</i>	0	0	
<i>Cladophora</i> sp(p).	1	0	
<i>Posidonia oceanica</i>	1	0	
<i>Ulva flexuosa</i>	1	0	
<i>Ulva rigida</i>	1	0	
<i>Vaucheria</i>	1	0	
BRYOPHYTES			
<i>Aloina</i> sp.	1	0	
<i>Barbula</i> sp.	1	0	
<i>Didymodon</i> sp.	1	0	
<i>Fossombronia</i> sp.	1	0	
<i>Rhynchostegiella tenella</i>	1	1	
<i>Scorpiurium circinnatum</i>	1	1	
<i>Timmiella barbuloidea</i>	1	0	
VASCULAR PLANTS			
<i>Acacia cyclops</i> A. Cunn. ex G. Don	1	1	
<i>Acacia karroo</i> Hayne	1	1	
<i>Acacia saligna</i> (Labill.) Wendl. f.	1	1	
<i>Achnatherum miliaceum</i> (L.) P.Beauv.	1	1	
<i>Aeluropus littoralis</i> (Gouan) Parl.	1	1	
<i>Aetheorrhiza bulbosa</i> L. subsp. <i>bulbosa</i>	1	1	
<i>Agave americana</i> L.	1	1	
<i>Ajuga iva</i> (L.) Schreb.	1	1	
<i>Allium duriaeanum</i> J. Gay	1	1	yes
<i>Allium magrebinum</i> ?	1	1	yes
<i>Allium schoenoprasum</i> L.	1	1	
<i>Allium subvillosum</i> Schultes & Schultes	1	1	
<i>Allium subvillosum</i> Salzm. ex Schult. & Schult.f.	1	1	
<i>Ambrosina bassii</i> L.	1	1	
<i>Ammophila arenaria</i> (L.) Link subsp. <i>arundinacea</i> H. Lindb.	1	1	
<i>Ampelodesmos mauritanicus</i> (Poir.) T. Durand & Schinz	1	1	
<i>Anagyris foetida</i> L.	1	1	
<i>Andryala integrifolia</i> L.	1	1	

TAXON	JBEL NADHOUR AND GHAR EL MELH KBA	SIDI ALI EL MEKKI IPA	ENDEMIC TO TUNISIA (LE FLOC'H <i>et al.</i> (2010)
<i>Anthemis cf. arvensis</i> L.	1	0	
<i>Anthemis secundiramea</i> Biv.	1	1	
<i>Anthyllis tetraphylla</i> L.	1	1	
<i>Anthyllis vulneraria</i> L.	1	1	
<i>Arisarum vulgare</i> Targ. Tozz. Subsp. vulgare	1	1	
<i>Artemisia absinthium</i> L.	1	1	
<i>Arthrocaulon macrostachyum</i> (Moric.) Piirainen & G.Kadereit	1	1	
<i>Arundo donax</i> L.	1	1	
<i>Arundo micrantha</i> Lam.	1	1	
<i>Asparagus acutifolius</i> L.	1	1	
<i>Asparagus albus</i> L.	1	1	
<i>Asperula aristata</i> L.	1	1	
<i>Asperula hirsuta</i> Desf.	1	0	
<i>Asphodelus ramosus</i> L. subsp. <i>ramosus</i>	1	1	
<i>Astragalus boeticus</i> L.	1	0	
<i>Atractylis cancellata</i> L.	1	1	
<i>Atriplex halimus</i> L.	1	0	
<i>Atriplex portulacoides</i> L.	1	1	
<i>Barnardia numidica</i> (Poir.) Speta	1	1	yes
<i>Bellis annua</i> L.	1	1	
<i>Bellis sylvestris</i> Cirillo	1	1	
<i>Beta vulgaris</i> L.	1	0	
<i>Bituminaria tunetana</i> C.Brullo, Brullo, Cambria, El Mokni & Giusso	1	1	
<i>Blackstonia grandiflora</i> (Viv.) Maire	1	1	
<i>Bolboschoenus glaucus</i> (Lam.) S.G.Sm.	1	0	
<i>Borago officinalis</i> L.	1	1	
<i>Bothriochloa ischaemum</i> (cf.) (L.) Keng	1	1	
<i>Brachypodium distachyon</i> (L.) P.Beauv.	1	1	
<i>Brachypodium hybridum</i>	1	1	
<i>Brachypodium retusum</i> (Pers.) P. Beauv.	1	1	
<i>Briza maxima</i> L.	1	1	
<i>Bromus diandrus</i> Roth	1	1	
<i>Bunium crassifolium</i> Batt.	1	1	yes
<i>Bupleurum semicompositum</i> L.	1	0	
<i>Cakile maritima</i> Scop. subsp. <i>maritima</i>	1	1	
<i>Calendula suffruticosa</i> Vahl	1	1	
<i>Calicotome villosa</i> (Poir.) Link	1	1	
<i>Campanula dichotoma</i> L.	1	1	
<i>Capparis spinosa</i> L.	1	1	
<i>Carex flacca</i> Schreb.	1	1	
<i>Carpobrotus edulis</i> (L.) N.E. Br. var. <i>edulis</i>	1	1	

TAXON	JBEL NADHOUR AND GHAR EL MELH KBA	SIDI ALI EL MEKKI IPA	ENDEMIC TO TUNISIA (LE FLOC'H <i>et al.</i> (2010))
<i>Centaurea fragilis</i> Durieu	1	1	
<i>Centaureum erythraea</i> Raf. subsp. <i>grandiflorum</i> (Pers.) Melderis	1	1	
<i>Ceratonia siliqua</i> L.	1	1	
<i>Chaenorhinum flexuosum</i> (Desf.) Lange	1	1	
<i>Chenopodium murale</i> L.	1	1	
<i>Cistus clusii</i> Dunal	1	1	
<i>Cistus creticus</i> L. subsp. <i>eriocephalus</i> (Viv.) Greuter & Burdet	1	1	
<i>Cistus salviifolius</i> L.	1	1	
<i>Clematis flammula</i> L.	1	1	
<i>Coincya tournefortii</i> (Gouan) Alcaraz, T.E.Díaz, Rivas Mart. & Sánchez-Gómez	1	0	
<i>Convolvulus althaeoides</i> L.	1	1	
<i>Convolvulus cantabrica</i> L.	1	1	
<i>Convolvulus lineatus</i> L.	1	1	
<i>Convolvulus siculus</i> (cf.) L.	1	1	
<i>Conyza canadensis</i> (L.) Cronquist	1	1	
<i>Coris monspeliensis</i> L. subsp. <i>monspeliensis</i>	1	1	
<i>Coronilla juncea</i> L. subsp. <i>juncea</i>	1	1	
<i>Crataegus monogyna</i> Jacquin	1	1	
<i>Crithmum maritimum</i> L.	1	1	
<i>Crucianella maritima</i> L.	1	1	
<i>Cupressus sempervirens</i> L.	1	1	
<i>Cuscuta epithimum</i> L. s.l.	1	1	
<i>Cutandia divaricata</i> (Desf.) Benth.	1	0	
<i>Cutandia maritima</i> (L.) Barbey	1	0	
<i>Cymodocea nodosa</i> (Ucria) Asch.	1	0	
<i>Cynanchum acutum</i> L.	1	0	
<i>Cynodon dactylon</i> (L.) Pers.	1	1	
<i>Cynomorium coccineum</i> L.	1	0	
<i>Cynosurus echinatus</i> L.	1	1	
<i>Cyperus capitatus</i> Vand.	1	1	
<i>Dactylis glomerata</i> L. s.l.	1	1	
<i>Damasonium bourgaei</i> Coss.	1	0	
<i>Daphne gnidium</i> L. subsp. <i>gnidium</i>	1	1	
<i>Daucus carota</i> L.	1	1	
<i>Daucus carota</i> L. cf subsp. <i>hispanica</i>	1	1	
<i>Daucus carota</i> L. subsp. <i>maximus</i> (Desf.) Ball	1	1	
<i>Daucus gingidium</i> L.	1	0	
<i>Daucus pumilus</i> (L.) Hoffmanns. & Link	1	1	
<i>Daucus rouyi</i> Spalik & Reduron	1	1	
<i>Delphinium</i> cf. <i>pubescens</i> DC.	1	0	
<i>Delphinium verdunense</i> Balb.	1	1	

TAXON	JBEL NADHOUR AND GHAR EL MELH KBA	SIDI ALI EL MEKKI IPA	ENDEMIC TO TUNISIA (LE FLOC'H <i>et al.</i> (2010))
<i>Desmazeria sicula</i> (cf.) (Jacq.) Dumort.	1	1	
<i>Dianthus caryophyllus</i> L.	1	0	
<i>Dianthus sylvestris</i> Wulfen subsp. <i>siculus</i> (C. Presl) Tutin	1	1	
<i>Diplotaxis muralis</i> (L.) DC.	1	1	
<i>Dittrichia graveolens</i> (L.) Greuter	1	1	
<i>Dittrichia viscosa</i> (L.) Greuter	1	1	
<i>Drimia fugax</i> (Moris) Stearn	1	1	
<i>Drimia numidica</i> (Jord. & Fourr.) J.C.Manning & Goldblatt	1	1	
<i>Drimia undata</i> Stearn	1	1	
<i>Ecballium elaterium</i> (L.) A. Rich.	1	1	
<i>Echinops spinosissimus</i> Turra	1	1	
<i>Echium sabulicola</i> Pomel	1	1	
<i>Elymus farctus</i> (Viv.) Runemark ex Melderis subsp. <i>farctus</i>	1	1	
<i>Ephedra fragilis</i> Desf. subsp. <i>fragilis</i>	1	1	
<i>Erica multiflora</i> L.	1	1	
<i>Erigeron floribundus</i> (Kunth) Sch.Bip.	1	0	
<i>Eryngium maritimum</i> L.	1	1	
<i>Eudianthe coeli-rosa</i> (L.) Fenzl ex Endl.	1	1	
<i>Euphorbia bivonae</i> Steud. Subsp. <i>bivonae</i>	1	1	
<i>Euphorbia dendroides</i> L.	1	1	
<i>Euphorbia lagascae</i> Spreng.	1	1	
<i>Euphorbia paralias</i> L.	1	1	
<i>Ficus carica</i> L. subsp. <i>carica</i>	1	1	
<i>Fumana laevipes</i> (L.) Spach	1	1	
<i>Fumana laevis</i> (Cav.) Pau	1	1	
<i>Fumana scoparia</i> Pomel	1	1	
<i>Fumana thymifolia</i> (L.) Spach ex Webb	1	1	
<i>Fumaria bicolor</i> Sommier ex Nicotra	1	0	
<i>Galactites tomentosus</i> Moench	1	1	
<i>Galium mollugo</i> L. subsp. <i>mollugo</i>	1	1	
<i>Galium poiretianum</i> Ball	1	1	
<i>Genista aspalathoides</i> Lam.	1	1	yes
<i>Geranium columbinum</i> L.	1	1	
<i>Geranium robertianum</i> L. subsp. <i>purpureum</i> (Vill.) Nyman	1	1	
<i>Gladiolus dubius</i> Guss.	1	1	
<i>Glaucium flavum</i> Crantz	1	1	
<i>Glebionis coronaria</i> (L.) Spach	1	1	
<i>Globularia alypum</i> L.	1	1	
<i>Halocnemum strobilaceum</i> (Pall.) M.Bieb.	1	0	
<i>Hedypnois rhagadioloides</i> (L.) F.W.Schmidt	1	0	

TAXON	JBEL NADHOUR AND GHAR EL MELH KBA	SIDI ALI EL MEKKI IPA	ENDEMIC TO TUNISIA (LE FLOC'H <i>et al.</i> (2010)
<i>Hedysarum spinosissimum</i> L. subsp. <i>capitatum</i> (Rouy) Asch. & Graebn.	1	1	
<i>Helianthemum syriacum</i> (Jacq.) Dum. Cours. subsp. <i>thibaudii</i> (Pers.) Meikle	1	1	
<i>Helichrysum conglobatum</i> (Viv.) Steud.	1	1	
<i>Hirschfeldia incana</i> (L.) Lagr.-Foss. subsp. <i>geniculata</i> (Desf.) Maire	1	1	
<i>Hordeum marinum</i> Huds.	1	0	
<i>Hyacinthoides lingulata</i> (Poir.) Rothm.	1	1	
<i>Hyoseris radiata</i> L. subsp. <i>lucida</i>	1	1	
<i>Hyparrhenia hirta</i> (L.) Stapf	1	1	
<i>Hypochaeris laevigata</i> (L.) Cesati	1	1	
<i>Juncus acutus</i> L.	1	0	
<i>Juncus maritimus</i> Lam.	1	0	
<i>Juncus subulatus</i> Forssk.	1	0	
<i>Juniperus oxycedrus</i> L. subsp. <i>macrocarpa</i> (Sm.) Ball	1	1	
<i>Juniperus phoenicea</i> L.	1	1	
<i>Lagurus ovatus</i> L.	1	1	
<i>Launaea fragilis</i> (Asso) Pau subsp. <i>fragilis</i>	1	1	
<i>Leontodon tuberosus</i> L.	1	1	
<i>Leopoldia maritima</i> (Desf.) Parl.	1	1	
<i>Limbaria crithmoides</i> (L.) Dumort. subsp. <i>longifolia</i> (Arcang.) Greuter	1	1	
<i>Limoniastrum monopetalum</i> (L.) Boiss.	1	0	
<i>Limonium intricatum</i> Brullo & Erben	1	0	
<i>Limonium pyramidatum</i> Brullo & Erben	1	0	
<i>Limonium virgatum</i> (Willd.) Fourr.	1	0	
<i>Linaria heterophylla</i> Desf. var. <i>dichroa</i> Litard. & Maire	1	1	yes
<i>Linaria multicaulis</i> subsp. <i>heterophylla</i> (Desf.) D.A.Sutton	1	1	
<i>Linum strictum</i> L. subsp. <i>spicatum</i> (Pers.) Nyman	1	1	
<i>Linum trigynum</i> L.	1	1	
<i>Lobularia maritima</i> (L.) Desv. Subsp. <i>maritimus</i>	1	1	
<i>Lonicera implexa</i> Aiton	1	1	
<i>Lotus creticus</i> L.	1	1	
<i>Lotus cytisoides</i> L.	1	1	
<i>Lysimachia arvensis</i> (L.) U.Manns & Anderb.	1	1	
<i>Malcolmia doumetiana</i> (Coss.) Rouy	1	1	yes
<i>Malva parviflora</i> L.	1	0	
<i>Malva subovata</i> (DC.) Molero & J.M.Monts.	1	1	
<i>Malva sylvestris</i> L.	1	1	
<i>Mandragora autumnalis</i> Bertel.	1	1	
<i>Marrubium vulgare</i> L.	1	1	

TAXON	JBEL NADHOUR AND GHAR EL MELH KBA	SIDI ALI EL MEKKI IPA	ENDEMIC TO TUNISIA (LE FLOC'H <i>et al.</i> (2010))
<i>Medicago cf. littoralis</i> Rohde ex Loisel.	1	0	
<i>Medicago marina</i> L.	1	1	
<i>Medicago polymorpha</i> L.	1	1	
<i>Melilotus italicus</i> (L.) Lam.	1	0	
<i>Mercurialis annua</i> L. subsp. <i>annua</i>	1	1	
<i>Micromeria inodora</i> (Desf.) Benth.	1	0	
<i>Moraea sisyrinchium</i> (L.) Ker-Gawl.	1	1	
<i>Nigella arvensis</i> L. subsp. <i>glaucescens</i> (Guss.) Greuter & Burdet	1	1	
<i>Olea europaea</i> L.	1	1	
<i>Oncostema cf. maireana</i> Brullo	1	1	
<i>Ononis diffusa</i> Ten.	1	0	
<i>Ononis ramosissima</i> Desf.	1	1	
<i>Onopordum platylepis</i> (Murb.) Murb.	1	1	
<i>Ophrys lutea</i> Cav. subsp. <i>lutea</i>	1	0	
<i>Opuntia ficus-indica</i> (L.) Mill.	1	1	
<i>Orobanche cf. foetida</i> Poir.	1	1	
<i>Osyris alba</i> L.	1	1	
<i>Oxalis pes-caprae</i> L.	1	1	
<i>Pallenis maritima</i> (L.) Greuter	1	1	
<i>Pallenis spinosa</i> (L.) Cass. subsp. <i>spinosa</i>	1	1	
<i>Pancratium maritimum</i> L.	1	1	
<i>Panicum repens</i> L.	1	1	
<i>Parapholis filiformis</i> (Roth) C.E.Hubb.	1	0	
<i>Parietaria judaica</i> L. subsp. <i>judaica</i>	1	1	
<i>Parietaria lusitanica</i> L.	1	1	
<i>Paspalum dilatatum</i> Poir.	1	1	
<i>Petrosedum sediforme</i> (Jacq.) Grulich	1	1	
<i>Phagnalon rupestre</i> (L.) DC.	1	1	
<i>Phagnalon saxatile</i> (L.) Cass.	1	1	
<i>Phagnalon sordidum</i> (L.) Rchb.	1	1	
<i>Phillyrea latifolia</i> L.	1	1	
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	1	0	
<i>Picris sinuata</i> (Lam.) Lack	1	0	
<i>Pinus halepensis</i> Mill.	1	1	
<i>Pinus pinaster</i> Aiton	1	1	
<i>Pinus pinea</i> L.	1	1	
<i>Pistacia lentiscus</i> L.	1	1	
<i>Plantago afra</i> L.	1	1	
<i>Plantago albicans</i> L.	1	1	
<i>Plantago coronopus</i> L. s.l.	1	1	
<i>Plantago lagopus</i> L.	1	1	
<i>Plantago serraria</i> L. / <i>P. macrorrhiza</i>	1	1	

TAXON	JBEL NADHOUR AND GHAR EL MELH KBA	SIDI ALI EL MEKKI IPA	ENDEMIC TO TUNISIA (LE FLOC'H <i>et al.</i> (2010))
<i>Plantago weldenii</i> Rchb.	1	1	
<i>Plumbago europaea</i> L.	1	1	
<i>Polygonum maritimum</i> L.	1	1	
<i>Portulaca oleracea</i> L. s.l.	1	1	
<i>Prasium majus</i> L.	1	1	
<i>Prospero pulchellum</i> (Munby) Speta	1	1	yes
<i>Prunus amygdalus</i> Batsch	1	1	
<i>Quercus coccifera</i> L.	1	1	
<i>Ranunculus bullatus</i> L.	1	1	
<i>Reichardia picroides</i> (L.) Roth	1	1	
<i>Reichardia tingitana</i> (L.) Roth	1	1	
<i>Reseda alba</i> L. subsp. <i>alba</i>	1	1	
<i>Retama raetam</i> (Forssk.) Webb & Berthel. subsp. <i>bovei</i> (Spach) Talavera & P.E.Gibbs	1	1	
<i>Rhamnus alaternus</i> L. subsp. <i>alaternus</i>	1	1	
<i>Rhamnus lycioides</i> L. subsp. <i>oleoides</i> (L.) Jahand. & Maire	1	1	
<i>Rhodalsine geniculata</i> (Poir.) F.N. Williams	1	1	
<i>Ricinus communis</i> L.	1	1	
<i>Rosmarinus officinalis</i> L. var. <i>officinalis</i>	1	1	
<i>Rosmarinus officinalis</i> L. var. <i>prostratus</i>	1	1	
<i>Rostraria litorea</i> (All.) Holub	1	1	
<i>Rubia peregrina</i> L.	1	1	
<i>Rubus ulmifolius</i> Schott	1	1	
<i>Rumex bucephalophorus</i> L.	1	1	
<i>Rumex roseus</i> L.	1	1	
<i>Rumex spinosus</i> L.	1		
<i>Ruppia cirrhosa</i> (Petagna) Grande	1		
<i>Ruscus hypophyllum</i> L.	1	1	
<i>Ruta chalepensis</i> L. subsp. <i>chalepensis</i>	1	1	
<i>Salicornia fruticosa</i> (L.) L.	1	0	
<i>Salicornia perennans</i> Willd.	1	0	
<i>Salsola kali</i> L. subsp. <i>kali</i>	1	1	
<i>Salvia verbenaca</i> L. s.l.	1	1	
<i>Satureja barceloi</i> (Willk.) Pau	1	1	
<i>Satureja graeca</i> L.	1	1	
<i>Satureja nervosa</i> Desf.	1	1	
<i>Scabiosa atropurpurea</i> L. subsp. <i>maritima</i> (L.) Arcang.	1	1	
<i>Schoenoplectus litoralis</i> (Schrud.) Palla	1	0	
<i>Schoenoplectus tabernaemontani</i> (C.C.Gmel.) Palla	1	0	
<i>Schoenus nigricans</i> L.	1	1	
<i>Scilla peruviana</i> L.	1	1	
<i>Scirpoides holoschoenus</i> (L. f.) Soják subsp. <i>holoschoenus</i>	1	1	

TAXON	JBEL NADHOUR AND GHAR EL MELH KBA	SIDI ALI EL MEKKI IPA	ENDEMIC TO TUNISIA (LE FLOC'H <i>et al.</i> (2010))
<i>Scolymus grandiflorus</i> Desf.	1	1	
<i>Scolymus hispanicus</i> L.	1	1	
<i>Scorzonera undulata</i> Vahl	1	1	
<i>Scrophularia sambucifolia</i> L.	1	1	
<i>Sedum album</i> L.	1	1	
<i>Sedum pubescens</i> Vahl	1	1	
<i>Selaginella denticulata</i> (L.) Spring	1	1	
<i>Senecio leucanthemifolius</i> Poir.	0	1	
<i>Sherardia arvensis</i> L.	1	1	
<i>Silene arenarioides</i> Desf.	1	1	
<i>Silene colorata</i> Poir.	1	1	
<i>Silene succulenta</i> Forssk.	1	1	
<i>Smilax aspera</i> L.	1	1	
<i>Solanum linnaeanum</i> Hepper & P.-M.L.Jaeger	1	1	
<i>Solanum nigrum</i> L. subsp. <i>nigrum</i>	1	1	
<i>Spergularia marina</i> (L.) Besser	1	0	
<i>Stipa tenacissima</i> L. s.l.	1	1	
<i>Suaeda maritima</i> (L.) Dumort.	1	0	
<i>Suaeda vermiculata</i> Forssk. ex J.F.Gmel.	1	0	
<i>Symphotrichum squamatum</i> (Spreng.) Nesom	1	1	
<i>Teucrium flavum</i> L. subsp. <i>glaucum</i>	1	1	
<i>Teucrium fruticans</i> L.	1	1	
<i>Thapsia garganica</i> L.	1	1	
<i>Thymbra capitata</i> (L.) Cav.	1	1	
<i>Thymelaea hirsuta</i> (L.) Endl.	1	1	
<i>Thymus algeriensis</i> Boiss. & Reut.	1	1	
<i>Tolpis virgata</i> (Desf.) Bertol.	1	1	
<i>Torilis nodosa</i> (L.) Gaertn.	1	0	
<i>Trifolium scabrum</i> L.	1	1	
<i>Trifolium stellatum</i> L.	1	1	
<i>Typha domingensis</i> Pers.	1	0	
<i>Umbilicus horizontalis</i> (Guss.) DC.	1	1	
<i>Urospermum dalechampii</i> (L.) Scop. ex F.W. Schmidt	1	1	
<i>Verbascum sinuatum</i> L.	1	1	
<i>Vitis vinifera</i> L.	1	1	
<i>Xanthium strumarium</i> L.	1	1	
<i>Zygophyllum album</i> L.	1	1	

Appendix C - IPA-Med / field sheet codes habitats

Species habitat classification according to the IUCN Habitats Classification Scheme (Version 3.0). Habitats highlighted in green are present in Ghar El Melh.

Classification des habitats d'espèces selon IUCN Habitats Classification Scheme (Version 3.0). Les habitats soulignés en vert sont présents à Ghar El Melh.

English	Code	Français
Forest	1	Forêt
Temperate Forest	1.4	Forêt tempérée
Broadleaved deciduous woodland	1.4.1	Forêts de feuillus caducifoliés
Broadleaved evergreen woodland	1.4.2	Forêts de feuillus sempervirents
Coniferous woodland	1.4.3	Forêts de conifères
Mixed deciduous and coniferous woodland	1.4.4	Formations mixtes d'espèces caducifoliées et de conifères
Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice	1.4.5	Alignements d'arbres, petits bois anthropiques, boisements récemment abattus, stades initiaux de boisements et taillis
Subtropical/Tropical Dry Forest	1.5	Forêt sèche tropicale ou subtropicale
Savanna	2	Savane
Dry Savanna	2.1	Savane sèche
Moist Savanna	2.2	Savane humide
Shrubland	3	Végétation arbustive
Temperate Shrubland	3.4	Végétation arbustive tempérée
Temperate and Mediterranean-montane scrub	3.4.1	Fourrés tempérés et méditerranéo-montagnards
Temperate shrub heathland	3.4.2	Landes arbustives tempérées
Thermo-Atlantic xerophytic scrub	3.4.3	Fourré thermo-Atlantique xérophytique (Thermo-Atlantic xerophytic scrub)
Riverine and fen scrubs	3.4.4	Fourrés ripicoles et des bas-marais
Hedgerows	3.4.5	Haies
Shrub plantations	3.4.6	Plantations d'arbustes
Subtropical/Tropical Dry Shrubland	3.5	Végétation arbustive sèche tropicale ou subtropicale
Subtropical/Tropical Moist Shrubland	3.6	Végétation arbustive humide tropicale ou subtropicale
Subtropical/Tropical High Altitude Shrubland	3.7	Végétation arbustive de haute altitude tropicale ou subtropicale
Mediterranean-type Shrubby Vegetation	3.8	Végétation arbustive de type méditerranéen
Maquis, arborescent matorral and thermo-Mediterranean brushes	3.8.1	Maquis, matorrals arborescents et fourrés thermoméditerranéens
Garrigue	3.8.2	Garrigues
Spiny Mediterranean heaths (phrygana, hedgehog-heaths and related coastal cliff vegetation)	3.8.3	Landes épineuses méditerranéennes (phryganes, landes-hérisson et végétation apparentée des falaises littorales)
Grassland	4	Prairie
Temperate Grassland	4.4	Prairie tempérée
Dry grassland	4.4.1	Pelouses sèches
Mesic grassland	4.4.2	Prairies mésiques
Seasonally wet and wet grasslands	4.4.3	Prairies humides et prairies humides saisonnières
Alpine and subalpine grasslands	4.4.4	Pelouses alpines et subalpines
Woodland fringes and clearings and tall forb stands	4.4.5	Ourlets, clairières forestières et peuplements de grandes herbacées non graminoides
Inland salt steppes	4.4.6	Steppes salées continentales

English	Code	Français
Sparsely wooded grasslands	4.4.7	Prairies peu boisées
Subtropical/Tropical Dry Lowland Grassland	4.5	Prairie sèche tropicale ou subtropicale de basse altitude
Subtropical/Tropical Seasonally Wet/Flooded Lowland Grassland	4.6	Prairie tropicale ou subtropicale de basse altitude saisonnièrement humide ou inondée
Subtropical/Tropical High Altitude Grassland	4.7	Prairie tropicale ou subtropicale de haute altitude
Wetlands (inland)	5	Zones humides (continentales)
Permanent Rivers, Streams, Creeks [includes waterfalls]	5.1	Rivières, cours d'eau, ruisseaux permanents (y compris cascades)
Seasonal/Intermittent/Irregular Rivers, Streams, Creeks	5.2	Rivières, cours d'eau et ruisseaux saisonniers, intermittents ou irréguliers
Shrub Dominated Wetlands	5.3	Zones humides arbustives
Bogs, Marshes, Swamps, Fens, Peatlands [generally over 8 ha]	5.4	Tourbières, marais, marécages (généralement plus de 8 ha)
Permanent Freshwater Lakes [over 8 ha]	5.5	Lacs d'eau douce permanents (plus de 8 ha)
Seasonal/Intermittent Freshwater Lakes [over 8 ha]	5.6	Lacs d'eau douce saisonnier/intermittent (plus de 8 ha)
Permanent Freshwater Marshes/Pools [under 8 ha]	5.7	Marais/étangs permanents d'eau douce (moins de 8 ha)
Seasonal/Intermittent Freshwater Marshes/Pools [under 8 ha]	5.8	Marais/étangs saisonniers/intermittents d'eau douce (moins de 8 ha)
Freshwater Springs and Oases	5.9	Sources d'eau douce et oasis
Tundra Wetlands [includes pools and temporary waters from snowmelt]	5.10	Toundra humide (incl. étangs et eaux temporaires des fontes de neige)
Alpine Wetlands [includes temporary waters from snowmelt]	5.11	Zones humides alpines (incl. eaux temporaires des fontes de neige)
Geothermal Wetlands	5.12	Zones humides géothermales
Permanent Inland Deltas	5.13	Deltas continentaux permanents
Permanent Saline, Brackish or Alkaline Lakes	5.14	Lacs permanents alcalins, salins ou saumâtres
Seasonal/Intermittent Saline, Brackish or Alkaline Lakes and Flats	5.15	Lacs ou marécages permanents alcalins, salins ou saumâtres
Permanent Saline, Brackish or Alkaline Marshes/Pools	5.16	Marais/étangs permanents alcalins, salins ou saumâtres
Seasonal/Intermittent Saline, Brackish or Alkaline Marshes/Pools	5.17	Marais/étangs alcalins, salins ou saumâtres saisonniers/intermittents
Rocky Areas [e.g. inland cliffs, mountain peaks]	6	Zones rocheuses (par exemple falaises continentales, sommets de montagne)
Screens	6.1	Éboulis
Inland cliffs. Rock pavements and outcrops	6.2	Falaises continentales, pavements rocheux et affleurements rocheux
Snow or ice-dominated habitats	6.3	Habitats dominés par la neige ou la glace
Miscellaneous inland habitats with very sparse or no vegetation	6.4	Habitats continentaux divers sans végétation ou à végétation clairsemée
Recent volcanic features	6.5	Reliefs volcaniques récents
Desert	8	Désert
Hot	8.1	Désert chaud
Temperate	8.2	Désert tempéré
Cold	8.3	Désert froid
Marine Coastal/Supratidal	13	Zone marine côtière
Sea Cliffs and Rocky Offshore Islands	13.1	Falaises littorales et îles rocheuses au large
Coastal Caves/Karst	13.2	Karst et grottes côtières
Coastal Sand Dunes	13.3	Dunes de sables côtières
Coastal Brackish/Saline Lagoons/Marine Lakes	13.4	Lacs marins, lagons salins ou saumâtres de zones côtières
Coastal Freshwater Lakes	13.5	Lacs d'eau douce de zone côtière
Artificial - Terrestrial	14	Zone terrestre artificielle

English	Code	Français
Arable Land	14.1	Cultures
Pastureland	14.2	Pâturages
Plantations	14.3	Plantations
Rural Gardens	14.4	Jardins de zone rurale
Urban Areas	14.5	Zones urbaines
Subtropical/Tropical Heavily Degraded Former Forest	14.6	Forêt secondaire tropicale ou subtropicale sévèrement dégradée
Artificial - Aquatic	15	Zone aquatique artificielle
Water Storage Areas [over 8 ha]	15.1	Zones de stockage d'eau (supérieures à 8 ha)
Ponds [below 8 ha]	15.2	Mares ou bassins (inférieurs à 8 ha)
Aquaculture Ponds	15.3	Bassins d'aquaculture
Salt Exploitation Sites	15.4	Marais salants
Excavations (open)	15.5	Zones d'excavation (ouvertes)
Wastewater Treatment Areas	15.6	Zone de traitement des eaux
Irrigated Land [includes irrigation channels]	15.7	Terres irriguées (y compris canaux d'irrigation)
Seasonally Flooded Agricultural Land	15.8	Zones agricoles saisonnièrement inondées
Canals and Drainage Channels, Ditches	15.9	Canaux de drainage et fossés
Karst and Other Subterranean Hydrological Systems [human-made]	15.10	Karst et autres systèmes hydrologiques souterrains (artificiels)
Marine Anthropogenic Structures	15.11	Structures marines artificielles
Mariculture Cages	15.12	Cages d'aquaculture
Mari/Brackish-culture Ponds	15.13	Etangs d'aquaculture
Introduced Vegetation	16	Végétation introduite
Other	17	Autres
Unknown	18	Inconnu

Appendix D - IPA-Med / field sheet codes menaces / threats

Typology according to the IUCN classification for the Red List worldwide (Threats classification scheme, version 3.1). Threats highlighted in orange are present in Ghar El Melh.

Typologie selon la classification de l'IUCN pour la Liste rouge mondiale (Threats classification scheme, version 3.1). Les menaces soulignées en orange sont présentes à Ghar El Melh.

English	Code	Français
Residential & commercial development	1	Développement commercial et résidentiel
Housing & urban areas	1.1	Zones urbaines et habitations
Commercial & industrial areas	1.2	Zones industrielles et commerciales
Tourism & recreation areas	1.3	Zones touristiques et récréatives
Agriculture & aquaculture	2	Agriculture et aquaculture
Annual & perennial non-timber crops	2.1	Cultures annuelles ou pluriannuelles (non-ligneuses)
Shifting agriculture	2.1.1	Agriculture itinérante
Small-holder farming	2.1.2	Petites exploitations agricoles
Agro-industry farming	2.1.3	Exploitations agro-industrielles
Wood & pulp plantations	2.2	Plantations pour le bois et la pulpe
Small-holder plantations	2.2.1	Petites plantations
Agro-industry plantations	2.2.2	Plantations agro-industrielles
Livestock farming & ranching	2.3	Élevage à petite et grande échelle
Nomadic grazing	2.3.1	Pâturage nomade
Small-holder grazing, ranching or farming	2.3.2	Pâturage et élevage de petites exploitations
Agro-industry grazing, ranching or farming	2.3.3	Pâturage et élevage agro-industriel
Energy production & mining	3	Production d'énergie et exploitation minière
Oil & gas drilling	3.1	Forages (gaz et pétrole)
Mining & quarrying	3.2	Exploitation de mines ou de carrières
Renewable energy	3.3	Energies renouvelables
Transportation & service corridors	4	Transports et infrastructures
Roads & railroads	4.1	Routes et voies ferrées
Utility & service lines	4.2	Réseaux et linéaires de services et de communication (électrique, téléphone, aqueduc...)
Biological resource use	5	Utilisation des ressources biologiques
Gathering terrestrial plants	5.2	Cueillette de plantes terrestres
Intentional use (species being assessed is the target)	5.2.1	Utilisation intentionnelle (l'espèce évaluée est la cible)
Unintentional effects (species being assessed is not the target)	5.2.2	Effets non-intentionnels (l'espèce évaluée n'est pas la cible)
Persecution/control	5.2.3	Contrôle et destruction
Motivation Unknown/Unrecorded	5.2.4	Motif inconnu
Logging & wood harvesting	5.3	Exploitation forestière et récolte de bois
Intentional use: subsistence/small scale (species being assessed is the target) [harvest]	5.3.1	Utilisation intentionnelle : subsistance ou à petite échelle (l'espèce évaluée est la cible) [récolte]
Intentional use: large scale (species being assessed is the target) [harvest]	5.3.2	Utilisation intentionnelle : à grande échelle (l'espèce évaluée est la cible) [récolte]
Unintentional effects: subsistence/small scale (species being assessed is not the target) [harvest]	5.3.3	Effets non-intentionnels : subsistance ou à petite échelle (l'espèce évaluée n'est pas la cible) [récolte]
Unintentional effects: large scale (species being assessed is not the target) [harvest]	5.3.4	Effets non-intentionnels : à grande échelle (l'espèce évaluée n'est pas la cible) [récolte]
Human intrusions & disturbance	6	Intrusions et perturbations humaines
Recreational activities	6.1	Activités récréatives
War, civil unrest & military exercises	6.2	Guerres, troubles civils et exercices militaires

English	Code	Français
Work & other activities	6.3	Travaux et autres activités
Natural system modifications	7	Modifications du système naturel
Fire & fire suppression	7.1	Incendies et lutte contre les incendies
Increase in fire frequency/intensity	7.1.1	Augmentation de la fréquence ou de l'intensité des incendies
Suppression in fire frequency/intensity	7.1.2	Diminution de la fréquence ou de l'intensité des incendies
Trend Unknown/Unrecorded	7.1.3	Tendance des changements inconnue
Dams & water management/use	7.2	Barrages et gestion ou utilisation de l'eau
Abstraction of surface water (domestic use)	7.2.1	Prélèvement d'eau de surface (utilisation domestique)
Abstraction of surface water (commercial use)	7.2.2	Prélèvement d'eau de surface (utilisation commerciale)
Abstraction of surface water (agricultural use)	7.2.3	Prélèvement d'eau de surface (utilisation agricole)
Abstraction of surface water (unknown use)	7.2.4	Prélèvement d'eau de surface (utilisation inconnue)
Abstraction of ground water (domestic use)	7.2.5	Prélèvement d'eau souterraine (utilisation domestique)
Abstraction of ground water (commercial use)	7.2.6	Prélèvement d'eau souterraine (utilisation commerciale)
Abstraction of ground water (agricultural use)	7.2.7	Prélèvement d'eau souterraine (utilisation agricole)
Abstraction of ground water (unknown use)	7.2.9	Prélèvement d'eau souterraine (utilisation inconnue)
Small dams	7.2.10	Petits barrages
Large dams	7.2.11	Grands barrages
Other ecosystem modifications	7.3	Autres modifications de l'écosystème
Invasive & other problematic species, genes & diseases	8	Espèces exotiques envahissantes et autres espèces, gènes ou maladies problématiques
Invasive non-native/alien species/diseases	8.1	Espèces ou maladies introduites et envahissantes
Unspecified species	8.1.1	Espèces non identifiées
Named species	8.1.2	Espèces identifiées
Problematic native species/diseases	8.2	Espèces ou maladies indigènes problématiques
Unspecified species	8.2.1	Espèces non identifiées
Named species	8.2.2	Espèces identifiées
Introduced genetic material	8.3	Matériel génétique introduit
Problematic species/diseases of unknown origin	8.4	Espèces ou maladies problématiques d'origine inconnue
Unspecified species	8.4.1	Espèces non identifiées
Named species	8.4.2	Espèces identifiées
Diseases of unknown cause	8.6	Maladie de cause inconnue
Pollution	9	Pollution
Domestic & urban waste water	9.1	Eaux usées domestiques et urbaines
Industrial & military effluents	9.2	Effluents industriels et militaires
Agricultural & forestry effluents	9.3	Effluents agricoles et forestiers
Garbage & solid waste	9.4	Détritus et déchets solides
Air-borne pollutants	9.5	Polluants atmosphériques
Geological events	10	Phénomènes géologiques
Avalanches/landslides	10.3	Avalanches et glissements de terrain
Climate change & severe weather	11	Changement climatique et phénomènes météorologiques graves
Habitat shifting & alteration	11.1	Altération et modification de l'habitat
Droughts	11.2	Sècheresses
Temperature extremes	11.3	Températures extrêmes
Storms & flooding	11.4	Tempêtes et inondations
Other impacts	11.5	Autres impacts
Other threats	12.1	Autres menaces