



THE STATUS AND DISTRIBUTION OF FRESHWATER BIODIVERSITY IN NORTHERN AFRICA

N. García, A. Cuttelod and D. Abdul Malak



NORTHERN AFRICA



The IUCN Red List of Threatened Species™ – Regional Assessment



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IUCN Freshwater training workshop, February 2007 in Rabat, Morocco. Photo © Kevin Smith



Executive Summary

Aim

The northern Africa Freshwater Biodiversity Assessment is a conservation status review of 877 northern African freshwater species belonging to five taxonomic groups – fish (128 taxa), molluscs (155 taxa), dragonflies and damselflies (odonata) (82 taxa), freshwater crabs (3 taxa) and aquatic plants (509 taxa). This work addresses the lack of readily available information on the status and distribution of inland water taxa as a basis for adequate representation of freshwater biodiversity within current and future decision-making on the management and conservation of the region's wetlands. This IUCN Red List publication compiles the results of the assessments of five taxonomic groups and provides the first overview of the conservation status of these species in the region in accordance with the IUCN regional Red List guidelines. Species at risk of regional extinction are mapped and conservation measures are proposed to reduce the probability of future declines.

Scope

The geographic scope of this report is defined in terms of the freshwater hydrology of the northern African region and is based on major river catchment delineations within the countries of Algeria, Egypt, Libyan Arab Jamahiriya, Morocco and Tunisia. The assessment region also includes parts of Mauritania, Mali, and the northern tip of Chad, and stops at the northern tip of Lake Nasser in southern Egypt. Freshwater species native to northern Africa and those introduced to the region before 1500 AD are included in this report. It should be noted that species from the Canary and Madeira Islands, and the northern African Spanish territories (Ceuta and Melilla) were not included within the assessment.

River system in Tunisia. Photo© Pedro Regato



Status assessment

IUCN Red List Criteria (IUCN 2001), the world's most widely accepted system for measuring relative extinction risk, were employed to assess the status of all species. Assessments were carried out following the *Guidelines for Application of IUCN Red List Criteria at Regional Levels* (IUCN 2003), and information on each species was compiled by a small team, in collaboration with Specialist Groups of the IUCN Species Survival Commission and other relevant experts, who actively supported the assessment and review. In total, more than 43 experts from the northern African region and elsewhere were involved in the process, either through direct involvement in the three review workshops or through correspondence. All assessments will be available online at www.iucnredlist.org/freshwater.

Results

- 28.2% of the 877 northern African freshwater taxa assessed are threatened with extinction at the regional scale, with a further 9.5% assessed as Near Threatened and 14.1% as Data Deficient.
- 18 freshwater taxa, previously present within the region, are Extinct at the global level, including one endemic fish, *Salmo pallaryi*, and 17 molluscs, the majority of which are native to the Palearctic northern African region (Maghreb). A further 32 species are Regionally Extinct, which means that they have disappeared from the region, but still exist in other parts of the world: 23 freshwater fish, 2 molluscs, 6 dragonflies and damselflies and 1 aquatic plant. Nevertheless, the mollusc *Margaritifera marocana*, which was previously thought to be regionally Extinct, was recently rediscovered and subsequently found to be a new species.
- Freshwater molluscs and aquatic plants both show a high degree of regional endemism, with 81.5% of species endemic to the region.
- Due to the limited number of river systems and wetland areas within the region, freshwater species are mainly concentrated in the Mediterranean Maghreb and the Nile River in Egypt, where the highest numbers of threatened species are also found.
- Habitat loss and degradation, mainly due to water abstraction and dam construction, together with pollution, are the major causes of species decline.

Conclusions/ Key messages

- A major priority for the region is to reduce the currently high number of species assessed as “Data Deficient” due to insufficient information on their current status and distributions. This requires new initiatives to conduct field surveys in the least known areas. This current lack of information on so many species represents a significant bottleneck in progress towards the effective management and conservation of the regions wetland biodiversity.
- The priority areas identified as centres of freshwater biodiversity and threat can help focus development and conservation actions in ways which aim to minimise impacts to freshwater species throughout the region.
- The involvement of communities with a stake in the long-term future of freshwater species and habitats across the region is critical to the success of conservation planning in order to assure the future sustainability of livelihoods, as well as the resources and services provided by functioning wetland ecosystems.

The canyon of Oued Ziz in Morocco, habitat of the Endangered Glittering Demoiselle (*Calopteryx exul*) Photo © Jean-Pierre Boudot



Chapter 1. Background

Van Damme, D.¹, García, N.²

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1.1 Situation analysis for northern Africa

Freshwater habitats and biodiversity are recognized to be under serious threat at global level (Revenge and Kura 2003; Leveque *et al.* 2005; Dudgeon *et al.* 2006). At African level, northern Africa is considered the poorest of all African sub-regions in terms of water resources, with an average of less than 950 m³ of water per habitant and year (Table 1.1*). The scattered rivers in the Maghreb are restricted to Morocco, and together with the endorheic Sahara region contrast with Egypt which has only one river, the Nile, which is also the largest river within the Northern Africa region (FAO 2003). A major pressure on the regions freshwater ecosystems is the high demand for freshwater which is likely to continue in the future due to an ongoing increase in economic and demographic development.

As delineated in this study (Figure 1.2), the northern Africa region extends from the Mediterranean coasts of Morocco, Algeria, Tunisia, Libyan Arab Jamahiriya and Egypt southwards to central Mauritania, north-western Mali as far south as Timbuktu, south Algeria - except for the southern side of the Hoggar range, the Libyan-Chadian border region of the Tibesti Mountains draining north the Egyptian-Sudanese border region - except for Lake Nasser (which is included in the north-eastern African Region). The Sahara desert covers most of this part of Africa, and it is therefore the poorest of all regions in terms of permanently flowing waters. Except for the Nile River, permanent rivers are only found in the northern part of Morocco, Algeria and Tunisia, - the region that is being fed by the rain and snow melt in the Atlas Mountains range.

Many of the region's freshwater species provide goods and services, such as fisheries, water purification and flood prevention, that benefit people in a direct or an indirect way. Due to this close relationship between people and freshwater habitats, especially in relation to the poorest classes of the population, the majority of the impacts affecting freshwater taxa have consequent effects on economies and people's livelihoods. This chapter highlights the main threats affecting freshwater ecosystems and their species, including dam construction, water abstraction, infrastructure development, invasive species, pollution and climate change.

Out of the 93 freshwater ecoregions defined for Africa by Thieme *et al.* (2005), 6 can be found within the northern African region boundaries used in this assessment: Permanent Maghreb (recently re-defined as Atlantic Northwest Africa and Mediterranean Northwest Africa by Abell *et al.* in 2008) (table 1.1), Temporary Maghreb, Nile Delta, and parts of the Lower Nile, Dry Sahel, and of the Red Sea Coastal region (Figure 1.1) Table 1.1.

The text below is based on information taken from Van Damme (1984), Brown (1994), Ramdani *et al.* (1987); Ghamizi (1998), Ghamizi *et al.* (1998), Ibrahim *et al.* (1999); Graf and Cummings (2007), Van Damme and Van Boclaer (2009) and on the collections and field notes of J. Ahuir.

Morocco possesses the most extensive river system in northern Africa. The precipitation that falls in the high mountain ranges of the Rif, Middle Atlas, High Atlas and Anti-Atlas feeds rivers generally flowing north-westward to the Atlantic or south-eastward toward the Sahara. The

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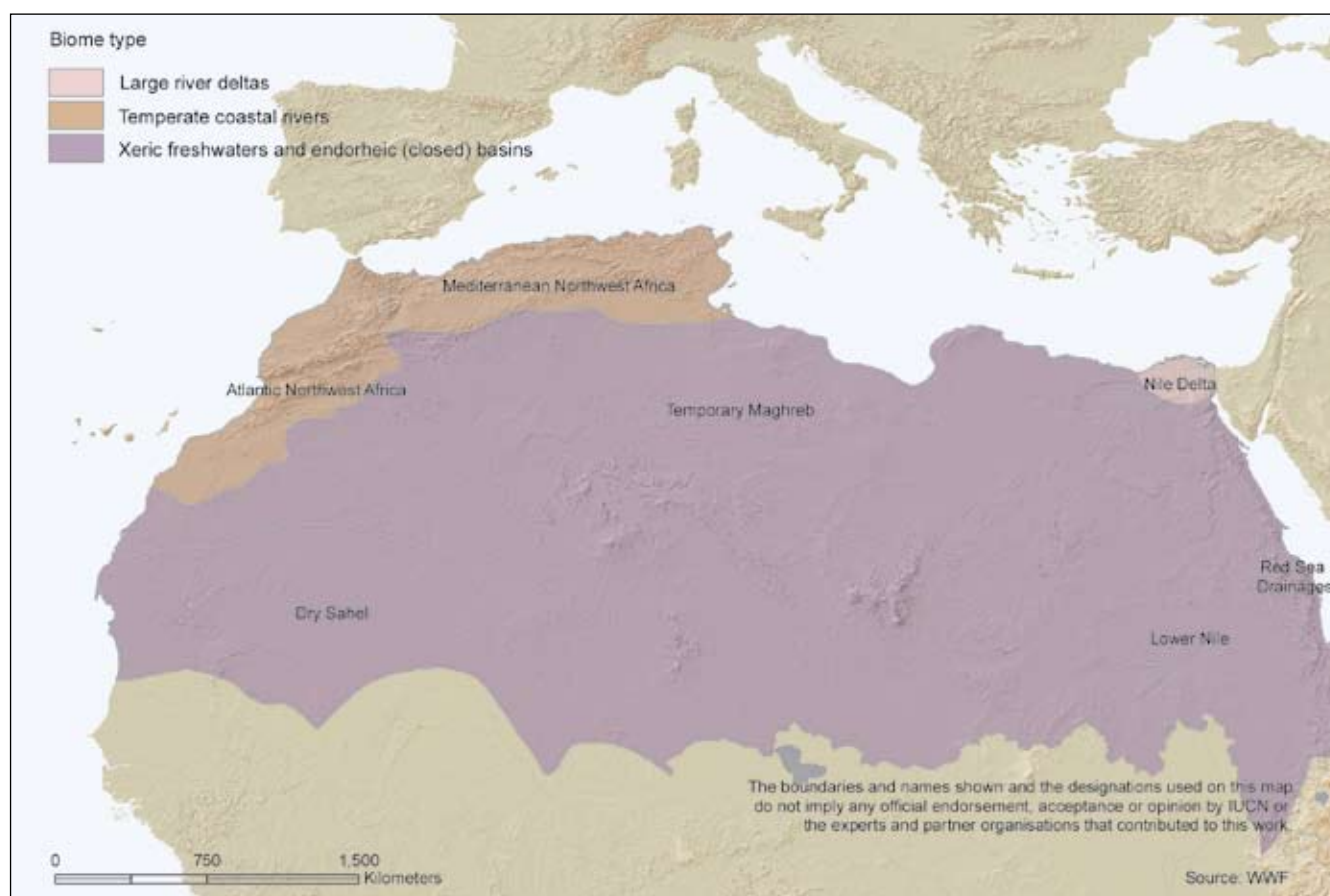
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Table 1.1. The 6 ecoregions defined in Thieme *et al.* (2005) and Abell *et al.* (2008), including information on their extent and conservation status*.

Ecoregion	Major Habitat Type	Ecoregion delimitation	Conservation Status
Permanent Maghreb	Mediterranean systems/ Temperate coastal rivers	River systems draining into the Atlas Mountains and flowing into the Atlantic Ocean and Mediterranean Sea and bound to the south by the northern portion of the Sahara.	Endangered
Nile Delta	Large River Deltas	It extends from Cairo to the Mediterranean Sea in northern Egypt.	Endangered
Dry Sahel	Xeric Systems	Placed between lake Chad catchment in the south, Maghreb in the north, the Atlantic coast in the west and the Nile in the east.	Relatively Intact
Lower Nile	Xeric Systems	From Khartoum, where the White and Blue Nile rivers converge, downstream to the Nile Delta.	Vulnerable
Red Sea Coastal	Xeric Systems	Along the shore of the Red Sea from Egypt to Djibouti.	Relatively intact
Temporary Maghreb	Xeric Systems	Covers the northern portion of the Sahara.	Relatively intact

* Taking into consideration the following countries: Algeria, Egypt, Libyan Arab Jamahiriya, Morocco and Tunisia.

Figure 1.1 Delineation of freshwater ecoregions within the assessment area, labelled as defined by WWF-US (Thieme *et al.* 2005).





Oued Moulouya is the main exception, flowing *ca* 500 km north-east from the Middle Atlas to the Mediterranean Sea. Principal river systems with outlets in the Atlantic are the Oued Oum er Rbia, Sebou, Bou Regreg, Tensift, Draa and Sous. The Oued Ziz, Rheris and Guir are the main rivers flowing southward towards the Sahara. Morocco also possesses a number of mountain lakes (e.g., Lac d'Ifni, Lac d'Isly) situated above the 1800m level, with vast hydroelectric reservoirs and coastal brackish marshes mainly along the Atlantic coast. There are no permanent rivers or standing waters below the Drâa River basin, and the groundwater is brackish.

All main Algerian rivers originate in the Tell Atlas and flow north to the Mediterranean, namely the Oued Chellif system (around 550 km in length) and the Oued Seybouse system (around 180 km in length). Algeria also holds numerous small rivers confined to the Mediterranean mountainous coast of the Tell Atlas. These present the character of mountain torrents, descending rapidly through deep and rocky channels, overflowing during the winter season and reducing to a trickle during the summer. Among the most important rivers are the Oued Harrach, Isser, Mazefran, Tafna, and Macta. In this green part of the country, remnants of formerly extensive lakes and marshlands still occur, namely Lake Fetzara (Anaba), L. Sebkha and L. El Melah (near Oran) and a complex of marshes and small lakes near El Kala. The caverns of Ghar Boumâaza,

discovered in 1931, form the largest African subterranean hydrological system. The Sahara Atlas parallels the Tell Atlas in the south. Between these two ranges extends the arid region of the Hauts Plateaux, containing vast hypersaline seasonal lakes such as Chott-el-Harbi and Chott-el-Chergui. To the south, in the Sahara, no permanent flowing waters exist, although fossil oueds underline the former occurrence of a significant hydrographical network during the Pluvial Periods of the quaternary era.

In Tunisia, the main and only perennial river is the Oued Medjerda system (450 km in length) that originates in Algeria and ends in the Gulf of Tunis (where it flows into the Mediterranean Sea). The largest lakes, Lac de Tunis and Lac Ichkeul, are brackish so some freshwater species occur in the surrounding marshes, as well as in the oasis Nouail, near Chott El Jerid.

In Libyan Arab Jamahiriya and northern Chad there are no permanent rivers but many springs, *seguias* (irrigation canals), pools, artificial wells and oases as well as salt marshes occur. The main regions with oases are those of Ghat, Sabha and Kufrah. The Great Man-made River is a gigantic complex of pipelines that carries water from the deep Nubian Sandstone aquifer in southern Libyan Arab Jamahiriya to the main cities in the north. The crater lakes of Tibesti, e.g., the Trou au Natron, are either saline or alkaline.

The area of Mauritania that falls within the northern African region is completely void of permanent rivers. Surface waters in this country were intensively sampled, e.g., by the famous French traveller and writer Théodore Monod.

No permanent standing or flowing freshwater bodies occur in the north-western part of Mali that is included in this assessment.

Around 25,000 to 30,000 years ago, the region of the Great Lakes in Central Africa tilted northward, and the only permanent river of the northern African region, and longest river in the world, the Nile, was formed in Egypt (see Van Damme and Van Bocxlaer 2009). Nowadays the Nile River has two main tributaries: the White Nile and the Blue Nile. The longest, the White Nile, rises in the Great Lakes region of central Africa, with the most distant source in southern Rwanda, and flows north from there through Tanzania, Lake Victoria, Uganda and southern Sudan. The Blue Nile starts at Lake Tana in Ethiopia, flowing into Sudan from the southeast. These two rivers meet in Sudan, cross Egypt northward opening to a large delta that empties into the Mediterranean Sea. For this assessment, only part of the Nile that flows from the Lake Nasser throughout Egypt to end in the Mediterranean Sea is considered.

In the utmost northwestern part of Sudan, included in the northern African region, a single water surface occurs, the Selima Oasis.

Wetland area in Libyan Arab Jamahiriya. Photo © Ameer Abdulla



1.1.1 Regional use and value of wetlands and their biodiversity

Wetlands have been essential to local communities since ancient times. These water bodies have always provided water, food, materials, and services such as transport, in addition to being a central scenery to the majority of their cultural life and social activities. However, this outlook changed during the first part of the last century, when population growth led to loss and degradation of wetlands following public health initiatives for their desiccation, the expansion of recent construction plans for housing and industries, the conversion into more productive agricultural landscapes, and the development of tourism. Further impacts on freshwater ecosystems are the construction of dams, over-exploitation of groundwater resources for agriculture and potable water, as well as river embanking.

The Ramsar site Réserve Naturelle du Lac des Oiseaux, in Wilaya d'El Tarf (Algeria). Photo © Boudjèma Samraoui



1.1.2 Freshwater species as indicators

There is an increasing need to integrate biodiversity information as a factor of relevance within new planning processes and to improve its availability to decision makers. To address this information deficiency, a group of taxa, considered as good indicators of the conservation status of this particular biome in the North African region, with a reasonable level of pre-existing information on their distribution and status, were chosen to be assessed: freshwater fish and molluscs, dragonflies and damselflies, freshwater crabs and aquatic plants. By combining these five groups in this study a wide range of trophic levels are represented, all of which play diverse ecological roles and therefore are thought to provide a useful indication on the overall status of the associated wetland ecosystems (Darwall *et al.* 2008).

1.2 The Precautionary Principle and species conservation

In the field of species conservation, especially when there is concern that some activities may potentially generate negative impacts, the precautionary principle is a key factor to contemplate in policy decision-making. This principle aims to justify the need to conserve all species in wetlands and points out that, in most cases, even when there is a lack of scientific certainty on the implications of certain threats and their associated consequences, this should not be used as a reason for postponing cost-

effective measures to prevent environmental degradation.

Even species sometimes considered not worthy for conservation action, due to their apparent lack of economic value or widespread distributions, are important and may be key components of their supporting food webs. Species which appear to be “redundant” and without any ecological or economic value may, under changing environmental conditions as often result from human actions, later be found to provide important services and occupy key roles within evolving ecosystems.

Child gathering water from the river. Morocco. Photo © Pedro Regato



Figure 1.2 The northern Africa assessment region.



1.3 Objectives of this study

This assessment of the status and distribution of northern African freshwater biodiversity aims to:

- i) Establish a regional network of experts and train them in biodiversity assessment tools such as the IUCN Red List Categories and Criteria, databases and Geographical Information Systems;
- ii) Collate the necessary information for assessment of conservation status and distributions of freshwater biodiversity (priority taxa) throughout northern Africa and map their distributions;
- iii) Present biodiversity information in a suitable format for stakeholders and decision makers for subsequent integration within the development/conservation planning process.
- iv) Store, manage, analyse and make widely available this biodiversity information within the IUCN data management system, the Species Information Service (SIS).

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Lake Fetzara in Algeria © Boudjéma Samraoui



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Chapter 2. Assessment methodology

García, N.¹, Cuttelod, A.¹, Abdul Malak, D.¹

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2.1 Selection of priority taxa

Priority taxa were selected to represent a range of trophic levels within the food webs that underlie and support wetland ecosystems. Together, the 5 selected taxa represent indicators of the overall conservation status of wetland ecosystems. The following 5 taxonomic groups: fishes, molluscs, dragonflies and damselflies, crabs and aquatic plants, were chosen as good representatives of the freshwater biome.

2.1.1 Fishes

A total of 128 fish taxa (112 species and 16 subspecies) were selected for this assessment. These taxa spend all or a critical part of their life cycle in fresh water or are confined to brackish waters.. The information gathered is a combination of two data sets. The first data set corresponds to the northern African fish component of the Mediterranean Endemic Freshwater fish assessment (Darwall and Smith 2006). From this assessment, 24 fish species were identified as occurring in the 5 northern African countries: Morocco, Tunisia, Egypt, Libyan Arab Jamahiriya and Algeria. All these species were reassessed to ensure inclusion of the most up-to-date information relevant to their current conservation status. The second data set includes 104 (88 species and 16 subspecies) species, including all remaining endemic species and all non-endemic species present in the region.

2.1.2. Molluscs

155 northern African freshwater and brackish molluscs were assessed following two distinctive biogeographic regions based on the composition of the communities in the beginning of the Holocene (Van Damme 1984): the Palearctic northern African region (Maghreb-Egypt) and the Afrotropical northern African region. In total, 118 and 51 mollusc species are native to the Maghreb-Egyptian and the Afrotropical regions respectively, some of them occurring in both areas. Due to ongoing taxonomic uncertainty for many taxa known to be present in the region, which were excluded from the assessment, the number of molluscs included is without doubt an underestimate of the real number of species but it does, nonetheless, provide a good picture of molluscan biodiversity across the region.

2.1.3 Odonates (dragonflies and damselflies)

Records collected by numerous odonatologists over a century and a half were used to map 83 northern African Odonata within the two suborders occurring in the region: 35 species of Zygoptera (damselflies) and 48 of Anisoptera (dragonflies).

2.1.4 Freshwater Crabs

Freshwater crabs in northern Africa are only represented by three species that belong to two genera: *Potamon* and *Potamonautes* (Cumberlidge 1999).

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Female of the African Grizzled Pintail, *Acisoma panorpoides* (Endangered), an Afrotropical relict species known from Siwa oasis and other parts of Egypt. Photo © Kevin Smith



2.1.5 Aquatic plants

The aquatic plants selected for assessment are macrophytes that are either strictly aquatic species – Hydrophytes - or that have photosynthetically active parts that are able to tolerate long periods submerged, or are floating – Helophytes (Cook 1996). The selection of families for assessment also takes into account their wider representation throughout other regions of Africa. Time constraints limited assessments to the species level. The importance of a future assessment at the subspecies level was highlighted as a priority, this region is particularly rich in endemic sub-species that might prove to be an important genetic pool.

2.2 Data collation and quality control

Key regional and international experts were identified by the IUCN Centre for Mediterranean Cooperation, in collaboration with IUCN members and partners, and through consultation with the relevant IUCN SSC Specialist Groups. These experts participated in a training workshop in Rabat (Morocco) in February 2007. They were trained in the use of IUCN Categories and Criteria as employed to assess the risk of extinction of each species, as well as in use of the IUCN Species database, the Species

Information Service Data Entry Module (SIS DEM) during this workshop and through further consultations.

Selected participants from the training workshop were then contracted to gather the existing data from different sources. Data were collected from the literature and regional or national reports on the distribution, biology and ecology, habitats, threats, utilization and conservation status of all selected species. These data were entered into the IUCN species database and distribution maps were created for each species (see section 2.3). Based on the available information, preliminary assessments of the conservation status of each species were completed according to the IUCN Red List methodology (see section 2.4).

A first evaluation workshop was held in Porto (Portugal) in October 2007 where the status of freshwater fish, molluscs, odonata, as well as selected aquatic plants was reviewed. This ensured that the most up-to-date, comprehensive and rigorous information was included in the assessment. A special session was dedicated to discussing the most appropriate conservation measures needed, in order to reduce the impact of the main threats identified during the Red List process. Additional experts were consulted, when needed, after the workshop to fill some data gaps. A second workshop was held in Tabarka (Tunisia) in February 2009 to finalize the review of the aquatic plants species. Due to the small number of crab species the review of these assessments was conducted through email consultation.

Following this review, the data were edited and consistency in the use of IUCN Red List Categories and Criteria was checked by the workshop participants and the IUCN Species Programme team.

IUCN Freshwater training workshop, February 2007 in Rabat, Morocco. Photo © Ahmed Azeroual



After data gathering, collation and corrections, IUCN experts from the Red List Unit and the Mediterranean Species Programme integrated the various data sets in order to draft the regional report. In parallel, equivalent assessments and reports were conducted for the western, eastern, central and southern African regions in order to present a comprehensive view of the conservation status of freshwater biodiversity at the pan-African scale.

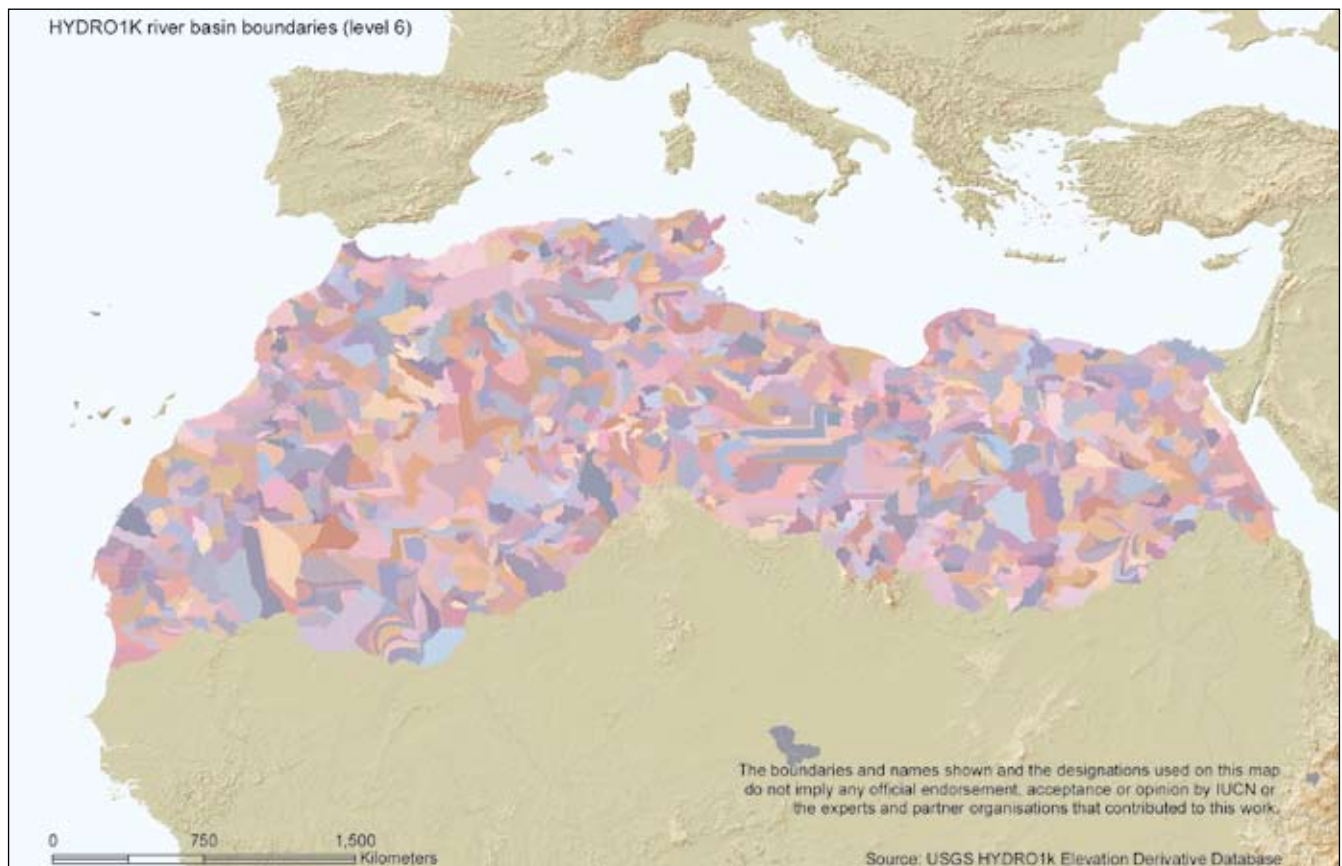
2.3 Species mapping

River basins were selected as the spatial unit for mapping and analysing species distributions as it is generally accepted that the river/lake basin or catchment is the most appropriate management unit for inland waters. Therefore, all species distribution were mapped to river sub-basins as delineated using the level 6 river basins defined by HYDRO1k Elevation Derivative Database (USGS EROS) using ArcView/ Map GIS software (see Figure 2.1). It is recognised that species ranges may not always extend throughout a river sub-basin but until finer scale spatial detail is provided each species is assumed to be present throughout the sub-basin where it has been recorded.

For the crabs and odonata, point localities (the latitude and longitude of the observations of a species) were used to identify the river catchments where a species occurs. However, in order to simplify displaying species distributions, these point localities are not displayed on the species distribution maps. Further sub-basins, where the species is expected to be present, but where no records yet exist, are also mapped and are labelled as “inferred basins”. For the other taxonomic groups, point localities were not available and maps were drawn based on expert knowledge and literature. This exchange of geographical information followed up with further discussion and a final consistency check provides reasonably comprehensive database on species spatial distributions across the northern African region.

A GIS Training workshop was held in Hammamet (Tunisia) in January 2009 to build regional freshwater expertise on the use of GIS in conservation, planning and management. This gathering aimed to train experts on the application of GIS techniques for the representation of freshwater species distribution and the analysis of these data in order to gain a better understanding of the status of the biodiversity and the application of these data sets for conservation planning.

Figure 2.1 Level 6 river basins as delineated by HYDRO1K Elevation Derivative Database (USGS EROS) and used to map and analyse species distributions.



Oued Seybouse, Algeria. Photo © Boudjéma Samraoui.



Participants of the GIS training workshop, January 2009 in Tunis, Tunisia. Photo © IUCN Med



2.4 Assessment of species threatened status

The conservation status of each species was assessed according to the *2001 IUCN Red List Categories and Criteria: Version 3.1* (IUCN 2001). In order to avoid an over- or underestimation of the regional risk of extinction, the *Guidelines for Application of the Red List Criteria at Regional Level* (IUCN 2003) were applied.

Species were classified within one of the 11 regional categories ranging from Least Concern for species that are not threatened to Extinct for species that have disappeared completely (see Figure 2.2). This system is based on a set of scientific quantitative criteria related to populations trends and size, geographical range, number of locations where the species is present, connectivity within these locations and past, present and predicted threats (for further information on IUCN Categories and Criteria, please check www.iucnredlist.org).

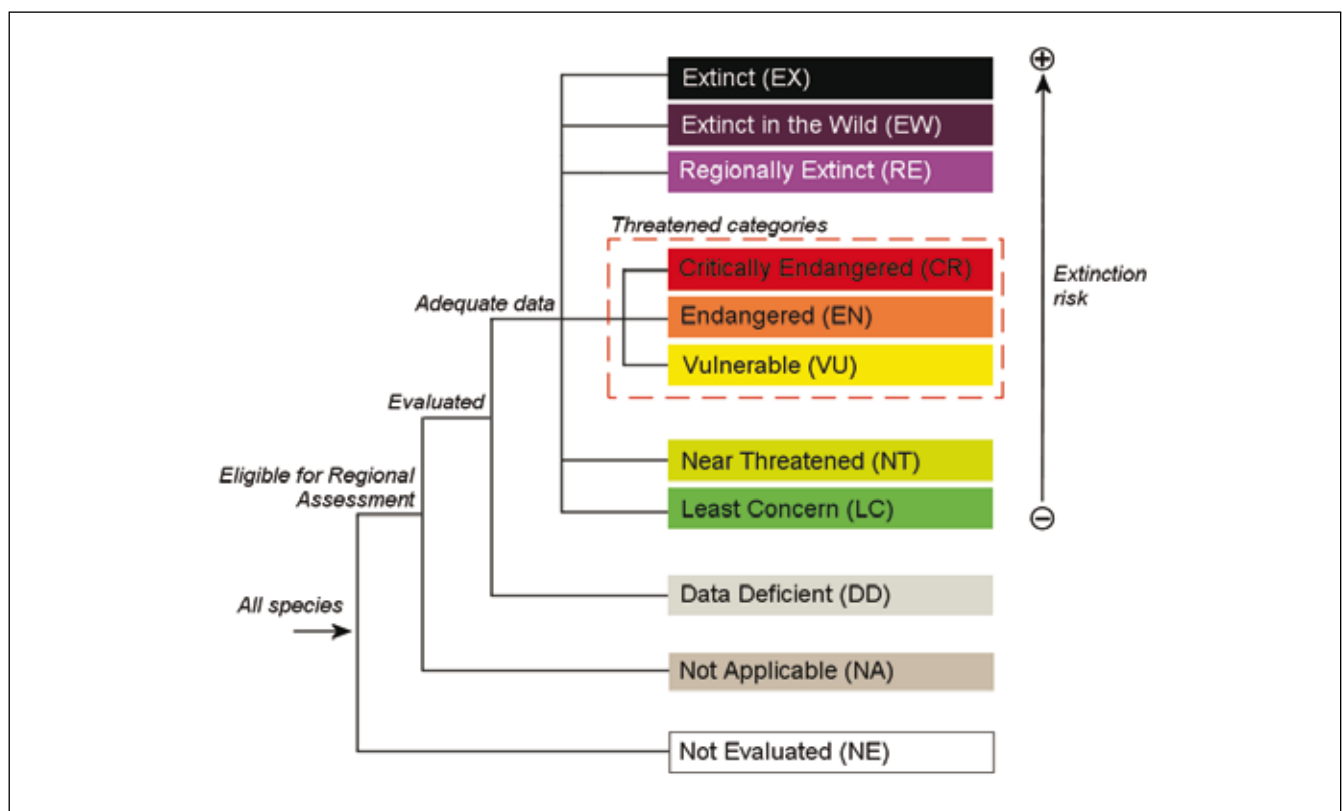
Species assessed under the categories Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) are considered as “threatened” and face the highest risk of extinction.

Exotic species that settled, or were introduced to northern Africa after 1500 AD were not considered for this assessment.

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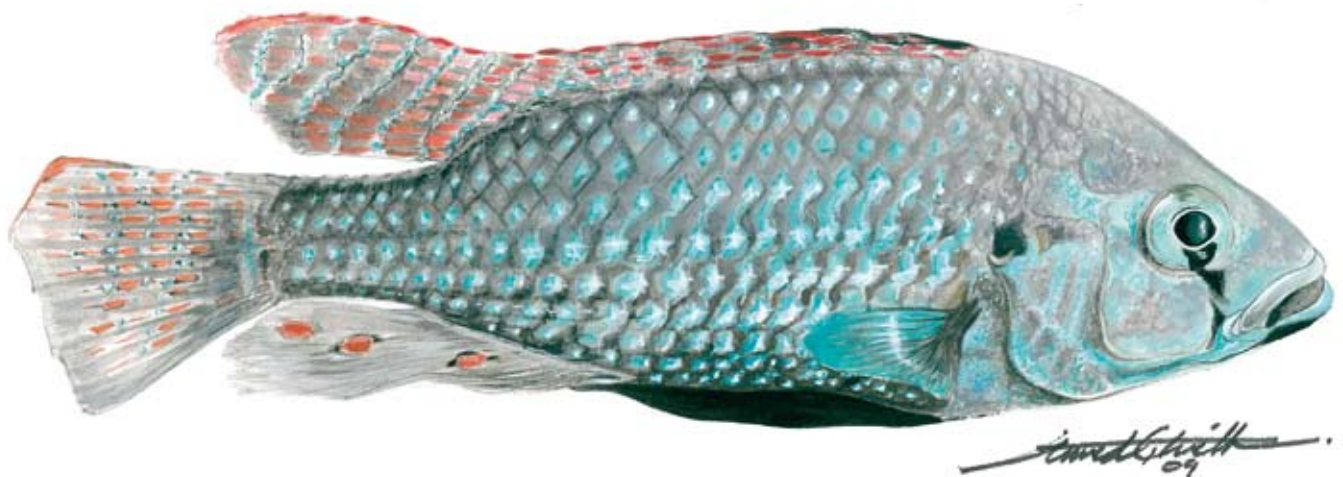
Figure 2.2 IUCN Red List Categories at the Regional Scale



Chapter 3. The status and distribution of freshwater fish

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3.1 Overview of the regional fauna.

Northern African fishes have a history marked by regional extinction, which has reduced the recorded/ former species richness by 19%. However, despite this, the geographical location, and specific climate (relatively high summer temperatures, and low rainfall), the number of endemic species in the northern African fish community remains high.

The major habitats where these species occur are permanent rivers, freshwater lakes and springs of underground waters such as oases of northern African river systems flowing into the Mediterranean Sea and the Atlantic Ocean. Consequently, the richness and diversity of freshwater fish are directly related to the availability of rivers and lakes and are therefore higher in Egypt, in keeping with the importance and perennity of the River Nile. In Morocco, freshwater fish richness is also high where species colonise lagoon habitats (e.g., eels) downstream of the rivers, natural lakes and reservoirs where several exotic species have been introduced (e.g., Cyprinicol taxa such as barbels). In addition, freshwater salmonids are also found in upstream rivers towards elevated regions like the Rif, the Middle and the High Atlas.

A total of 128 northern African endemic and non-endemic fish were assessed for the freshwater biome (112 species and 16 subspecies). Approximately 27% are minnows, carps and barbels (Cyprinidae family), such as the Endangered Senegal minnow *Raiamas senegalensis* and the Vulnerable Three spot barb *Barbus perince*.

Freshwater fish of the *Haplochromis* genus. Siwa region in Egypt. Photo © Kevin Smith



Barbus molouyensis is a widespread barbel endemic to the Moulouya River basin in northern Morocco (Least Concern). Photo © Ahmed Yahyaoui



The Northeast of Algeria is one of the northern African regions where the number of endemic freshwater fish is highest. The Lac Bleu. Photo © Boudjèma Samraoui.



Table 3.1. Total number of freshwater fish, endemic and threatened for each family in the northern African region.

Family	Total	Number of endemics	Number of threatened taxa
CYPRINIDAE	34	22	11
CICHLIDAE	16	3	3
MOCHOKIDAE	12	0	3
MORMYRIDAE	9	0	5
BAGRIDAE	8	0	2
ALESTIIDAE	8	0	1
CITHARINIDAE	6	0	2
CYPRINODONTIDAE	5	3	1
SCHILBEIDAE	4	0	1
SALMONIDAE	3	3	1
CLARIIDAE	4	0	2
CLUPEIDAE	2	0	0
POECILIIDAE	2	0	0
POLYPTERIDAE	2	0	0
COBITIDAE	1	1	1
BLENNIIDAE	1	0	0
MALAPTERURIDAE	1	0	1
ANGUILLIDAE	1	0	1
MONODACTYLIDAE	1	0	0
OPHICHTHIDAE	1	0	0
PROTOPTERIDAE	1	0	0
TETRAODONTIDAE	1	0	0
GYMNARCHIDAE	1	0	0
LATIDAE	1	0	0
ARAPAIMIDAE	1	0	0
ARIIDAE	1	0	0
ANABANTIDAE	1	0	0
TOTAL	128	32	35

Looking more in detail at the singularity of the group, a quarter (25%) of the taxa present in the region is endemic, which means that 32 fish are unique to the region. More than two thirds (69%) of this endemic fauna belong to the Cyprinidae family (minnows, barbels and carps), and the rest to the Cichlidae (cichlids) (Table 3.1), Cyprinodontidae (pupfishes), Salmonidae families (salmonids) and Cobitidae (true loaches). Of the 34 species belonging to the Cyprinidae family, 26 of these are barbells (genus *Barbus*) making this the most common genus in the region. This genus represents more than 20% of the total number of freshwater fish, as well as 59% of the total endemics, namely the barbells “Luciobarbus”.

The Red List status of freshwater fish families present in the northern African region is represented in the Figure 3.1.

The status of the Mormyridae and Citharinidae families is very alarming. 44.4% and 66.7% of these taxa respectively are already extinct in the region, as well as 55.6% and 33.3% respectively being currently threatened.

The Cobitidae and Anguillidae families are each represented in the region by only one species (*Cobitis maroccana* and *Anguilla anguilla*). Both species are threatened which places the whole family in the region under threat.

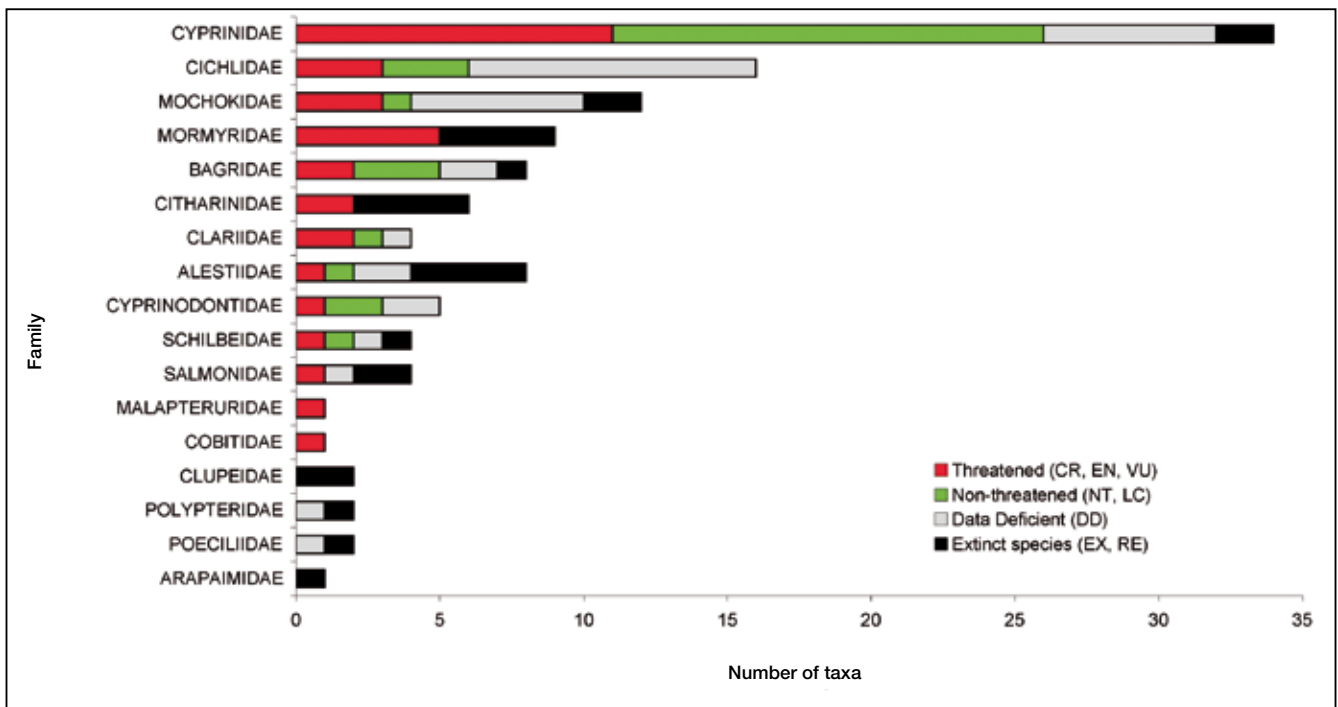
According to Vivier (1948), Morocco is the northern African country where the diversity of barbels is highest, with 11 species. This diversity declines towards the east where Algeria has only 4 species and Tunisia counts a total of 2 species (Kraïem 1994; Vivier 1948) making the enforcement of an advanced systematic revision of Moroccan endemic fish species, such as barbels required (Doadrio 1994; Doadrio *et al.* 1998).

The Least Concern *Barbus lepineyi* is restricted to the Draa river system in Morocco. Photo © Ahmed Yahyaoui





Figure 3.1 Number of Threatened, Non-Threatened, Data Deficient, or Extinct (and Regionally Extinct) freshwater fish for each Family in the northern African region. Families with Non-Threatened, Extinct or Regionally Extinct species were excluded from the graph for simplification.



The Sahara aphantius *Aphanius saourensis* is the freshwater fish under higher risk of extinction in the northern African region, (Critically Endangered). Photo © Heiko Kaerst.



Table 3.2 Number of freshwater fish in each regional Red List Category in the northern African region.

	Regional Red List Category	Total (%)	Number of regional endemics (%)
	Extinct (EX)	1 (0.8%)	1 (3.1%)
	Regionally Extinct (RE)	23 (18.0%)	0 (0%)
Threatened categories	Critically Endangered (CR)	1 (0.8%)	1 (3.1%)
	Endangered (EN)	8 (6.3%)	2 (6.3%)
	Vulnerable (VU)	26 (20.3%)	7 (21.9%)
	Near Threatened (NT)	2 (1.6%)	2 (6.3%)
	Least Concern (LC)	26 (20.3%)	11 (34.4%)
	Data Deficient (DD)	41 (32.0%)	8 (25%)
	Total number of taxa assessed*	128	32 (100%)

* Excluding species that are considered Not Applicable.

Figure 3.2 Proportion of freshwater fish in each regional Red List Category in the northern African region.

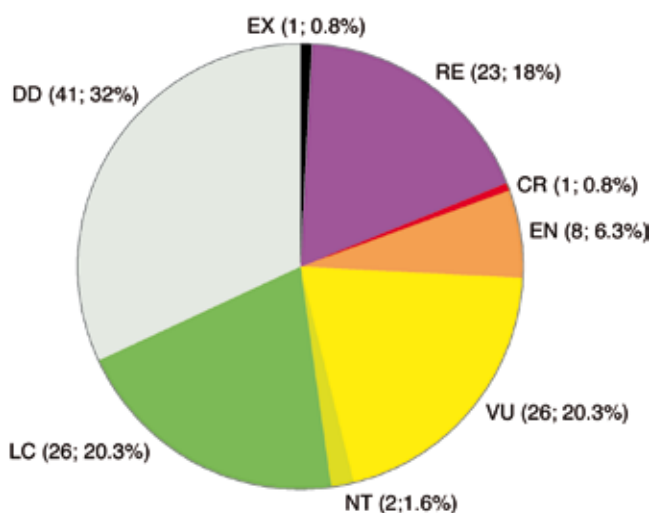
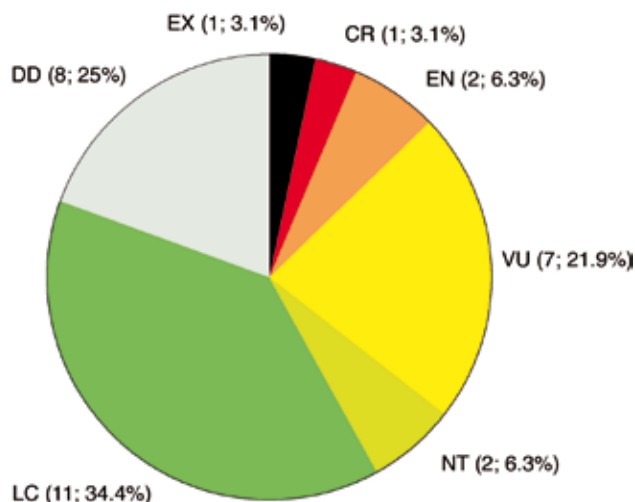


Figure 3.3 Proportion of endemic freshwater fish in each regional Red List Category in the northern African region.



Barbus nasus is assessed as Near Threatened in the region and restricted to the Atlas Mountains of Morocco due to a significant reduction of its area of distribution in the past. Photo © Ahmed Yahyaoui





3.2 Conservation status (IUCN Red List Criteria: Regional Scale)

27.3% of the total taxa assessed (128 species and subspecies) at the regional level were found to be threatened. A further 1.6% are Near Threatened, while only about a fifth (20.3%) are Least Concern. Almost a third of the species (32%) are considered Data Deficient, which means that there was not enough information to classify them within one or the other Red List category. However, it should be noted that this does not imply that these are not threatened; on the contrary, they may prove to be threatened when more data become available (Smith and Darwall 2006).

Among the 27.3% threatened species (Table 3.2), 20.3% are Vulnerable, 6.3% are Endangered and one species (0.8%), the Sahara aphantius (*Aphanius saourensis*) native to Algeria, is Critically Endangered.

When considering the uniqueness of the region, ten endemic species to northern Africa (31.3%- of all the endemics) are categorized as threatened (CR, EN, VU)

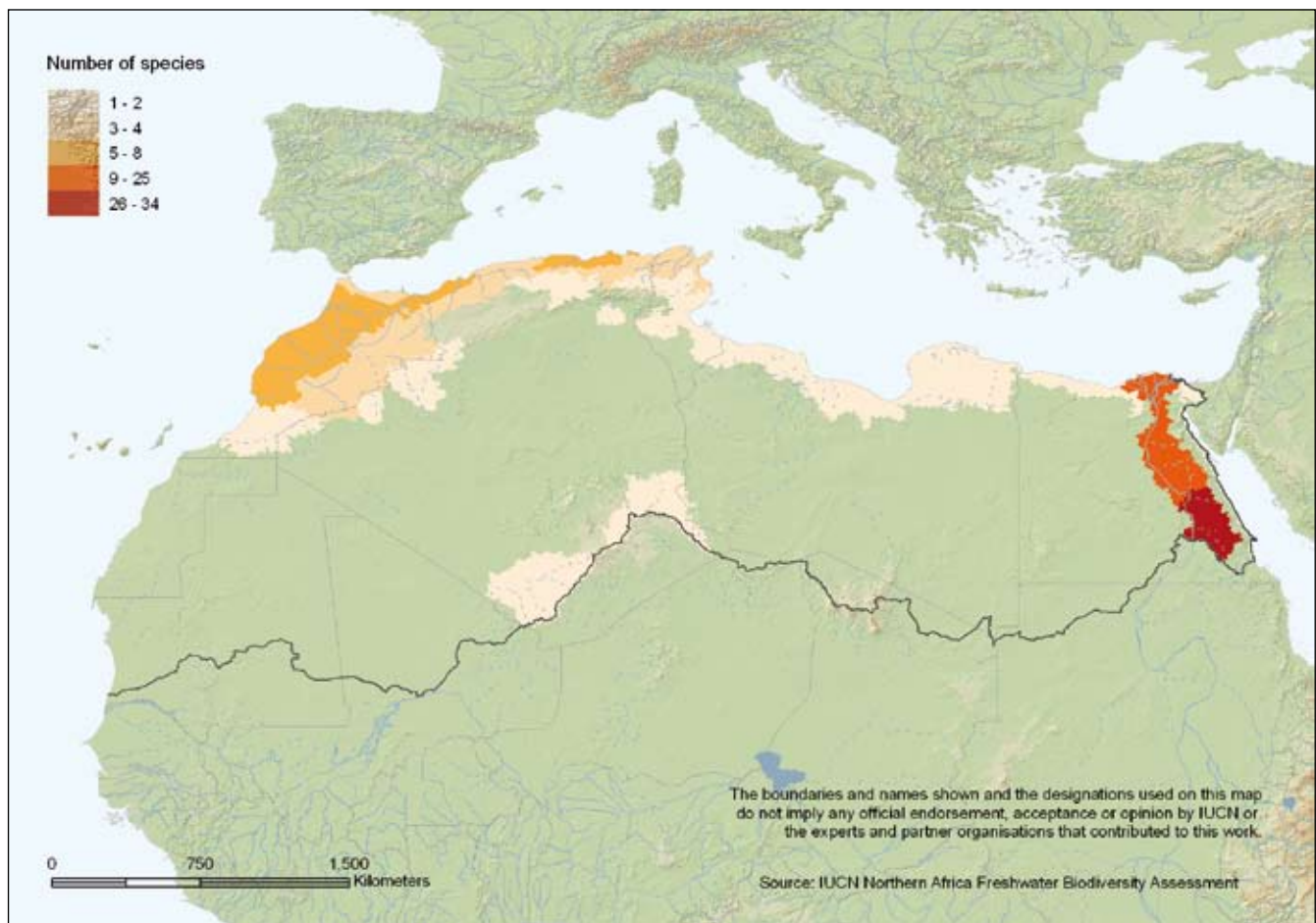
under IUCN criteria (Table 3.2) being *Aphanius saourensis*, *Haplochromis desfontainii*, *Barbus ksibi*, *Barbus reinii*, *Barbus harterti*, *Barbus issenensis*, *Barbus paytonii*, *Cobitis maroccana* and *Pseudophoxinus punicus* and *Salmo akairos* (see Figures and Tables 3.2 and 3.3).

3.3 Patterns of species richness

3.3.1 All evaluated taxa

In the northern African region, there is a concentration of freshwater fish species in the north and west of the region in Morocco, Algeria and Tunisia, and along the Nile River in Egypt (particularly the upper Nile). This high richness also extends to the vicinity of Lake Nasser but this is outside the area of assessment (Figure 3.4). This distribution is related to the very limited river systems and wetland areas of northern African countries, with the exception of some species surviving in more stressful conditions and oases. In the Maghreb region, the richness declines from the Atlantic coast of Morocco (Atlas) towards the south-eastern side. In Morocco, taxa are concentrated on aquatic ecosystems of the middle and

Figure 3.4 The distribution of fish in the northern African region, showing the highest numbers in the Upper Nile River with a declining tendency towards the north.



high Atlas and Rif such as the Oueds Sebou, Oum Rbia, Moulouya, Loukkos, Lakes of Middle Atlas, coastal lagoons and estuaries of large Moroccan rivers. In Algeria, because of its great wetland diversity, Numidia and environs have the highest species richness of aquatic organisms (Samraoui and de Bélair 1997, 1998).

3.3.2 Threatened taxa

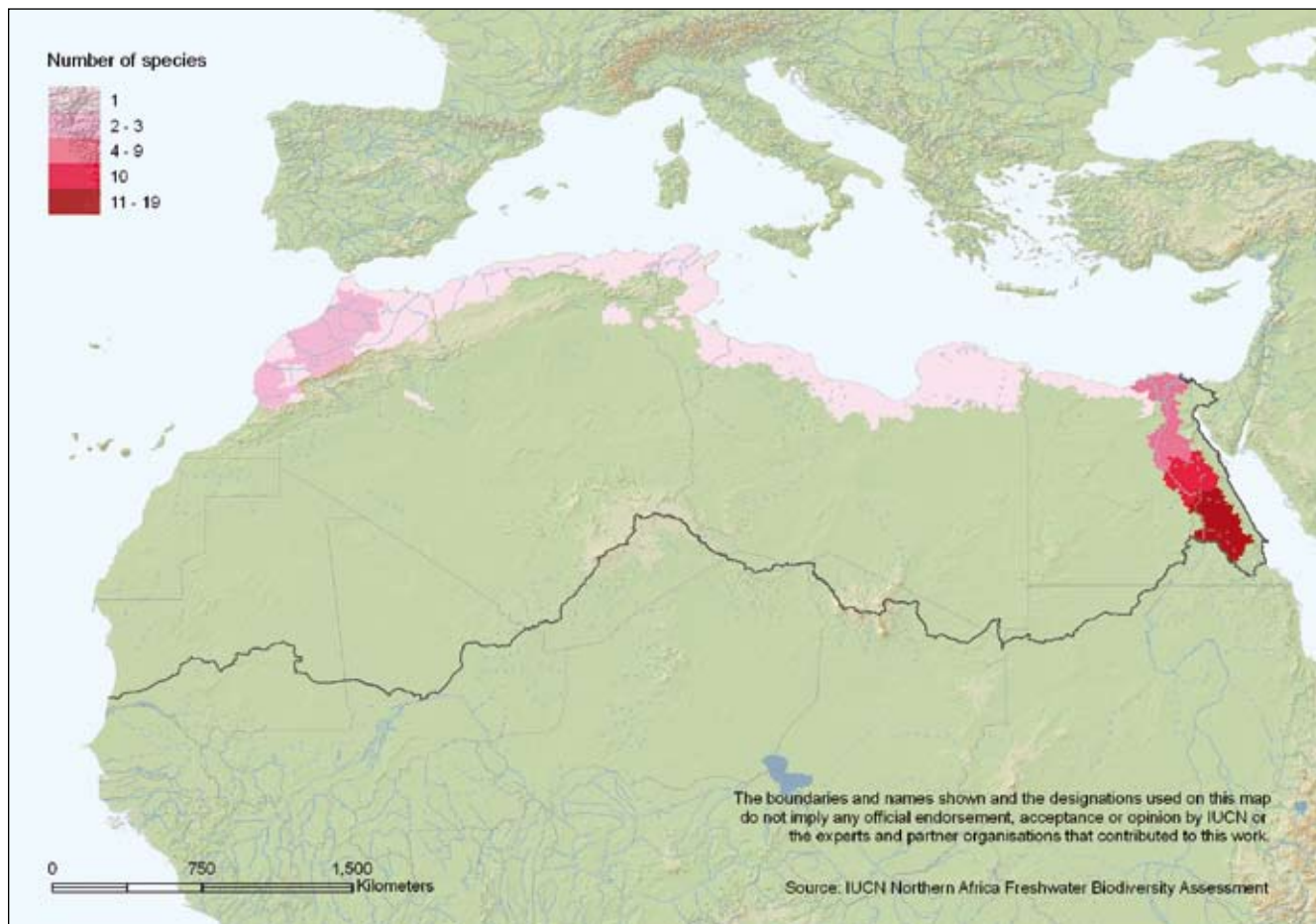
The majority of the threatened taxa are found in the Nile River, especially in the Lower Nile. This trend is mainly attributed to water pollution and human impacts. Moreover, the taxa present in the river systems of Morocco, flowing into the Atlantic and Mediterranean Sea, include a relatively high number of threatened fish that are susceptible to extinction risks due to the decline in area and quality of their habitat in addition to the seasonality of the presence of water bodies (Figure 3.5; Table 3.3).

The most threatened fish in the region is the Critically Endangered Sahara aphantius *Aphanius saourensis*,

endemic to Algeria (Blanco *et al.* 2006). This species is suffering an increasing decline in its population due to the introduction of the invasive North American Mosquitofish (*Gambusia holbrooki*) as a biological controlling agent, excessive ground water withdrawal for agricultural purposes, drying of wetlands, and water pollution (Blanco, Hrbek and Doadrio, 2006). It is to note that the North American Mosquitofish is a species that has become naturalized all over the world (Courtney and Meffe 1989), impacting on aquatic ecosystems (Hurlbert and Mulla 1981, Samraoui 2002, Leyse *et al.* 2004), and preying on insects, amphibians and small fish (Swanson *et al.* 1996, Englund 1999, Hamer *et al.* 2002).

In addition, the freshwater species *Haplochromis desfontainii* and *Pseudophoxinus punicus*, which are native to Tunisia and Algeria, are under a high threat of extinction (Endangered at the northern African regional level) as a result of groundwater extraction, dams, water pollution and drought (Pellegrin 1921; Kraiem pers. comm.).

Figure 3.5 Distribution of freshwater fish in regionally threatened categories. The Nile River basin is the region with the highest number of threatened taxa showing a declining tendency from south to north.





Barbus issenensis is restricted to the Sous and Massa basins in Morocco. It is threatened by the decline in area and quality of its habitat due to water extraction and agricultural, industrial and domestic pollution. (Vulnerable)
Photo © Ahmed Yahyaoui



Habitat destruction for urbanisation and groundwater extraction are affecting the entire distribution of *Barbus ksibi* in the wadi Ksob (Morocco). (Vulnerable). Photo © Ahmed Yahyaoui



Table 3.3 Threatened freshwater fish of the northern African region

Family	Species	Common name	IUCN Red List status	Endemic to northern Africa?
CYPRINODONTIDAE	<i>Aphanius saourensis</i>	Sahara aphanus	CR	Yes
ANGUILLIDAE	<i>Anguilla anguilla</i>	European eel	EN	
CYPRINIDAE	<i>Chelaethiops bibie</i>	Turkana sardine	EN	
CICHLIDAE	<i>Haplochromis desfontainii</i>	-	EN	Yes
CICHLIDAE	<i>Hemichromis bimaculatus</i>	Jewelfish	EN	
CYPRINIDAE	<i>Labeo coubie</i>	African carp	EN	
CYPRINIDAE	<i>Leptocypris niloticus</i>	Nile minnow	EN	
CYPRINIDAE	<i>Pseudophoxinus punicus</i>	-	EN	Yes
CYPRINIDAE	<i>Raiamas senegalensis</i>	Senegal minnow	EN	
ALESTIIDAE	<i>Alestes dentex</i>	Nile robber	VU	
BAGRIDAE	<i>Auchenoglanis biscutatus</i>	Black spotted catfish	VU	
BAGRIDAE	<i>Auchenoglanis occidentalis</i>	Spotted catfish	VU	
CITHARINIDAE	<i>Citharinus citharus citharus</i>	Moon fish	VU	
CITHARINIDAE	<i>Citharinus latus</i>	Moon fish	VU	
CICHLIDAE	<i>Haplochromis bloyeti</i>	Lesser perch	VU	
CLARIIDAE	<i>Heterobranchus bidorsalis</i>	Eel-like fattyfin catfish	VU	
CLARIIDAE	<i>Heterobranchus longifilis</i>	Vundu	VU	
COBITIDAE	<i>Cobitis maroccana</i>	-	VU	Yes
CYPRINIDAE	<i>Barbus harterti</i>	-	VU	Yes
CYPRINIDAE	<i>Barbus issenensis</i>	-	VU	Yes
CYPRINIDAE	<i>Barbus ksibi</i>	-	VU	Yes
CYPRINIDAE	<i>Barbus paytonii</i>	-	VU	Yes
CYPRINIDAE	<i>Barbus perince</i>	Three spot barb	VU	
CYPRINIDAE	<i>Barbus reinii</i>	-	VU	Yes
MALAPTERURIDAE	<i>Malapterurus electricus</i>	African electric catfish	VU	
MOCHOKIDAE	<i>Mochokus niloticus</i>	Dwarf Nile catfish	VU	
MORMYRIDAE	<i>Marcusenius cyprinoides</i>	Thisk-lipped fish	VU	
MORMYRIDAE	<i>Mormyrus caschive</i>	Eastern bottlenose	VU	
MORMYRIDAE	<i>Mormyrus kannume</i>	Bottlenose	VU	
MORMYRIDAE	<i>Petrocephalus bane bane</i>	Churchill	VU	
MORMYRIDAE	<i>Pollimyrus isidori isidori</i>	Elephant fish	VU	
SALMONIDAE	<i>Salmo akairos</i>	-	VU	Yes
SCHILBEIDAE	<i>Schilbe uranoscopus</i>	Butter catfish	VU	
MOCHOKIDAE	<i>Synodontis clarias</i>	Squeaker	VU	
MOCHOKIDAE	<i>Synodontis serratus</i>	Shield-head catfish	VU	

3.3.3 Endemic taxa

The coastal Mediterranean rivers of Algeria and Tunisia, especially those of Numidia and environs, show the highest concentrations of endemic fish (Figure 3.6). The geographical position, diversity of relief, as well as the importance of the hydrographic system explains this uniqueness. The central and western parts of Morocco are also of particular importance for the endemic freshwater fish of the region as 19 of the 27 endemic taxa occur in this area. The catchments where these numbers are most significant are the basins of Moulouya, Oum Rbia, Sebou, Bou Regreg and Loukkos Rivers, and in the High Atlas region. Four species and subspecies of *Aphanius* occur in Algeria, two of which are endemic, one Data Deficient *A. apodus* and one Critically Endangered *A. saourensis*.

Salaria fluviatilis a Least Concern species endemic to the northern African region that inhabits riverine habitats and lakes of Morocco and Algeria, Ourgha river, Morocco. Photo © Ahmed Yahyaoui



3.3.4 Extirpated taxa

A significant number (18%) of fish taxa has disappeared from the region and these are therefore listed in either the Extinct (1 taxon) or Regionally Extinct (23) categories. The Regionally Extinct taxa are representatives of 11 families: Alestiidae, Arapaimidae, Bagridae, Citharinidae, Clupeidae, Cyprinidae, Mochokidae, Mormyridae, Poeciliidae, Polypteridae and Schilbeidae. Almost all of these freshwater fish (96%) were present within the Nile River basin in Egypt (22 of the 23 RE fish). (Figure 3.7; Table 3.4).

The endemic salmonid *Salmo pallaryi*, was native to the Atlas Mountains in northern Morocco and is the only species that is Extinct at the global scale since the 1930s. The introduction of the common carp, *Cyprinus carpio*, is thought to be the reason for its disappearance (Azeroual 2003, Kottelat 1997). The repeated introductions of four species of carp (*Cyprinus carpio*, *Aristichthys nobilis*, *Hypophthalmichthys molitrix* and *Ctenopharyngodon idella*) and other exotic fish (*Stizostedion lucioperca*, *Lepomis gibbosus*, *Gambusia holbrooki*) at Lake Oubeira greatly impoverished the zooplankton of this Ramsar site and led to the disappearance of autochthonous species like *Alosa*

Figure 3.6 Distribution of endemic freshwater fish is prevalent in the northeast of Algeria, western Tunisia, and around the Atlas region in Morocco.

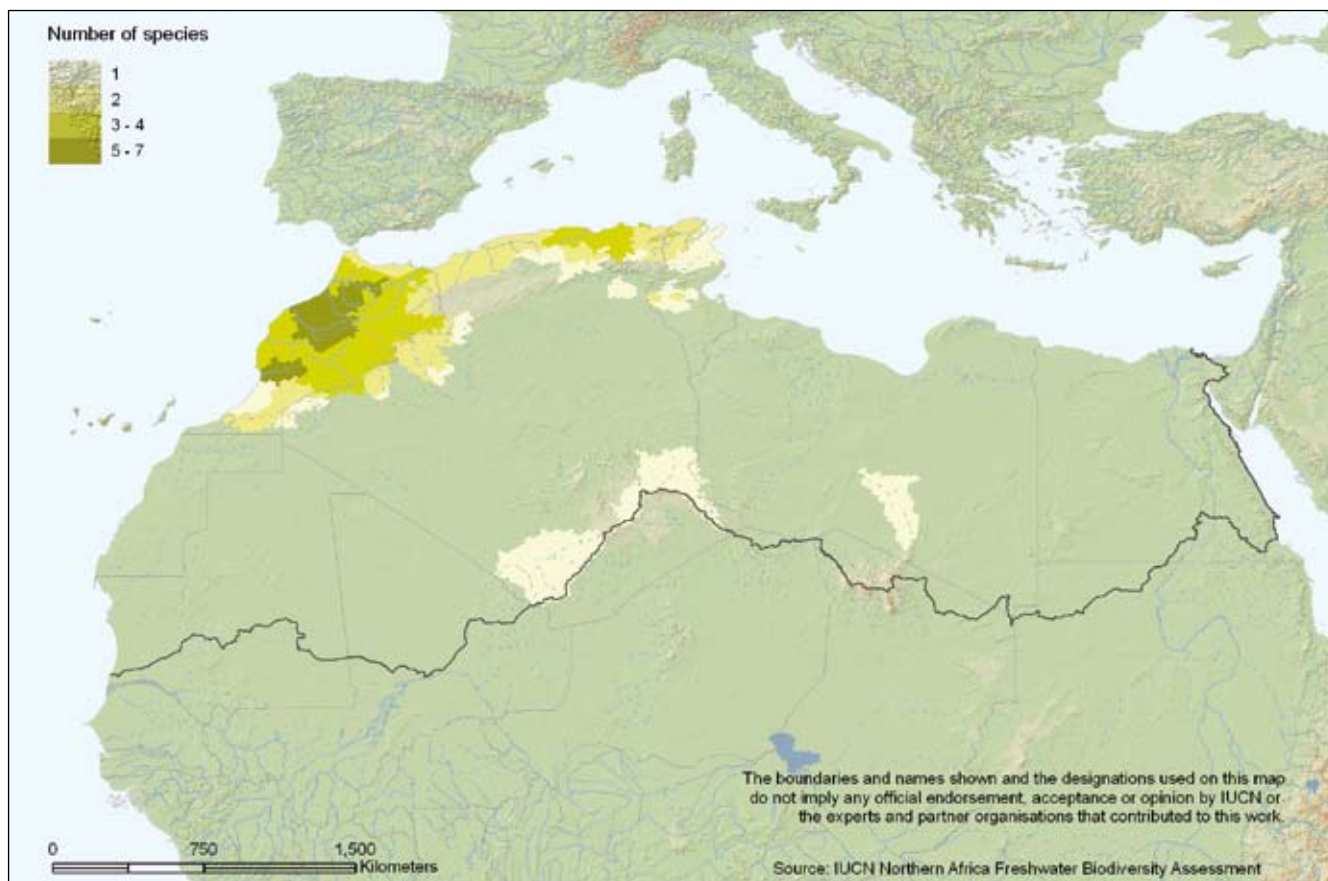




Figure 3.7 Distribution of extirpated freshwater fish is prevalent in the Nile River region in Egypt.

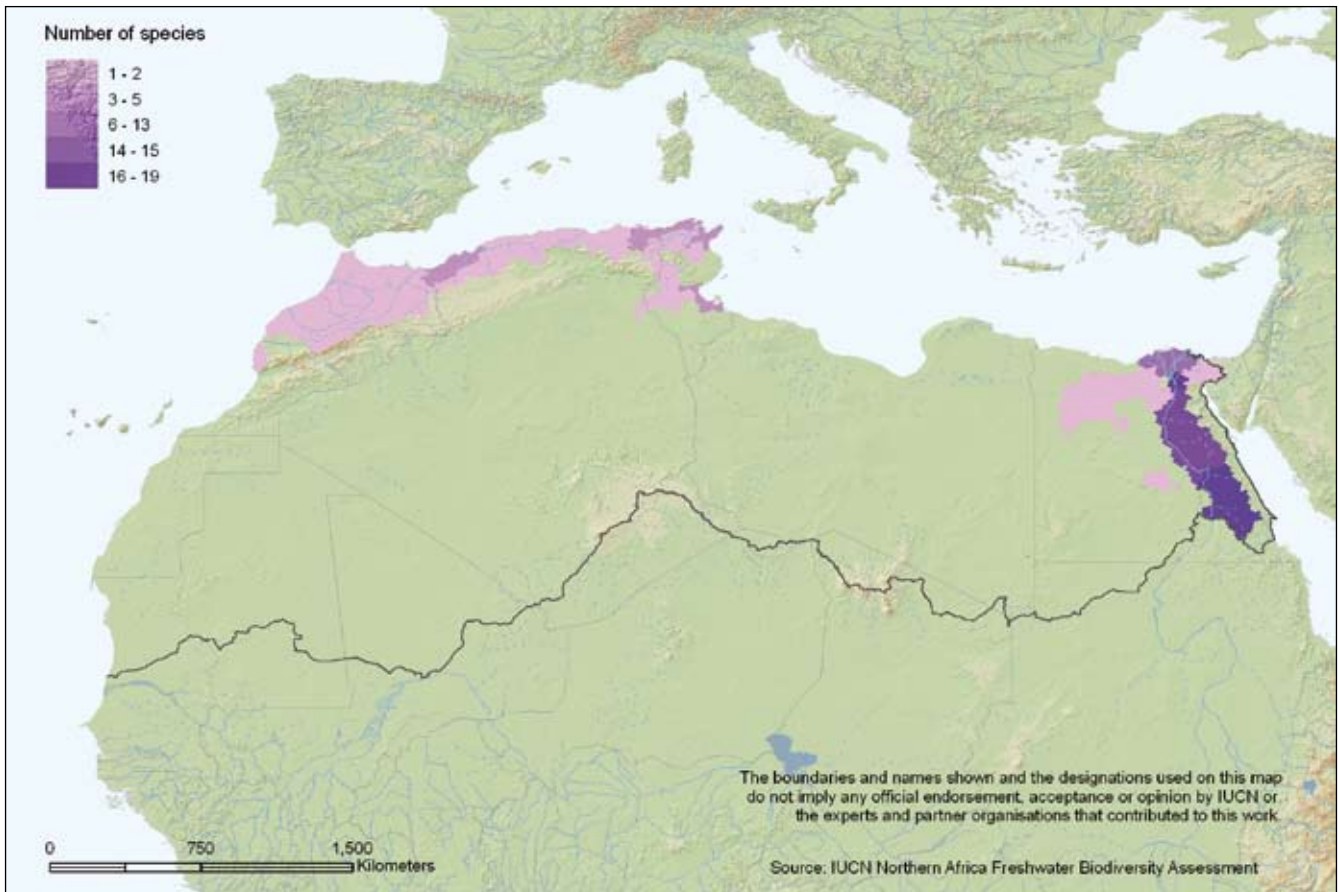
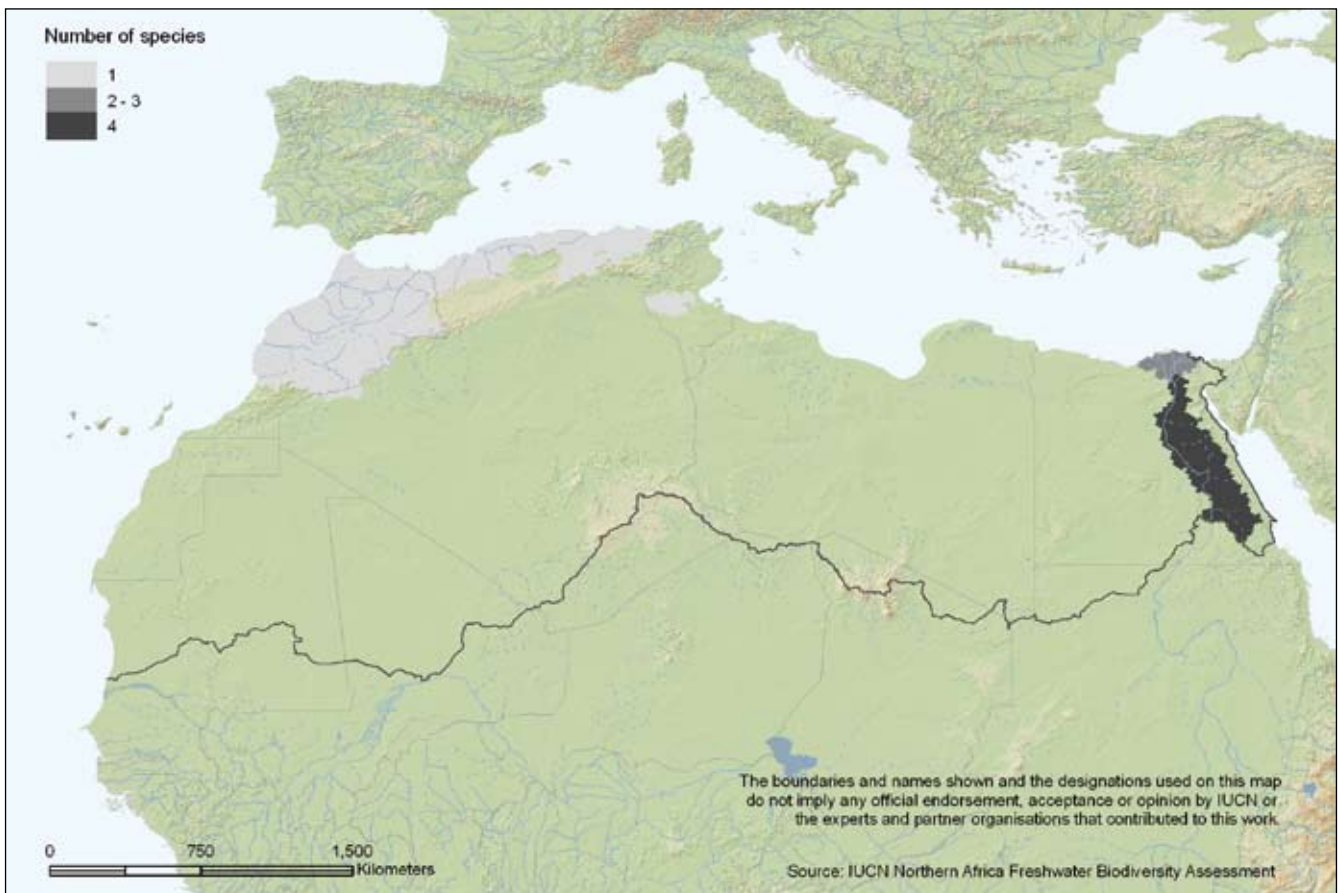


Figure 3.8 Distribution of Data Deficient freshwater fish in the northern Africa assessment region.



fallax and *Aphanius fasciatus* (Samraoui and de Bélair 1998, Samraoui 2002). The impact of the widespread dissemination of the Common Carp (*Cyprinus carpio*) across most Algerian dams and reservoirs has not yet been assessed but is expected to be detrimental (Crivelli 1983).

The species *Alosa fallax* and *Alosa alosa* (left and right respectively) were assessed as Regionally Extinct in the northern African region. The photographs were taken at the Moulouya River basin. Photos © Mohammed Melhaoui



3.3.5 Data Deficient taxa

Among the assessed freshwater fish, almost one third (32%) of them is Data Deficient. In the region, a total of 6 endemics are assessed in this category, highlighting the lack of information available to evaluate the status of northern African freshwater fish. There is a clear need for more research on the status of northern African freshwater fish, especially the endemic species that only occur in this region, namely: *Aphanius desioi*, *Oreochromis ismailiaensis*, *Varicorhinus maroccanus*, *Barbus antinorii*, *Aphanius apodus* and *Salmo macrostigma* (Figure 3.8).

Table 3.4. List of the Extinct freshwater fish of the northern African region including the Regionally Extinct (RE), and the Globally Extinct (EX).

Order	Family	Scientific name	IUCN Red List Category (northern Africa)*	Countries of presence
CHARACIFORMES	ALESTIIDAE	<i>Alestes baremoze</i>	RE	Egypt
CHARACIFORMES	ALESTIIDAE	<i>Brycinus macrolepidotus</i>	RE	Egypt
CHARACIFORMES	ALESTIIDAE	<i>Hydrocynus brevis</i>	RE	Egypt
CHARACIFORMES	ALESTIIDAE	<i>Micralestes acutidens</i>	RE	Egypt
CHARACIFORMES	CITHARINIDAE	<i>Distichodus engycephalus</i>	RE	Egypt
CHARACIFORMES	CITHARINIDAE	<i>Distichodus rostratus</i>	RE	Egypt
CHARACIFORMES	CITHARINIDAE	<i>Ichthyborus besse besse</i>	RE	Egypt
CHARACIFORMES	CITHARINIDAE	<i>Nannocharax niloticus</i>	RE	Egypt
CLUPEIFORMES	CLUPEIDAE	<i>Alosa alosa</i>	RE	Morocco, Algeria, Tunisia
CLUPEIFORMES	CLUPEIDAE	<i>Alosa fallax</i>	RE	Morocco, Algeria, Tunisia, Egypt
CYPRINIFORMES	CYPRINIDAE	<i>Barbus anema</i>	RE	Egypt
CYPRINIFORMES	CYPRINIDAE	<i>Barbus neglectus</i>	RE	Egypt
CYPRINODONTIFORMES	POECILIIDAE	<i>Micropanchax loati</i>	RE	Egypt
OSTEOGLOSSIFORMES	ARAPAIMIDAE	<i>Heterotis niloticus</i>	RE	Egypt
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Hyperopisus bebe bebe</i>	RE	Egypt
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Mormyrus hasselquistii</i>	RE	Egypt
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Mormyrus niloticus</i>	RE	Egypt
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Petrocephalus bovei bovei</i>	RE	Egypt
POLYPTERIFORMES	POLYPTERIDAE	<i>Polypterus bichir bichir</i>	RE	Egypt
SILURIFORMES	BAGRIDAE	<i>Clarotes laticeps</i>	RE	Egypt
SILURIFORMES	MOCHOKIDAE	<i>Synodontis batensoda</i>	RE	Egypt
SILURIFORMES	MOCHOKIDAE	<i>Synodontis membranaceus</i>	RE	Egypt
SILURIFORMES	SCHILBEIDAE	<i>Siluranodon auritus</i>	RE	Egypt
SALMONIFORMES	SALMONIDAE	<i>Salmo pallaryi</i>	EX	Morocco



3.4 Major threats to fishes of northern Africa

The main threats that are causing the decline of freshwater fish in northern Africa are habitat loss due to human activities such as groundwater extraction and water pollution, and natural disasters such as drought and temperature extremes. These threats affect more than 60% of the total freshwater fish and a 25% of all the threatened freshwater fish of the northern African region (Figure 3.9).

Although there is still a lot of uncertainty about the major threats affecting this group and its conservation status,

dams have been identified as one of the impacts with significant negative effects on the species and subspecies distribution and ecology. They have been found to affect 67 (around 52%) of the 128 assessed taxa and more than 26 of the threatened ones.

Harvesting for food and invasive species are also threats that affect freshwater fish in northern Africa but to a lesser extent.

The only Critically Endangered species in the region, *Aphanius saourensis*, is endemic to the Oued Saoura basin in Algeria, where it is present only in one relic population in the Sahara desert. Previous records show that it has

Figure 3.9 Main Threats to freshwater fish in northern Africa.

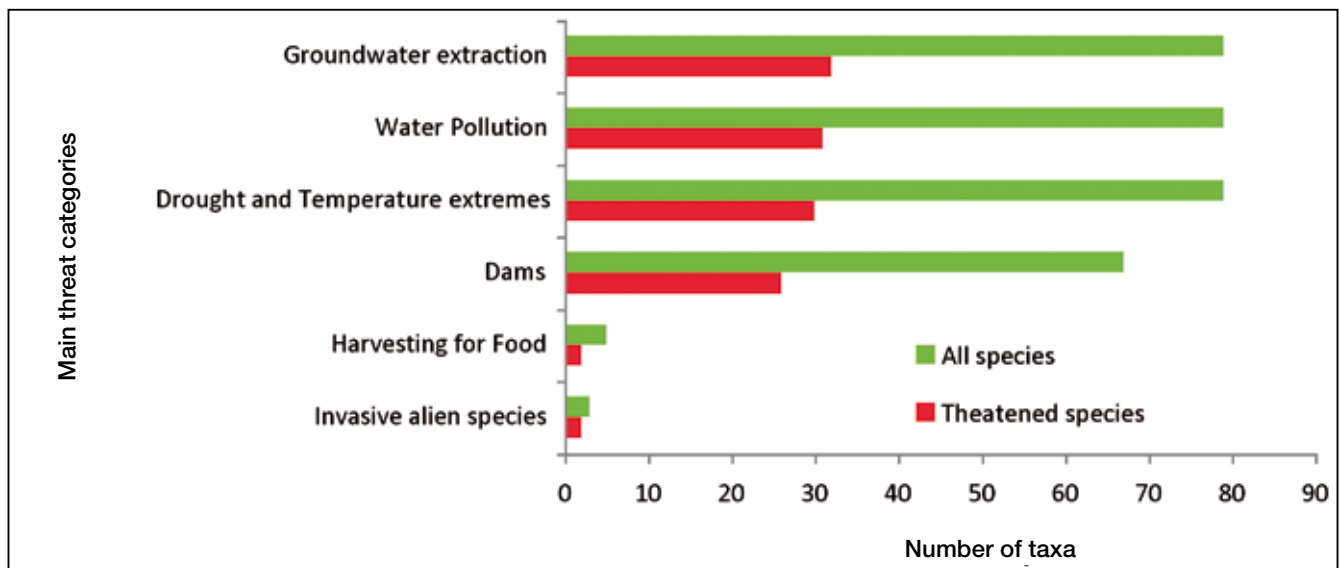
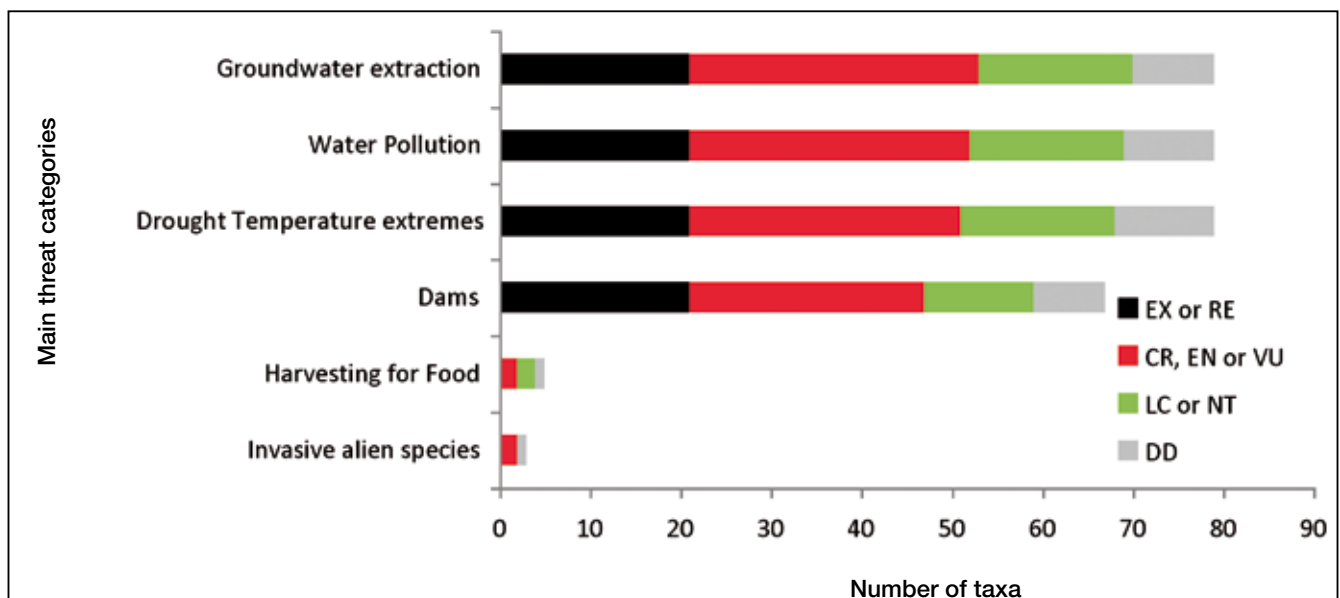


Figure 3.10. Proportion of freshwater fish under each threat and their Red List categories



European eel *Anguilla anguilla* is Vulnerable in northern Africa and present in the countries of Morocco Algeria, Libyan Arab Jamahiriya, Tunisia and in Egypt along the River Nile especially the Delta region and coastal lagoons. Photo © Fabio Pupin



disappeared from various other localities (Oued Zousfana basin at Igli, El Ouata and Kerzaz - all in the greater Saoura basin). This species of the Cyprinodontiformes family is mainly threatened by displacement caused by the introduced *Gambusia* species. Other threats include unsustainable groundwater withdrawal for agricultural purposes, the drying of wetlands, water pollution due to agriculture, and domestic and industrial practices (Blanco, Hrbek and Doadrio 2006). Although there is an ongoing small captive breeding program taking place for this taxon in the region, its survival is doubtful in the future due to its current critical status.

More than 85% of the Endangered and Vulnerable freshwater fish (30 taxa) are threatened by dam construction and groundwater extraction, in addition to water pollution (Figure 3.10).

In northern Africa, the Endangered species *Anguilla anguilla* can be found in the Oum Er-Biâ, Sebou, Loukkos and Moulouya Rivers, Merja Zerga lagoon in Morocco, and along all coastal wetlands of Algeria, Lybia, Tunisia and along the Delta region of the River Nile and coastal lagoons in Egypt (Chetto *et al.* 2001). This species is threatened by over-fishing of silver eels in deltas, estuaries and lagoons along northern Africa. In addition, parasitic pathologies (Saraiva and Eiras 1996, Loucif 2009), pollution, the development of water management - construction of dams, embankment, pumping and derivation of rivers, extraction of gravel - groundwater extraction and natural drought are also affecting this fish (Bruslé 1994).

Groundwater Extraction and Water Pollution

The intensification of agriculture has lead to habitat loss due to groundwater extraction from rivers and wetlands, used for irrigation and potable water, affecting more than 92% of the threatened freshwater fish in the region. Water pollution is also a major cause of threat within the

Pumps for water extraction in the Siwa basin, Egypt. Photo © Kevin Smith





northern African freshwater biome as a consequence of the uncontrolled use of pesticides and fertilisers in agriculture, as well as solid waste (i.e., plastic bags) and a negative impact associated to domestic and industrial activities, affecting a high percentage (62%) of the assessed taxa listed in the threatened categories.

Natural Disasters

Natural disasters are the second cause of decline for almost two thirds of the freshwater fish in the region, 30 of which are categorized as threatened. Drought is becoming a major problem as a consequence of climate change, transforming streams, which historically have run as permanent, into seasonal or temporary flows. Excluding the mountainous areas, the Maghreb is a region with low levels of rainfall progressing towards desertification due to the increase in the dry season. According to the Blue Plan (2009), the areas which border on the desert zone of northern Africa are among the most vulnerable to climate change impact in the Mediterranean. This is likely to worsen the droughts, their impact and extent. Furthermore worrying outlooks are already revealed, as 21 of the 23 Regionally Extinct species were identified in the past as threatened by drought.

Dams

Habitat loss due to the construction of dams transforms the hydrological landscape of northern African rivers and constitutes a major threat to 26 fish taxa. These infrastructures regulate floods, control flows and water levels of rivers. In addition, dams modify river quality features such as water temperature, oxygen content and sediment load. From an ecological point of view, spawning zones and refuge habitats are transformed or have already disappeared hindering by this the capacity

of migrant species to complete their life cycles when different stages need to take place in widely distributed localities up- or downstream of each other. As a result, this was identified as a threat factor for 7 taxa classified as Endangered and 19 as Vulnerable in the IUCN Red List of Threatened Species. Furthermore, 23 taxa which are already extinct in the region were threatened by the construction of dams in the past.

The infrastructure development of the Aswan Dam in the Egyptian Nile River acts as a barrier to the water flow impeding by this the reproduction cycles and migratory routes of the fish species. This dam, due to nutrients trapping, is expected to be the reason behind the extinction at regional level of several taxa due to their restricted range. At least 80% of the 24 northern African freshwater fish that are listed as Extinct in the region could be found in the past within the River Nile Basin (21 species).

Harvesting for food

Over-fishing through unsustainable fishing techniques (small mesh, hand trawls, submerged nets, blocking of whole width of rivers during migration with nets and traps) and during the closed season when the species is spawning, is affecting populations of four species and one subspecies of freshwater fish. These taxa, *Lates niloticus* (EN), *Anguilla anguilla* (EN), *Barbus bynni bynnii* (VU), *Hydrocynus forskahlii* (VU) and *Alestes dentex* (VU), are unsustainably harvested for food.

Invasive Alien Species

Introduced invasive species threaten at least two species of fish endemic to the region, the Critically Endangered Sahara aphantius (*Aphantius saourensis*), which is threatened due to the introduction of the North American gambusia

Dam of the Moulouya River basin, Morocco. Photo © IUCN Med



The invasive alien species native from North American *Gambusia holbrooki*. Photo © Frank Teigler





(*Gambusia holbrooki*), and the Data Deficient *Salmo macrostigma* (DD) which is threatened due to hybridisation with the introduced trout, *Oncorhynchus mykiss*. Most introduced freshwater fishes have been established intentionally for fishing purposes or as a means to reduce the eutrophication of lakes, dams and irrigation channels (Azeroual *et al.* 2000, Azeroual 2003).

This phenomenon is due mainly to the high reductions of the flow of watercourses, heating up the waters at high altitude. The best example among the vertebrates is that of Barbels (*Barbus callensis* in particular), which occur to 1900 meters above sea level in certain water courses (for example oued Guigou in Middle Atlas) considered usually as habitats for Salmonids.

3.5 Conservation recommendations

Integrated River Basin Management (IRBM) is a key conservation action required to stop population decline and prevent new extinctions for the assessed fish species of the highly managed northern Africa freshwater biome. This is a multidisciplinary approach for the management of the resources and services provided by the river system assuring their sustainable utilization in short, medium and long-term time scales. An additional measure that can be considered as a part of the IRBM is to regulate the effects of dam construction on the life cycle of fish populations, by providing a continuous environmental flow and predicting by-passes where migrant species, such as eels, can use for crossing the dams. Reforestation of river margins would help to reduce the amount of lime and sediments carried by the river flow that can clog the fish gills. Furthermore, measures to reduce groundwater over-extraction and predict artificial spawning grounds at the level of streams when water is derived for irrigation would

be valuable. In agriculture, water pollution is a major problem generated as a consequence of the use of uncontrolled levels of chemicals in pesticides and fertilizers. These levels need to be standardized, and the promotion of efficient use of both surface and groundwater by using more sustainable water irrigation techniques (e.g., drop by drop, night time irrigation) is required. From the legislative side, the enforcement of sustainable fishing techniques and habitat and species conservation are additional measures which could prove valuable for freshwater fishes.

3.6 Conclusions

- Even when around 30% of the total northern African freshwater fish is threatened, there is still an evident lack of information about population distribution, ecology and threats to these taxa in the region – this is the case for almost 32% of the fishes categorized as Data Deficient. This result implies that a much higher number of species could prove to be under threat after further research.
- More than one fifth of the endemic taxa are threatened with extinction, including the Critically Endangered Sahara aphanius (*Aphanis saourensis*). Northern African countries therefore have a special responsibility to design and effectively implement conservation plans to preserve these species.
- An astonishing 19% of the fish present in the freshwater biome is already extinct from the region, including the Moroccan endemic species *Salmo pallaryi*, which has disappeared at the global level. 24 of the 25 Regionally Extinct taxa had an area of distribution along the Nile River in Egypt, and their regional extinction could be a consequence of the construction of the Aswan Dam.
- The majority (highest richness) of the threatened taxa are occurring in the Nile basin in Egypt, and in the north and western Morocco.
- Groundwater extraction, water pollution and dam construction are the three main causes of freshwater fish decline, affecting 69% of the total threatened fish fauna of northern African rivers. Drought is also a major threat for 23% of the taxa and is becoming increasingly important due to the impacts of climate change.
- Further research action and Integrated River Basin Management including dams, pollution, waste dumping control and legislation enforcement are the key conservation measures needed to prevent future extinctions in this extinction-prone and threatened group.



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Chapter 4. The status and distribution of freshwater molluscs

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4.1 Overview of the regional fauna

The Moroccan river system is the most extensive within the northern African region, where a diversified molluscan fauna appears to live in the aquifers in the karstic underground. In addition to the historical records, during the last decade an abundance of new species and genera has been discovered in this country (Ghamizi 1998). There are no permanent rivers or standing waters and the groundwater is brackish south of the Drâa River basin. Hence, only some Palearctic freshwater molluscs (*Melanopsis praemorsa*, *Melanopsis* sp. ?, *Pseudamnicola* sp.)* are known to be extant and exclusively restricted to wells. Two *Melanopsis* species, one probably new to science, have been discovered recently in the vicinity of Ad Dakhla (Villa Cisneros) (collector J. Ahuir).

Small stream used by population in the Imin Ifri region in High Atlas, Morocco. Photo © Mohamed Ghamizi



Most Algerian Mediterranean rivers are not suitable for the survival of the majority of freshwater molluscs, with the exception of those belonging to the genera *Theodoxus*. As a general rule, molluscs do not occur in these temporary waters and are confined to wells and springs at the foot of both mountain chains and the more easterly situated Aurès Mountains, which is drained by a number of seasonal rivers such as the Oued el Abiod. Towards the south, in the Sahara, no permanent flowing waters exist and molluscan life is confined to some oases and gueltas (temporary lakes created from resurgence of groundwater), mainly along the seasonally flowing Oued Saoura. A 19th century report mentions blind fish, freshwater molluscs and crabs surfacing with artesian water from a well Mezer

drilled by French engineers along the bed of the Wadi Righ (or Rhir) in the Algerian Sahara south of Chott El Melrhir, parts of which are saline and parts fresh. This indicates that a diversified underground malacofauna exists or rather did exist in this part of the Sahara. This fauna was never studied and possibly may be extinct due to increased salinity and mineralization of the aquifers in that region. The most southern large fresh water body, the Guelates Afilala in the Ahaggar range, also contains a very poor diversity of malacofauna.

Most mollusc species in Tunisia are confined to the Oued Medjerda, which is the only perennial river in the country (main temporary rivers are the O. Mellègue, O. Khaled, O. Marouf, etc.). Furthermore, the largest lakes Lac de Tunis and Lac Ichkeul are brackish, though a number of freshwater species do occur in the marshes surrounding the latter. In the rest of the country, virtually only subterranean hydrobiids have been described from wells, springs and warm sources with the most southern limit the region of the Chott el Jerid at the Gulf of Gabés. The exception is the Oued Berreshaf, a small stream that descends the eastern slope of the Aurès Mountains in which some fluvial populations (e.g., *Melanopsis*) still occurred in the beginning of the 20th century. The malacofauna of the Lebna Reservoir has not been studied.

Rivers in Libyan Arab Jamahiriya and the Aozou Strip contain a poor ubiquitous Afrotropical fauna (including the species *Biomphalaria pfeifferi*, *Bulinus truncatus* and *Melanoides tuberculata*) and the Palearctic *Planorbis planorbis* was recorded from Ghat more than 50 years ago. Molluscs are absent from the lakes of Wau and Namus due to their high salinity, and therefore the only malacologically interesting part in the country is the mountainous coastal region of Cyrenaica, from which several subterranean hydrobiids (genus *Pseudamnicola*) have been recorded but never properly described. These evidences suggest that further investigation of wells and springs in this karstic area could lead to the discovery of a number of new endemic subterranean species and it is possible that the springs at the eastern slope of Jabal Tarabulus (west coast) also contain hydrobiids, although there is a lack of information from this region. The possibility of stygobiont life in the wells of the Great Man-made River can be disregarded, as their depths of 500 meters make freshwater molluscs survival impossible

* The species that are listed against a *genus name?* are provisionally placed in this genus pending further research, as there is no anatomical data to confirm the placement in the genus.

in those waters. Although intensive work was carried out to survey the Tibesti Mountains, no living freshwater molluscs have been recorded from the northern slopes of the disputed Aozou Strip between Libyan Arab Jamahiriya and Chad, included in the northern African Region.

In the oases and gueltas of the Mauritanian Hadrar, the mountainous region near Atar, a few ubiquitous Afrotropical molluscs are known to be transported by birds and humans.

In the northwestern part of Mali, included in the northern Africa region considered for this freshwater biodiversity assessment, no permanent standing or flowing freshwater bodies occur. During the Holocene wet phase, vast lakes and an extensive river network existed connecting this region with Niger and hence containing the same Afrotropical molluscan fauna as can be found in this river. However, no live molluscs have currently been recorded from this area.

Before the erection of the Aswan Dam, molluscs were mainly confined to the Delta of the Egyptian Nile, the only permanent river in this country. However, in the last decades many species appear to have extended their range over its whole length (Ibrahim *et al.* 1999; Soliman pers. comm. 2008). Apart from the Nile, a few ubiquitous freshwater molluscs have been recorded from Siwa,

Dakhla and Kharga Oases. The water salinity of lakes and lagoons along the coast between Libyan Arab Jamahiriya and Egypt ranges from a moderate to a wide range of salinity, and is inhabited by a large number of Mediterranean marine and brackish species, as well as some populations of *Hydrobia musaensis* and *Melanoides tuberculata* in the parts with low salinity levels. No malacofauna is found in the highly saline or hyperhaline waters of Lake Quarun.

There is a possibility that a similar circummediterranean type of malacofauna inhabited the canyon-river created by the Eonile (the name given to the first River Nile) during the Messinian salinity crisis (around 5.96 and 5.33 Ma). However, when the Atlantic Ocean broke through at Gibraltar and the Mediterranean rose again, over almost its whole length (up to Aswan) the Eonile became a sea arm and freshwater life disappeared. Its successors, the Pliocene Palaeonile and the Early Pleistocene Protonile, were also relatively small rivers. During arid periods both became seasonal and there is no indication for any continuity of the malacofauna.

The only water surface occurring in the utmost northwestern part of the country that is included in the present assessment of the northern Africa freshwater biodiversity is the Selima Oasis, but records only mention Early Holocene molluscs, no modern ones.

The Siwa Oasis in Egypt. Photo © Kevin Smith





4.1.1 Molluscan biogeography

The molluscan biogeography of the region is straightforward. Based on the composition of the molluscan communities since the beginning of the Holocene, Van Damme (1984) divided northern Africa into two parts belonging to the Palearctic Region and the Afrotropical (=Ethiopian) Region respectively. According to this, the following areas of the Mediterranean Subregion belong to the Palearctic Region (Figure 4.1):

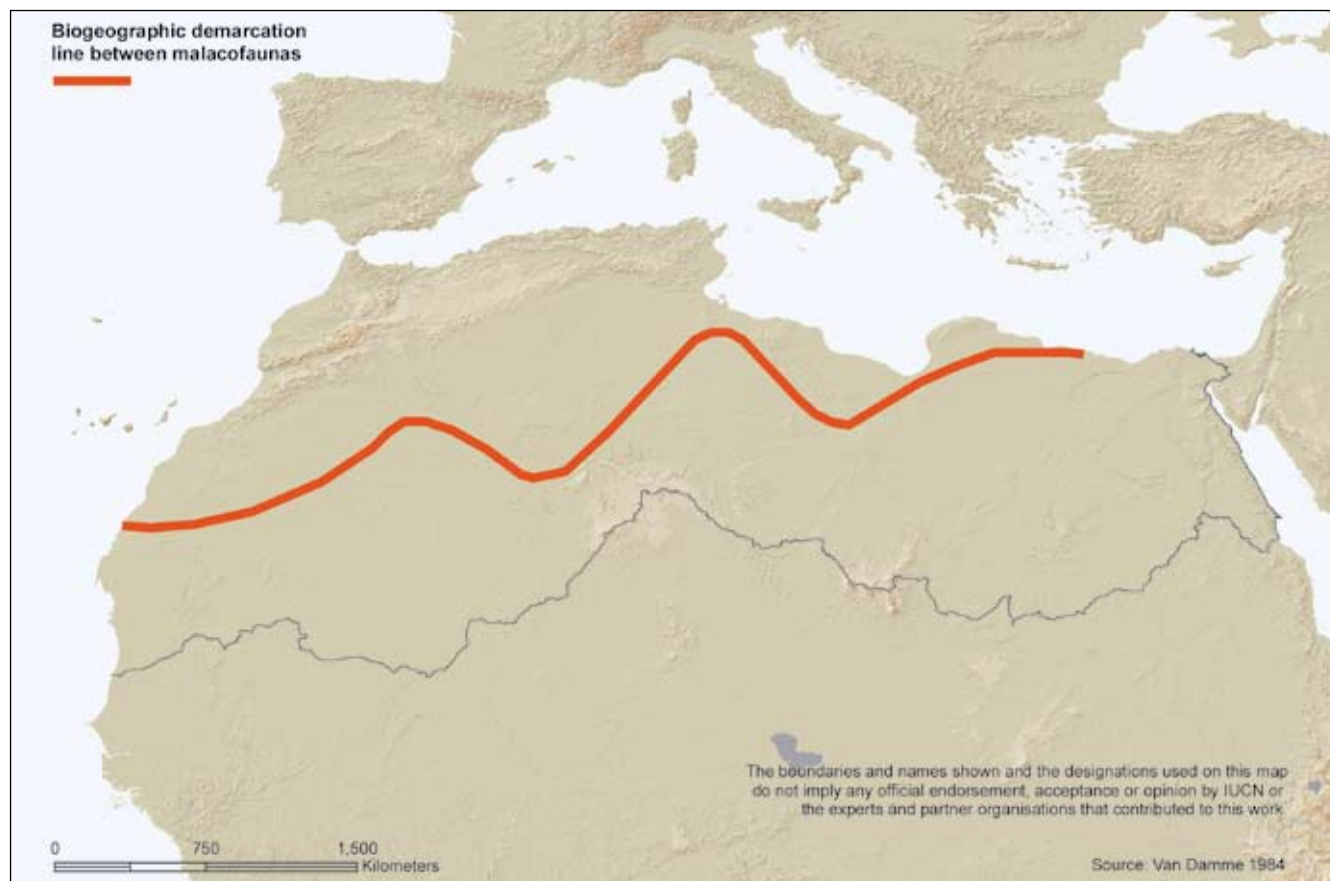
- 1) An endemic Maghrebian distribution, e.g., the genus *Eideella*;
- 2) An Ibero-Maghrebian distribution, e.g., the genus *Horatia*;
- 3) A western Mediterranean or Alboran distribution, e.g., the genus *Mercuria* and;
- 4) A circummediterranean distribution, e.g., the genus *Pseudamnicola*. The species-complexes mentioned also do show these distribution patterns.

Compared to other parts of the Mediterranean region, the degree of endemism is uncommonly high in Maghreb, which made Van Damme (1984) suggest that for freshwater molluscs a Maghrebian Province should be distinguished biogeographically.

The Maghrebian malacofauna appears to have possessed its typical features since at least the Late Miocene (about 6 to 7 million years ago) or even earlier. During the Oligocene-Miocene the northern part of Maghreb and the southern part of the Iberian Peninsula formed the Rif-betic Cordillera surrounding the Alboran Sea; hence they belonged to the same biogeographic region. During the Messinian Salinity Crisis in the Late Miocene, after the Mediterranean dried out, the freshwater lakes (e.g. Lago Mare) that formed on its bottom were invaded by faunal elements from the freshwater lakes in the Dacic-Pannonian Basin (a region of the Black Sea and Caspian Sea) and from there they spread into Iberia and Maghreb. The common traits shared by in the freshwater malacofauna extending from Turkey in the east to Spain and Morocco in the west go back to that geological period. The Maghrebian malacofauna hence should be considered as an ancient one, persisting and diversifying for at least 6 million years (Heller 2007).

The malacofauna of the modern Nile has clearly always been dominated by Afrotropical elements, even during the Glacial Maximum stage of the last Ice Age. Palearctic elements do occur in the Nile but their number and range has fluctuated since it came into existence. Nowadays,

Figure 4.1. Map of the northern African Region with the biogeographic demarcation line between malacofaunas, respectively dominated (>80%) by Palearctic elements and by Afrotropical elements (redrawn after Van Damme 1984).



only 6 Palaearctic species and endemics of Palaearctic origin, all gastropods, are found in the region, namely *Theodoxus niloticus*, *Valvata nilotica*, *Lymnaea truncatula*, *Hydrobia musaensis*, *Hydrobia ventrosa* and *Planorbis planorbis*, but a number of Palaearctic species such as *Unio abyssinicus* (closely related to the Levantine *Unio tigridis*) and *Pisidium subtruncatum*, that occurred during cold and wet Holocene phases, have now retreated to the Ethiopian Highlands or became regionally extinct (e.g., *Lymnaea peregra* and *Pisidium amnicum*). In the northern part of Maghreb, the Palaearctic component is more than 90%, it never reached more than 25% in the Egyptian Nile since its existence and is now dwindling (presently <15%). The lack of a larger Palaearctic component and, in particular, of representatives of ancient circum-mediterranean species groups, such as the *Potomida littoralis* and the *Melanopsis praemorsa* species complexes in Lower Egypt, remains a biogeographic riddle (Van Damme and Van Bocxlaer 2009).

From the most northern part of Libyan Arab Jamahiriya, the Cyrenaica region, crenobiont hydrobiids related or identical to those from Tunisia and *Theodoxus numidicus* (uncertain identification) have been recorded, indicating that this area belongs biogeographically to the Magrebian Province. More detailed investigations may yield a number of subterranean hydrobiid endemics, indicating that in this part of Libyan Arab Jamahiriya the ancient fauna did persist and radiate. The rest of Libyan Arab Jamahiriya, contains a single Palaearctic species (*Planorbis planorbis*) and a few ubiquitous Afrotropical gastropods that are spread by birds and humans. No traces are left of the fauna of the Late Miocene Eosahabi River, a vast water body with a length of 3,000 kilometers that existed for 2 million years during the Late Miocene and ran from its source in the Central African Republic over Chad to the Gulf of Sirt. The last period that a large but short-lived river system was active in Libyan Arab Jamahiriya was around 8,000 years ago. It flowed from a vast lake in the Serir Tibesti north to the Serir Calanscio and finally bent north-eastward to join the Nile near Cairo (Van Damme and Van Bocxlaer 2009).

South of the Palaearctic/Afrotropical boundary line shown in Figure 4.1, the remainder of the northern African region does not possess any perennial active river systems, the Nile excepted, and the scattered standing waters only contain a few bird- and man-spread ubiquitous Afrotropical species.

Brackish water species. The northern African malacofauna of oligo- and mesohaline waters is the

poorest of all African regions studied, mainly consisting of species belonging to the genera *Hydrobia*, *Semisalsa*, *Pirenella* and *Cerastoderma*. Except for a single endemic *Hydrobia* (*H. djerbaensis*) in the Bay of Tunis, most species appear to have a wide range either along the western Mediterranean coasts (e.g., *H. minoricensis*) or along the Atlantic coasts of the Iberian Peninsula and Morocco (e.g., *H. joosseii*).

4.1.2 Taxonomic problems in northern African freshwater malacology

Abundant studies were produced from the beginning of the 19th century until the first decades of the 20th century on the Maghrebian and Egyptian freshwater molluscs. Monographic works like Bourguignat's splendidly illustrated 'Malacologie de l'Algérie' (Bourguignat 1864) are among the most expensive and rarest books ever published on land and freshwater molluscs. Unfortunately these early works do not conform to the modern taxonomic concept of the biospecies, as each somewhat different morphological population was considered to represent a distinct species without taking into account intraspecific variability. Thus in the genus *Melanopsis* about 200 different species were described from the Mediterranean region. Inversely, due the fact that the 19th century taxonomy was based virtually exclusively on the diagnosis of the shell and operculum, the number of species and genera of Hydrobiidae, which can only be distinguished by anatomic characteristics was severely underestimated (the number of genera has risen from 5 to 15).

As part of the struggle against the parasite *Schistosoma* (responsible for the Bilharziasis disease or Schistosomiasis) and its intermediate snail hosts, taxonomic research on the Egyptian malacofauna started in earnest around 1950. As a result this fauna presently is more than adequately revised. In the Maghreb however, political upheavals kept research paralyzed for several more decades. When it was finally resumed in the 1970-80s, after a gap of about 50 years (Boeters 1976, Van Damme 1984, Kristensen 1985), many 19th century type localities had long disappeared and much of the type material was not readily available. These factors greatly impeded revisions and the early attempts were flawed as they took place during a period when taxonomic fashion had shifted from hyper-splitting to hyper-lumping. As a result, the particular identity of the Maghrebian malacofauna was erased almost completely, since most Maghrebian endemic species were considered to be identical to or at best geographic forms of widespread Sibero-european species. This also happened with molluscs in other parts of the Mediterranean region, e.g., those of



the Iberian Peninsula, Italy and the Levant. Some circummediterranean taxa, e.g., the more than 200 species of *Melanopsis*, were lumped into a single species, *Melanopsis praemorsa* (Tchernov 1975).

Since the 1990s the use of improved anatomic, morphometric and molecular techniques led to the conclusion that the supposed representatives of widespread Sibero-european species on the Iberian Peninsula had been geographically sufficiently long isolated to be considered as distinct and that circummediterranean species such as *Melanopsis praemorsa* (and probably also *Unio mancus* and *Potomida littoralis*) need to be considered as super-species or as species complexes (Heller *et al.* 2002, Glaubrecht 1993).

While the extreme lumping of the Iberian, Italian and Levantine malacofaunas has been corrected for a large part, the revision of the taxonomy of the Maghrebian fauna still needs to start. Ongoing investigations (Ramdani *et al.*

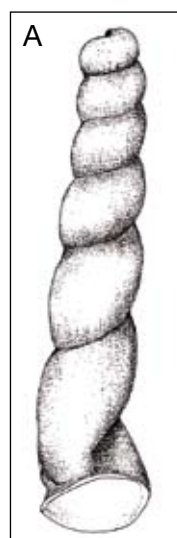
Two representatives of the genus *Melanopsis* in north-western Africa recognized as distinct and threatened species in the present IUCN report A. *Melanopsis chlorotica* (Critically Endangered). It is likely that this species is gone over its former range in the Moroccan lowlands (Aouza Plain). Only a few populations in the Middle Atlas (range < 10 km²) remain; B. *Melanopsis mourebeyensis*: endemic to the downstream part of the Oued Oum er Rbia, Morocco (Endangered). Photos © J. Ahuir



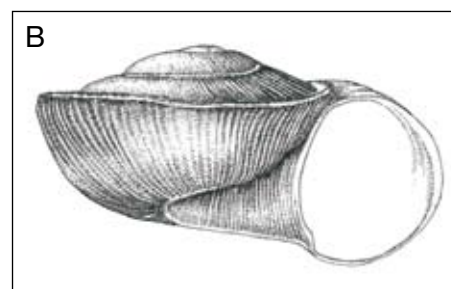
1987, Ghamizi 1998, Ghamizi *et al.* 1999, Bodon *et al.* 1999, Araujo *et al.* 2009) do indicate the presence of a highly diversified endemic subterranean group of hydrobiids and a high degree of endemism in the gastropod genus *Melanopsis* (Melanopsidae) and in the bivalve genera *Margaritifera* (Margaritiferidae). Unfortunately the research has been limited to Morocco and due to lack of funding, has virtually halted in this country as well.

Taking into account the known distribution patterns and marked distinctive morphological features, it has been stated that a significant amount of species, synonymized during the lumping period, are endemic taxa. In addition, the ongoing speleological exploration of the extensive Maghrebian cave-complexes will certainly increase the already sizable number of subterranean hydrobiids further. Finally, and equally certain, is the sad fact that many endemic species will only be reinstated in their former taxonomic status when they have become extinct and many as yet undiscovered underground snails will finally only see the light of day as empty shells.

The present IUCN list of the northern African freshwater molluscs is hence not a mere compilation of existing, readily available taxonomic and distributional data. The evaluators and assessors were in this particular case obliged to critically weigh up the merits of the 19th century splitters' and the 20th century lumpers' taxonomy of problematic groups such as *Theodoxus*, *Melanopsis*, *Anodonta*, *Unio*, *Potomida* and the many hydrobiid genera. They had to decide which populations should be considered as distinctive on the species (or subspecies)



Representatives of the endemic underground hydrobiids of Maghreb, exemplifying the acute conservation problems this highly threatened group poses by lack of investigation and taxonomic studies. A. *Giustia costata* (H= 0,7 mm), new genus and species collected from two wells at Lamsantah, Beni Mellal region, Morocco (Critically Endangered). B. '*Iglica*' *soussensis* (L= 2.2mm) from a well near Tamsia, region of Agadir, Morocco (Critically Endangered). Drawings by Van Damme based on photographs in Ghamizi, 1998). Discovered in 1996 these species have not yet been officially described (PhD dissertation of Mohamed Ghamizi 1998).



level. This was done extremely cautiously and the number of distinct northern African molluscs recognized here is without doubt an underestimation of the real number. What matters is that it nonetheless gives, for the first time, a good idea of the importance of the Maghreb region as a hotspot of freshwater molluscan biodiversity within the already highly diverse circummediterranean region.

4.2 Conservation status (IUCN Red List Criteria: Regional Scale)

In total, 155 freshwater molluscs were evaluated, as 3 species were considered as introduced in the region and therefore classified as Not Applicable (*Biomphalaria glabrata*, *Helisoma duryi*, and *Lymnaea columella*). Almost half (45.2%) of the northern African mollusc species evaluated according to the IUCN Red List Categories and Criteria methodology are threatened with extinction,

with 17.4% classified as Critically Endangered, 19.4% as Endangered and 8.4% as Vulnerable (see Table 4.1). While information is lacking for almost 17% of the species in the region, which are therefore considered as Data Deficient. Almost a quarter of the mollusc species in northern Africa (22.6%) is classified as Least Concern (LC) (Figures 4.2, 4.3 and Table 4.1). However, this percentage differs dramatically when the mollusc fauna of this region is divided according to their biogeographic distribution shown in Figure 4.1. Thus, in the fauna belonging to the Afrotropical Region (39 species), 59% are classed as Least Concern (Figure 4.4 and Table 4.3) while in the fauna belonging to the Palaearctic Region (120 species), this category contains only 12.5 % (Figure 4.4 and Table 4.2). Conversely, the sum of the species in the threatened categories is 7.7% for Afrotropical northern Africa (Figure 4.5 and Table 4.3) and 55.8% for Palaearctic northern Africa (Figure 4.4 and Table 4.2).

Table 4.1 The number of mollusc species in each Red List category in the northern African region.

IUCN Red List Category	Number of Species (%)	Number of regional endemics (%)
Extinct (EX)	17 (11%)	15 (17.6%)
Regionally Extinct (RE)	2 (1.3%)	0 (0%)
Threatened categories	Critically Endangered (CR)	27 (17.4%)
	Endangered (EN)	30 (19.4%)
	Vulnerable (VU)	13 (8.4%)
	Near Threatened (NT)	5 (3.2%)
	Least Concern (LC)	35 (22.6%)
Data Deficient (DD)	26 (16.8%)	18 (21.2%)
Total number of taxa assessed*	155 (100%)	85 (100%)

* Excluding taxa considered Not Applicable.

Figure 4.2 The proportions of freshwater molluscs in each Red List Category in the northern Africa region.

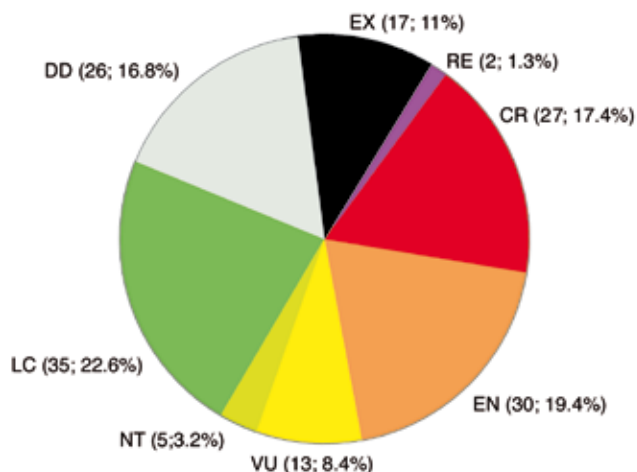
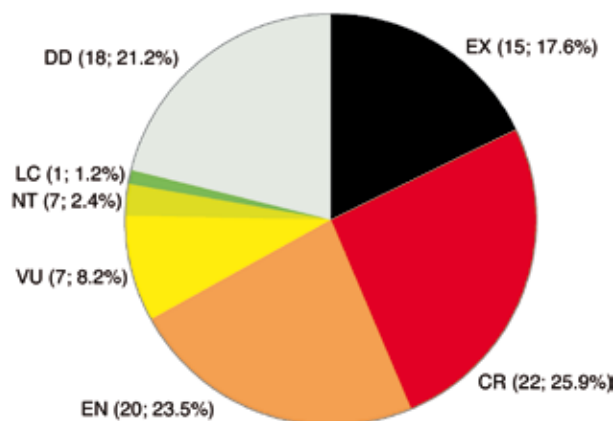


Figure 4.3 The proportions of endemic freshwater molluscs in each Red List Category in the northern Africa region.





In addition, the meaning of the assessment 'Data Deficient' differs in both biogeographic regions. In Afrotropical northern Africa the 'Data Deficient' classification usually means that the species is still present but that data are lacking on its present distribution and/or that its taxonomic status is doubtful. Probably none of these should be considered as Extinct or Critically Endangered. However, in Palearctic northern Africa, a sizable number of species have been assigned to this category because they are only known from the original 19th century description and their present status and range is unknown. In other words, a number of these DD species may be Extinct or Critically Endangered. In view of these marked differences between the biogeographic regions it makes little sense to discuss northern African molluscs as a single group.

Table 4.2 The number of mollusc species in each Red List category in Palearctic northern Africa (Maghreb).

	IUCN Red List Category	Number of Species (%)
Threatened categories	Extinct (EX)	16 (13.3%)
	Regionally Extinct (RE)	2 (1.7%)
	Critically Endangered (CR)	26 (21.7%)
	Endangered (EN)	30 (25.0%)
	Vulnerable (VU)	11 (9.2%)
	Near Threatened (NT)	4 (3.3%)
	Least Concern (LC)	15 (12.5%)
	Data Deficient (DD)	16 (13.3%)
	Total number of taxa assessed*	120 (100%)

* Excluding taxa considered Not Applicable.



Marocopsis agadirensis is an Endangered species endemic to the northern African region. It is restricted to very small populations, and threatened by pollution of wells and the decreasing of water level due to water abstraction. Photo © Mohamed Ghamizi

Figure 4.4 The proportions of freshwater molluscs species in each Red List Category in Palearctic northern Africa (Maghreb).

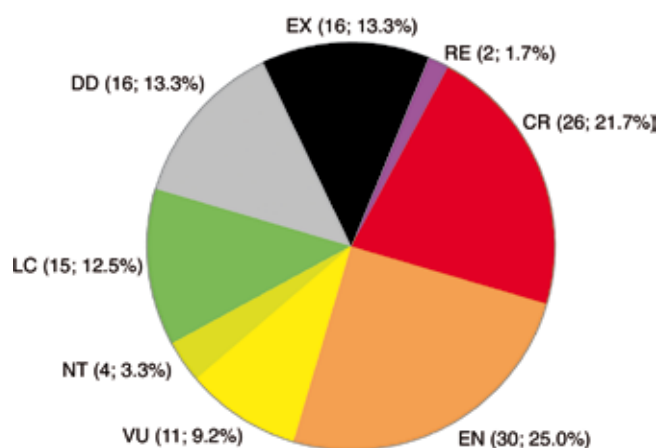


Table 4.3 The number of mollusc species in each red list category in Afrotropical northern Africa.

	IUCN Red List Category	Number of Species (%)
Threatened categories	Extinct (EX)	1 (2.6%)
	Regionally Extinct (RE)	1 (2.6%)
	Critically Endangered (CR)	1 (2.6%)
	Endangered (EN)	0 (0%)
	Vulnerable (VU)	2 (5.1%)
	Near Threatened (NT)	1 (2.6%)
	Least Concern (LC)	23 (59%)
	Data Deficient (DD)	10 (25.6%)
	Total number of taxa assessed*	39 (100%)

* Excluding taxa considered Not Applicable.

Figure 4.5 The proportions of freshwater molluscs species in Afrotropical northern Africa.

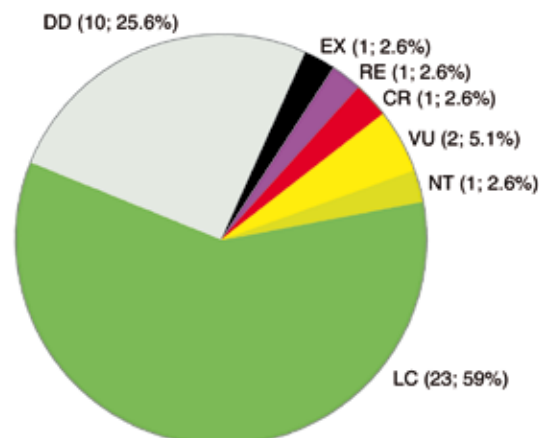


Table 4.4 Threatened species of freshwater molluscs of the northern Africa region.

Family	Scientific name**	IUCN Red List Category (North Africa)	Endemic to the region?
ETHERIIDAE	<i>Etheria elliptica</i>	CR	
HYDROBIIDAE	<i>Attebania bernasconii</i>	CR	Yes
HYDROBIIDAE	<i>Belgrandiella</i> (?) sp.nov. ' <i>ramdani</i> ' (<i>nomen nudum</i>)	CR	Yes
HYDROBIIDAE	<i>Bythinella</i> (?) sp nov. ' <i>tiznitensis</i> ' (<i>nomen nudum</i>)	CR	Yes
HYDROBIIDAE	<i>Giustia costata</i>	CR	Yes
HYDROBIIDAE	<i>Giustia mellalensis</i>	CR	Yes
HYDROBIIDAE	<i>Giustia saidai</i>	CR	Yes
HYDROBIIDAE	<i>Heideella</i> (?) sp nov. ' <i>kerdouensis</i> ' (<i>nomen nudum</i>)	CR	Yes
HYDROBIIDAE	<i>Heideella</i> (?) <i>valai</i> sp. nov. (<i>nomen nudum</i>)	CR	Yes
HYDROBIIDAE	<i>Heideella andreae</i>	CR	Yes
HYDROBIIDAE	<i>Heideella</i> sp. nov. ' <i>makhfamanensis</i> ' (<i>nomen nudum</i>)	CR	Yes
HYDROBIIDAE	<i>Iglica soussensis</i>	CR	Yes
HYDROBIIDAE	<i>Mercuria</i> cf. <i>zopissa</i>	CR	
HYDROBIIDAE	<i>Mercuria punica</i>	CR	Yes
HYDROBIIDAE	<i>Pseudamnicola leprevieri</i>	CR	Yes
HYDROBIIDAE	<i>Pseudamnicola pallaryi</i>	CR	Yes
HYDROBIIDAE	<i>Semisalsa aponensis</i>	CR	Yes
MARGARITIFERIDAE	<i>Margaritifera marocana</i>	CR	Yes
MELANOPSIDAE	<i>Melanopsis brevicula</i>	CR	Yes
MELANOPSIDAE	<i>Melanopsis chlorotica</i>	CR	Yes
MELANOPSIDAE	<i>Melanopsis saharica</i>	CR	Yes
PISIDIIDAE	<i>Pisidium milium</i>	CR	
PISIDIIDAE	<i>Pisidium nitidum</i>	CR	
PISIDIIDAE	<i>Pisidium tenuilineatum</i>	CR	
UNIONIDAE	<i>Anodonta lucasi</i>	CR	Yes
UNIONIDAE	<i>Anodonta pallaryi</i>	CR	Yes
UNIONIDAE	<i>Unio foucauldianus</i>	CR	Yes
HYDROBIIDAE	<i>Giustia bodoni</i>	EN	Yes
HYDROBIIDAE	<i>Giustia gofasi</i>	EN	Yes
HYDROBIIDAE	<i>Giustia janai</i>	EN	Yes
HYDROBIIDAE	<i>Giustia meskiensis</i> (<i>nomen nudum</i>)	EN	Yes
HYDROBIIDAE	<i>Giustia midarensis</i>	EN	Yes
HYDROBIIDAE	<i>Heideella</i> (?) sp. nov. ' <i>boulali</i> ' (<i>nomen nudum</i>)	EN	Yes
HYDROBIIDAE	<i>Heideella</i> (?) sp. nov. ' <i>knidirii</i> '	EN	Yes
HYDROBIIDAE	<i>Heideella</i> (?) sp. nov. ' <i>salahi</i> ' (<i>nomen nudum</i>)	EN	Yes
HYDROBIIDAE	<i>Horatia</i> sp. nov. ' <i>aghabalensis</i> ' (<i>nomen nudum</i>)	EN	Yes



Family	Scientific name**	IUCN Red List Category (North Africa)	Endemic to the region?
HYDROBIIDAE	<i>Horatia</i> sp. nov. ' <i>haasei</i> ' (<i>nomen nudum</i>)	EN	Yes
HYDROBIIDAE	<i>Hydrobia maroccana</i>	EN	Yes
HYDROBIIDAE	<i>Hydrobia minoricensis</i>	EN	
HYDROBIIDAE	<i>Maroccopsis agadirensis</i>	EN	Yes
HYDROBIIDAE	<i>Mercuria cf balearica</i>	EN	
HYDROBIIDAE	<i>Mercuria</i> sp. nov. ' <i>mirlheftensis</i> ' (<i>nomen nudum</i>)	EN	Yes
HYDROBIIDAE	<i>Pseudamnicola cf. spirata</i>	EN	
LYMNAEIDAE	<i>Lymnaea</i> (? <i>Stagnicola</i>) <i>maroccana</i>	EN	Yes
LYMNAEIDAE	<i>Lymnaea</i> (<i>Lymnaea</i>) <i>stagnalis</i>	EN	
LYMNAEIDAE	<i>Lymnaea</i> (<i>Stagnicola</i>) <i>palustris</i>	EN	
MELANOPSIDAE	<i>Melanopsis letourneuxi</i>	EN	Yes
MELANOPSIDAE	<i>Melanopsis magnifica</i>	EN	Yes
MELANOPSIDAE	<i>Melanopsis mourebeyensis</i>	EN	Yes
MELANOPSIDAE	<i>Melanopsis scalaris</i>	EN	Yes
NERITIDAE	<i>Theodoxus meridionalis</i>	EN	
PISIDIIDAE	<i>Pisidium subtruncatum</i>	EN	
PLANORBIDAE	<i>Anisus spirorbis</i>	EN	
PLANORBIDAE	<i>Armiger crista</i>	EN	
PLANORBIDAE	<i>Hippeutis complanatus</i>	EN	
UNIONIDAE	<i>Potomida littoralis</i>	EN	Yes
UNIONIDAE	<i>Unio durieui</i>	EN	Yes
AMPULLARIIDAE	<i>Lanistes varicus</i>	VU	
ANCYLIDAE	<i>Ancylus strictus</i>	VU	
HYDROBIIDAE	<i>Belgrandia</i> (?) sp. nov. ' <i>wiwanensis</i> ' (<i>nomen nudum</i>)	VU	Yes
HYDROBIIDAE	<i>Heideella andraea</i>	VU	Yes
HYDROBIIDAE	<i>Hydrobia djerbaensis</i>	VU	Yes
HYDROBIIDAE	<i>Pseudamnicola conovula</i>	VU	
HYDROBIIDAE	<i>Pseudamnicola meluzzii</i>	VU	Yes
MELANOPSIDAE	<i>Melanopsis subgraeßliana</i>	VU	Yes
NERITIDAE	<i>Theodoxus marteli</i>	VU	Yes
NERITIDAE	<i>Theodoxus numidicus</i>	VU	Yes
PISIDIIDAE	<i>Pisidium personatum</i>	VU	
PLANORBIDAE	<i>Gyraulus laevis</i>	VU	
PLANORBIDAE	<i>Segmentorbis angustus</i>	VU	

** The species that are listed as *nomen nudum* have been described as species in a Ph. D. thesis, however, this publication does not meet the criteria as a valid publication for International Code of Zoological Nomenclature (ICZN). Until they are published as full species according to ICZN, they cannot be included on the Global Red List of Threatened Species.

4.3 Patterns of species richness and endemism

4.3.1 Species richness of freshwater molluscs in Palearctic northern Africa

In the Palearctic part of northern Africa the highest number of species was recorded by Ghamizi (1998) in the Middle Atlas (39 species), followed by the flat highland of the Atlantic meseta (32 species), the regions of the High Atlas and the Rif (29 species), and the Anti-Atlas (27 species). To the south from the Oued Seyad (Goulimine), i.e., in the basin of the Oued Drâa and the rivers draining into the Sahara, the species richness rapidly declines. Only 3 species are found in the Atlantic region south of the Drâa and none in the Saharan rivers in the Moroccan/ Algerian border region. To the east, in the only large Moroccan river system draining into the Mediterranean, the Oued Moulouya, the species richness is around 27 species and this seems also to be the case in Mediterranean Algerian Tell Atlas. The number appears to decline to 20 species in northern Tunisia and drops to less than 10 species in the Palearctic part of Libyan Arab Jamahiriya (Cyrenaica). In Algeria and Tunisia, south of

the Saharan Atlas and Aurès ranges, the species richness rapidly dwindles to below 5 species of which 2 or 3 are Afrotropical (Figure 4.6).

The species richness shows a gradual decline from west to east, the richest communities still occurring in the region of the Atlantic meseta and mountains, which receives the

Anodonta lucasii is an endemic species listed as Critically Endangered at the level of the northern African region. Its populations are native to slow flowing streams and marshes of the Mediterranean coastal region of Algeria and Tunisia but currently restricted to a unique location in Tunisia. Photo © The Mussel Project

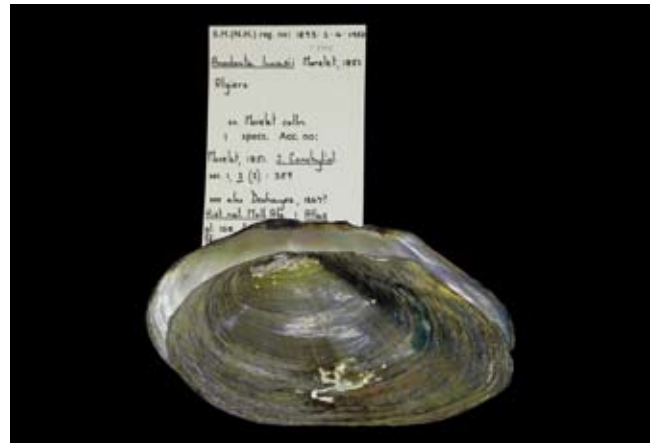
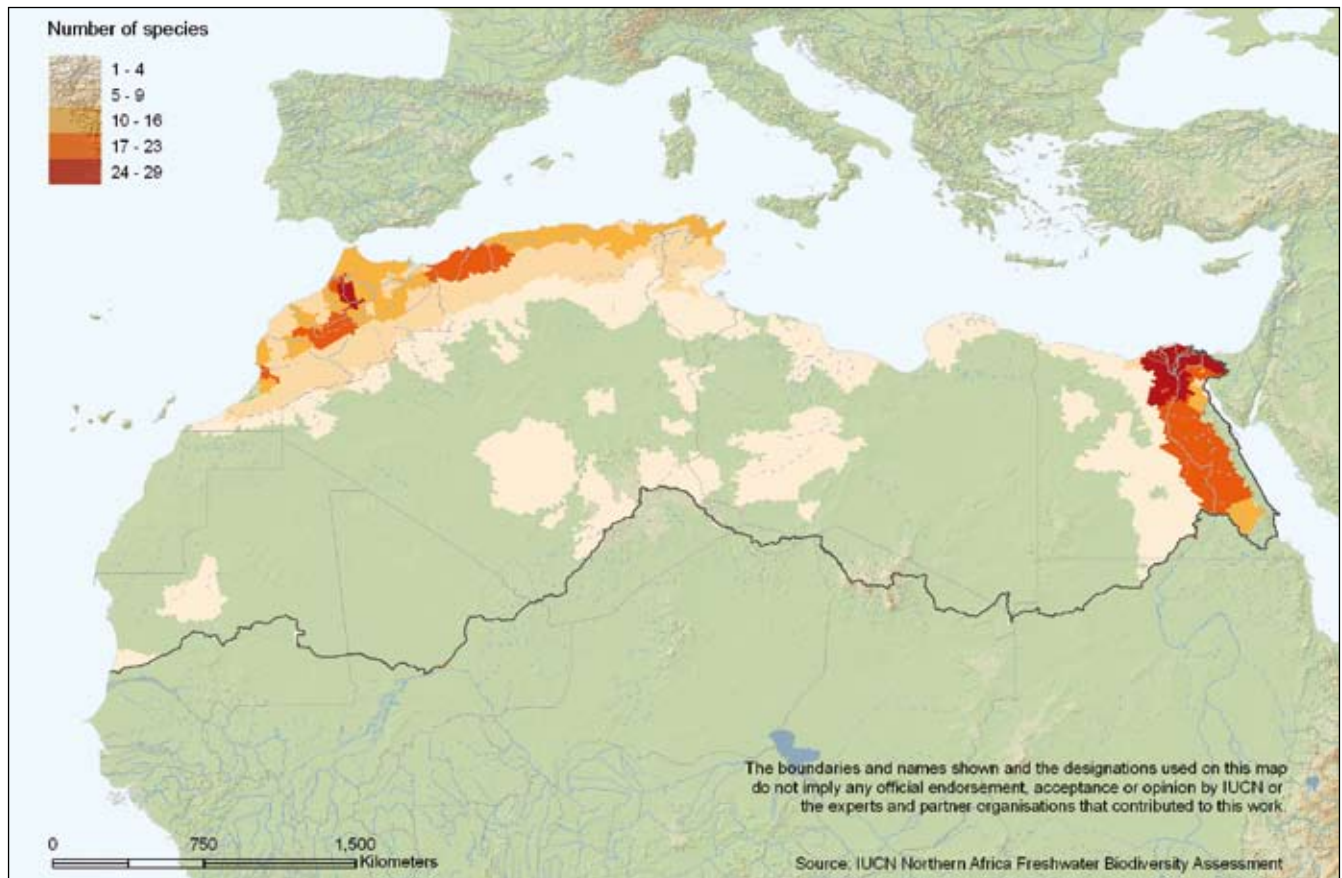


Figure 4.6 Distribution of freshwater mollusc species in northern African region. In the western part the highest concentrations are found in the Atlas Mountains and the adjacent Atlantic meseta in Morocco. In the eastern part only the Nile contains a rich fauna.





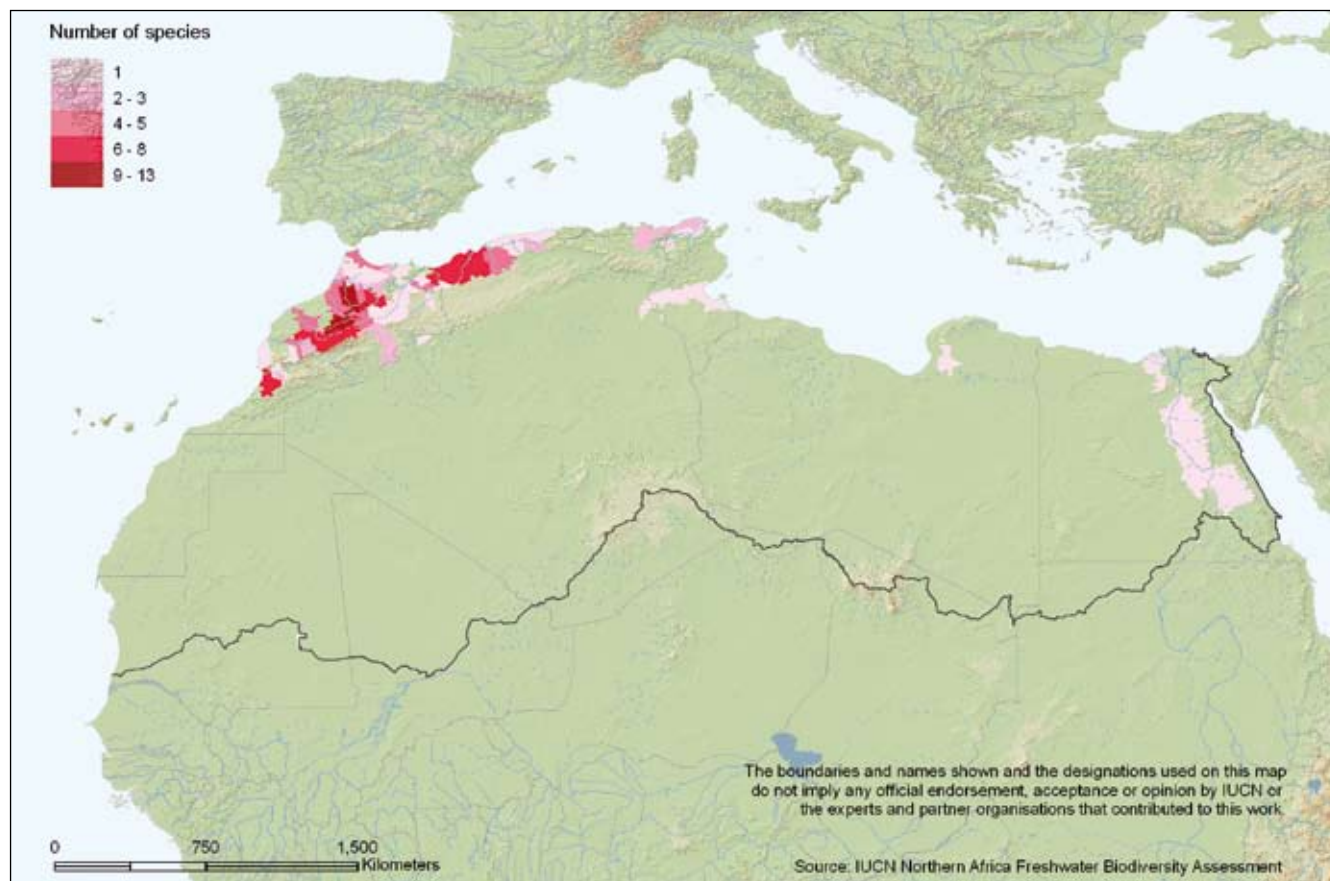
highest precipitation and has the lowest mean annual temperature. The declining species richness towards the east (Algeria and Tunisia) seems clearly linked with anthropogenic factors such as pollution and overexploitation of surface and ground waters. This conclusion is based on the fact that the 19th century records do mention a sizable number of subterranean species, which may be assumed to be extinct because the wells and springs in which they were collected do not exist anymore. In addition, a number of Palearctic species which appear to have been already strongly localized in the 19th century, are most likely also gone due to the increasing aridity related to the fact that many swamps and lakes in Algeria have been drained for agriculture in addition to the effects of pollution.

It should be stressed however, that the lower species richness, particularly in the Oued Moulouya basin and in the Algerian Tell Atlas, may be partly an artefact due to lack of sampling during the last decades. The detailed survey of hydrobiids of wells and springs by Ghamizi (1998) did increase the species richness by 30 in western and middle Morocco. But the number of species in surface waters clearly also decreases from west to east.

Anodonta pallaryi is Critically Endangered due to its restricted distribution limited to one hydroelectric reservoir in Morocco and invasive species. Photo © The Mussel Project



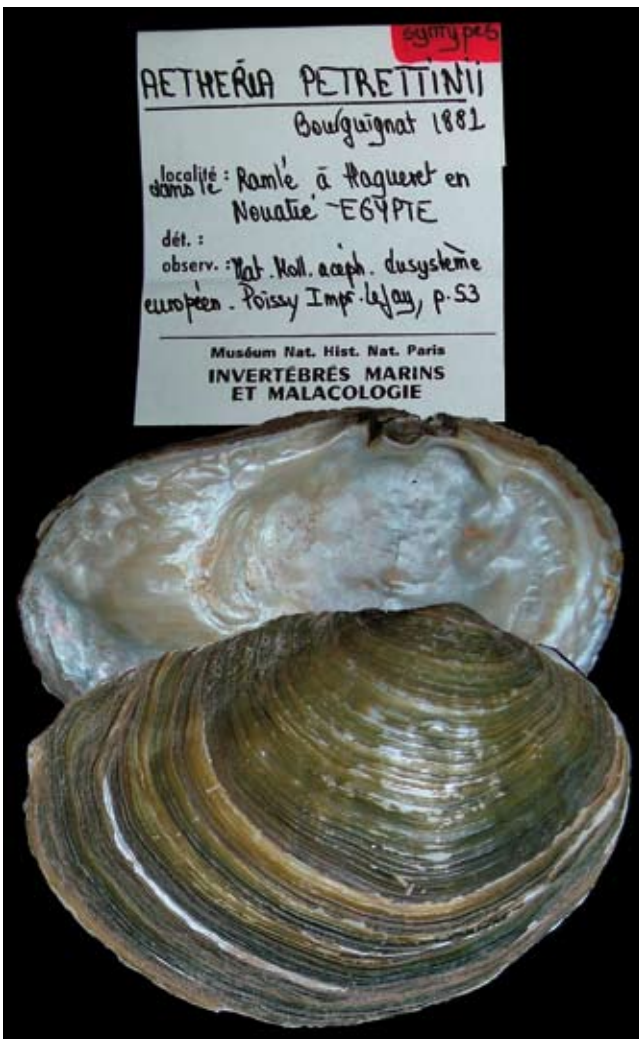
Figure 4.7 Distribution of threatened freshwater molluscs in northern African region. The highest concentrations are found in the Atlas Mountains of Morocco.



Potomida littoralis fellmanni is an Endangered taxon endemic to Algeria, Morocco and Tunisia, living in different types of substrate in slow moving and standing waters. Its remaining populations are in serious decline and in need of protection and investigation. The picture shows a specimen, collected in the Fes province of Morocco. Photo © The Mussel Project



The Critically Endangered bivalve *Anodonta lucasii* is endemic to slow flowing streams and marshes of the Mediterranean coastal region of Algeria and Tunisia. Drainage of sites and alteration of its habitat due to infrastructure development are the main threats affecting this species. Photo © The Mussel Project



4.3.2 Species richness of freshwater molluscs in Afrotropical northern Africa

The highest species richness in Afrotropical Africa is found in the Egyptian Nile where 39 species are present. In the 20th century, due to the disappearance of swampy habitats along the borders of the Egyptian Nile, many smaller gastropod species that live in debris and among aquatic vegetation became restricted to the slow flowing and stagnant canals of the Nile Delta where vegetation was still abundant and the bottom was muddy. Since the building of the Aswan Dam, the stream velocity of the Egyptian Nile was decreased, resulting in the extension over a larger distributional range of most Nilotic species. Compared to the Nilotic molluscan community recorded in 19th century, the present one shows only a slight decrease in species richness, due to the disappearance of a couple of Palearctic species that were already relicts one hundred years ago. Their disappearance may have been caused by global climate change. It should be pointed out however, that the only endemic Afrotropical bivalve in Egypt, *Chambardia letourneuxi*, which was confined to the Delta has not been collected since the late 19th century and should be considered as Extinct. Hence tropical species have also been affected.

Beyond the borders of the Nile the Sahara begins, as a rule, species richness decreases to a few species, and never more than 5. Even during the Holocene wet phases this whole region was relatively species poor with a maximum of 10 to 13 species in all parts where no stable hydrographic connections developed. Only the fossil molluscan communities of Wadi Howar (Egypt) and the Oued Tilemsi (Mali), now both dry, were richer.

4.3.3 Patterns of species richness of threatened species

As already stated, there is a marked difference between the species richness distribution in northern Africa as a whole and the distribution of species in threatened categories (Figure 4.7).

4.3.3.1 Species richness of threatened species in the Palearctic part of northern Africa

In the Palearctic part of the region, the distribution pattern of the total species richness and the species richness of threatened species does not differ markedly. This is due to the fact that subterranean hydrobiids with a limited distribution constitute a significant proportion



Figure 4.8. Distribution of endemic molluscs of northern Africa, illustrating the high degree of endemism in the Maghreb, in particular in the Moroccan Atlas Mountains.

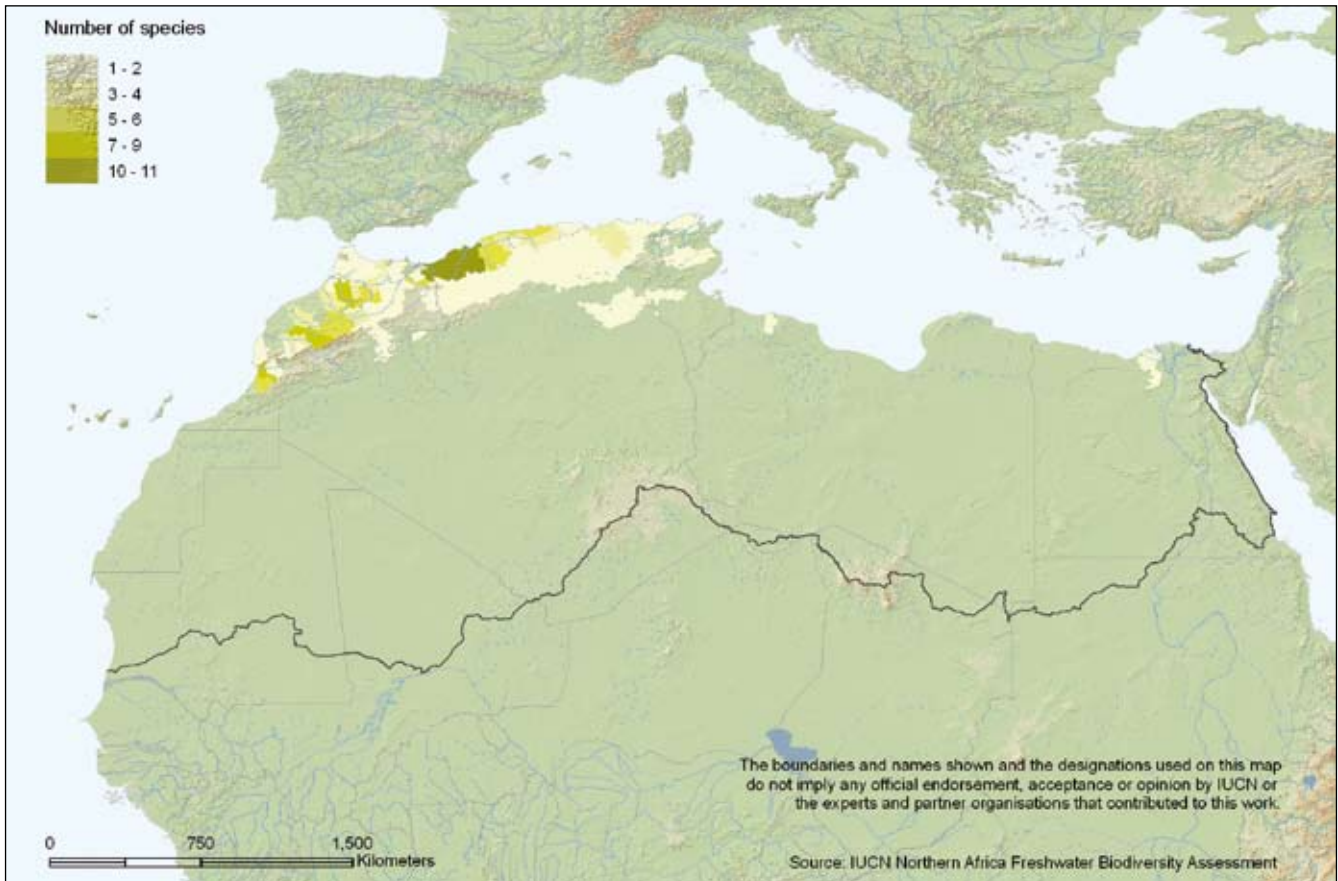
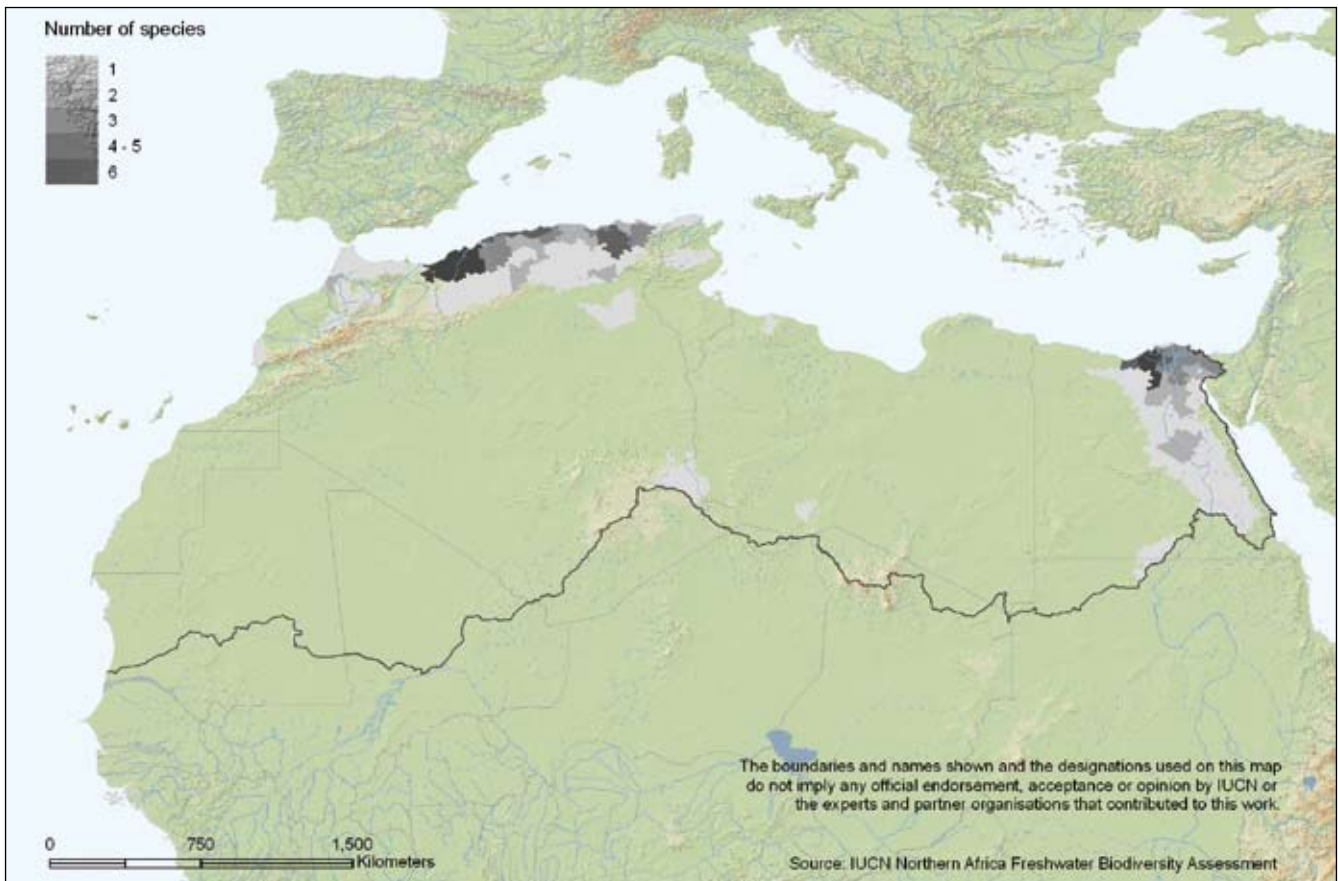


Figure 4.9 Distribution of freshwater molluscs of northern Africa classified as Data Deficient, showing highest concentrations in the Nile Delta and north Algeria as a result of a lack of taxonomic reviews.



of the community. Some regions, in the Moroccan Middle Atlas, the eastern coastal meseta and Algeria for example, have not been fully explored, and the above statement may reflect differences in sampling intensity instead of the real situation. However, the distribution of the species richness of Maghrebian *Melanopsis* species with limited distributions and hence are threatened give a good idea of the decrease of threatened species in surface waters from west to east.

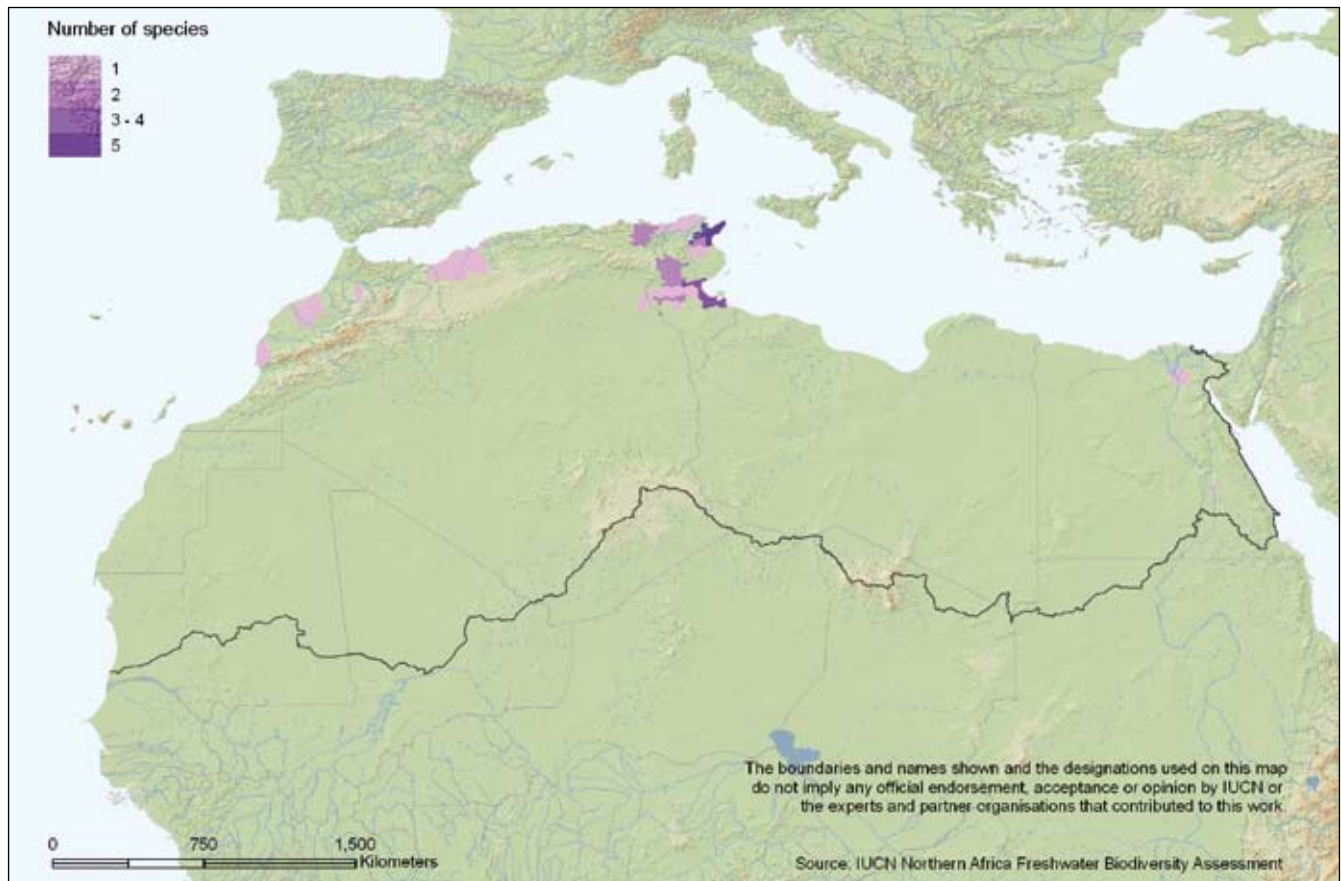
4.3.3.2 Species richness of threatened molluscs in the Afrotropical part of northern Africa

In the Afrotropical part of the region, the global species richness and the richness of threatened species do not coincide, as the number of regionally threatened species is very low. In a supra-regional context the number of threatened species is zero since all Afrotropical species whose taxonomic status is known (and not the taxonomically highly dubious ‘endemic’ species of the *Ferrissia*-complex) do have a wide distribution in Africa. The Palearctic species are widespread in the Palearctic region and the few endemics of Palearctic origin (*Theodoxus niloticus*, *Valvata nilotica*, *Gyraulus ehrenbergi* and *Hydrobia musaensis*) do not fall in a threatened category.

4.3.4 Distribution of endemic species

The dispersal strategy of freshwater molluscs in northern Africa differs greatly from group to group: some are easily dispersed by birds (e.g., Planorbidae, Pisidiidae), others use fish as host in their larval stage (e.g., Margaritiferidae, Unionidae) and others have very limited dispersal capacities (e.g., Viviparidae). While hydrobiids living in surface waters appear to be easily dispersed by birds, the highly restricted distribution of most subterranean hydrobiids (often only recorded from a single well or source) indicates that their distribution capacity is very low. In Maghrebian Africa the number of species with restricted ranges in surface waters, i.e., confined to one river system or, in some cases, to two adjacent systems is clearly highest in the Moroccan rivers running towards the Atlantic. These contain, not taking into account the Hydrobiidae, several *Melanopsis* species, *Margaritifera marocana*, *Unio foucauldianus* and *Anodonta pallaryi*. In Algeria and Tunisia there is only one non-hydrobiid species with restricted range in each country (*Melanopsis subgraëllsiana* and *Anodonta lucasi*, respectively). On the contrary, there are none in the Libyan Arab Jamahiriya (Figure 4.8).

Figure 4.10 Distribution of extirpated freshwater mollusc of northern Africa (RE and EX).





In the Afrotropical part of northern Africa, the only taxonomically valid species with a restricted range is *Gyraulus ehrenbergi*, which has only been found in the Egyptian Nile system (including Lake Nasser, which does not belong to the region assessed in this report).

4.3.5 Data deficient species

As already stated, many Palaearctic species in northern Africa have been classed as Data Deficient (DD) because they have not been collected since the 19th or the early 20th century. The lack of anatomical studies of the original material makes it impossible to ascertain if, for instance, the populations of small hydrobiids in thermal waters near Constantine and Biskra (Algeria), originally described as *Amnicola seminium* (Morelet 1857) actually belong to the same species. It may well be that several species have been lumped together but since only empty shells remain, the taxa is considered as Data deficient. The risks of most of these DD endemic hydrobiids being already extinct are considerable.

In Afrotropical northern Africa there are few Data Deficient cases. Concerning the *Ferrissia* complex it pertains to a taxonomic matter of hyper-splitting that has not yet been corrected, concerning species such as *Gyraulus costulatus*, a species easily confounded with *G. ehrenbergi*, it pertains to uncertainty of its occurrence in the northern African Region (Figure 4.9).

4.3.6 Extirpated species

Seventeen species are considered as Regionally Extinct in northern Africa, including strongly localized endemic hydrobiids collected from wells and springs that stand dry. Some Regionally Extinct Sibero-European species are also added to this number. These occurred during the early-middle Holocene over a larger area in northern Africa and have since retreated to mountain lakes in Maghreb and in the Ethiopian Highlands. Their disappearance from the most southerly limit of their range seems to have been accelerated since the 1970s. Most of the Palaearctic species that were recorded from only one locality in northern Africa have been placed in the category ‘Critically Endangered’ on the present study, though they probably are Regionally Extinct. However, since it pertains to small-sized easily overlooked species, e.g., Pisidiidae, the possibility that some populations still survive was taken into account. The number of extirpated species in the Palaearctic part of the northern African Region is most likely an underestimation as many DD and CR species may also be gone. Conversely, the

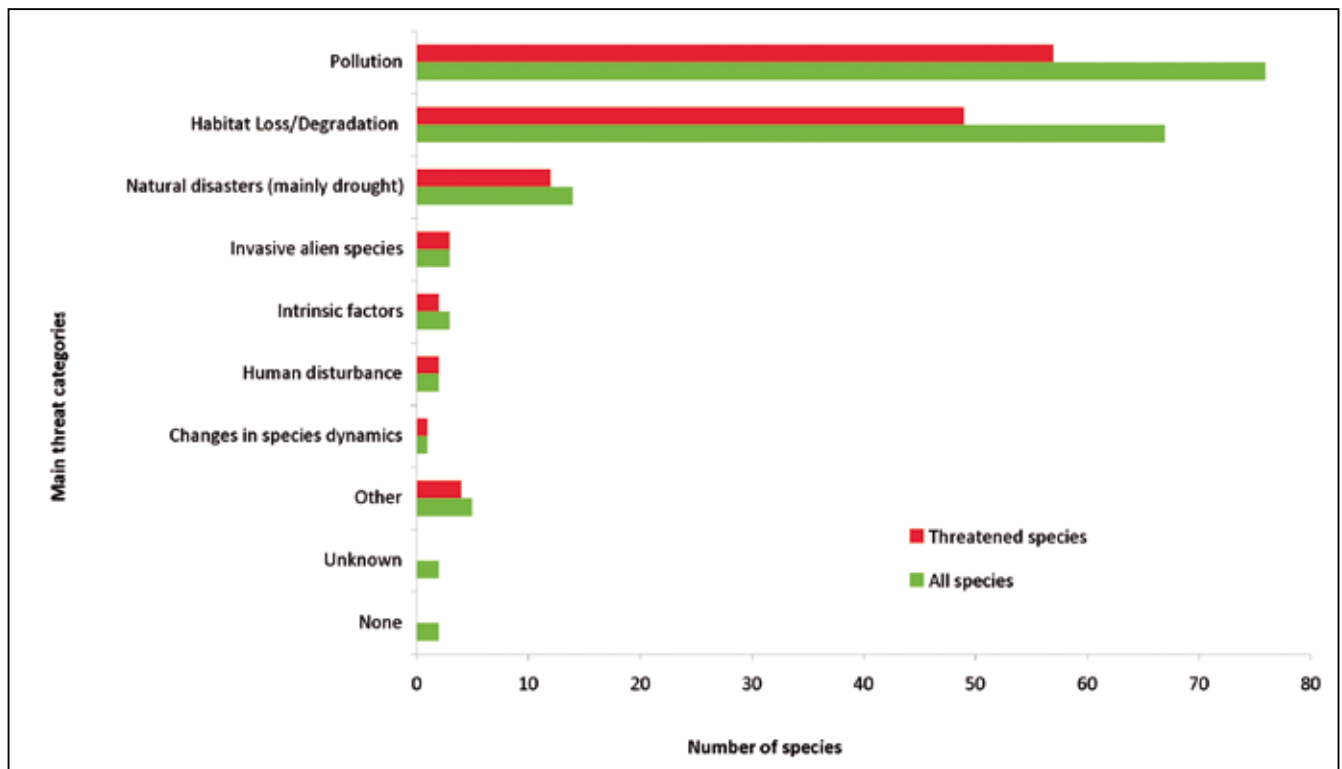
Table 4.5. List of the Extinct freshwater molluscs of the northern African region including the Regionally Extinct (RE), and the Globally Extinct (EX).

Family	Scientific name*	Red List Category
BITHYNIIDAE	<i>Bithynia leachi</i>	EX
HYDROBIIDAE	<i>Bythinella</i> (?) <i>limnopsis</i>	EX
HYDROBIIDAE	<i>Bythinella</i> (?) <i>mauritanica</i>	EX
HYDROBIIDAE	<i>Bythinella</i> (?) <i>microcochlia</i>	EX
HYDROBIIDAE	<i>Bythinella</i> (?) <i>punica</i>	EX
HYDROBIIDAE	<i>Hydrobia</i> (?) <i>gracilis</i>	EX
HYDROBIIDAE	<i>Mercuria</i> (?) <i>letourneuxiana</i>	EX
HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>barratei</i>	EX
HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>desertorum</i>	EX
HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>doumeti</i>	EX
HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>globulina</i>	EX
HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>latasteana</i>	EX
HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>oudrefica</i>	EX
HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>ragia</i>	EX
HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>singularis</i>	EX
IRIDINIDAE	<i>Chambardia letourneuxi</i>	EX
LYMNAEIDAE	<i>Lymnaea auricularia</i>	EX
BITHYNIIDAE	<i>Bithynia tentaculata</i>	RE
PISIDIIDAE	<i>Pisidium amnicum</i>	RE

Margaritifera marocana (Critically Endangered). This putatively extinct subspecies of the European *M. auricularia* species was rediscovered in the Oued Derna (Morocco) by the shell collector José Ahuir in 2006. It was a small population (ca. 50 specimens) consisting of old individuals. The next year a large population with juveniles was found in the Oued Abid by Prof. Dr. M. Ghamizi. Tissue samples of both populations were analysed in the National Museum of Natural History in Madrid and proved the Magrebian populations to be genetically distinctive. Photo © Mohamed Ghamizi



Figure 4.11 Main Threats to freshwater molluscs in northern Africa.



Irrigation channel in Morocco. Photo © M.Ghamizi





unionoid, *Margaritifera auricularia marocana*, originally described by Pallary (1918), was considered as Extinct and rediscovered in 2006, to what subsequent genetic research revealed it is a distinct species (*M. marocana*) not a subspecies (Araujo *et al.* 2009).

In the Afrotropical part of northern Africa only a single species, the unionoid *Chambardia letourneuxi*, is extirpated. This species was described for the first time in the 19th century on the basis of early to middle Holocene specimens from Lower Egypt, and considered to be extinct. In the early 20th century some live specimens were collected in the Delta and misidentified (Graf and Cummings 2007). No specimens have been found since and it may be assumed that the species is gone. The reason for this extirpation is unknown. *Chambardia letourneuxi*, an endemic of the Nile Delta, may have been out competed by the much larger *Chambardia rubens*.

4.4 Main Threats to Freshwater mollusc in northern Africa

Increasing periods of droughts and climatologic destabilisation

Severe droughts lasting several years and interrupted by catastrophic floods have become more the rule than the exception in the Palaearctic part of the northern African

Region. As a result the beds of the lowland stretches of large rivers are often devoid of water and what remains becomes heavily polluted by industrial and domestic runoff. During the subsequent torrential floods, about every 5 to 7 years, enormous amounts of sediment are transported, further destroying the aquatic habitats (siltation). As a result only the upper reaches of the river systems in the mountainous regions of the Atlas ranges still contain water of good quality for the whole year.

Water abstraction

In Maghreb, large-scale river habitat destruction due to excessive water abstraction for domestic, industrial and agricultural use is a threat that has reached catastrophic proportions. Having already begun in the 19th century during French occupation, e.g., the draining of vast parts of the Algerian Lake Fetzara for viniculture, it has accelerated dramatically since the 1980s. Water abstraction is the main reason why endemic lowland species, such as *Anodonta pallaryi*, here listed as Critically Endangered (CR), are on the verge of extinction or may already be extinct. Overuse of the underground water reserves has resulted in the rise of underlying saline waters and in the decrease of the freshwater levels. Many artesian wells and springs are now dry and the remaining water in the aquifers has become mineralized in several regions (sulfides). In a region with a unique diversity of

Salinization of the Oued er Rbia catchment area. Photo. Middle Atlas, Morocco. Photo © Pedro Regato



subterranean hydrobiids, this inevitably led to a high degree of extinction in this group, whose significance and speed we are not able to estimate due to lack of research.

It is said that every drop of the Nile water has already been used before it reaches Egypt. Though water abstraction is high, the malacofauna of the Nile does not seem to be adversely affected. In other countries such as Libyan Arab Jamahiriya and Mauritania, water abstraction from the underground waters may lead to the disappearance of surface waters and therefore of molluscan populations, none of which however, belong to an endemic species.

Pollution

In Maghreb, agro-industry and large urban agglomerations are mainly concentrated in the lower regions where water is available. Unfortunately, Libyan Arab Jamahiriya excepted, there exists virtually no water sanitation. The effluents and nitrates from chemical fertilisers cause severe eutrophication in surface and ground waters. In addition, massive amounts of polluted soil are eroded from arable lands, causing siltation with sediments containing pesticides and fertilizers. The effects of pollution are hence as dramatic as those of the water abstraction, not only for

the surface waters but equally for water quality in the aquifers. Pollution of Maghrebian surface waters extends to small rivers in the mountain regions. The quality of the Nile water is good except for parts of the Nile Delta.

Salinization

Salinization is most acute in the shallow coastal aquifers of Maghreb due to the fact that agriculture and population concentrations are most intense in these fertile regions. Research e.g., of the Bou-Areg aquifer (north-eastern Morocco) and the Cap Bon aquifer (north-eastern Tunisia) have demonstrated that salinization is caused by (1) intrusion of seawater, (2) backflow of agricultural drainage water with concentrated salts and (3) influence of marly gypsum-bearing deposits. The negative influence on populations of underground hydrobiids must be significant. In Tunisia for instance, the overexploitation of the Cap Bon aquifer led to the salinization of more than 2,800 freshwater wells (Gaaloul *et al.* 2003). In Libyan Arab Jamahiriya the whole shallow coastal aquifer has become saline due to seawater intrusion. In inland shallow aquifer salinity increase is caused by a combination of backflow of agricultural drainage water and intrusion from saline water from the underlying Continental Intercalaire aquifer.

Women washing clothes in the Ait Mizane stream, activity that generates water pollution as a result of use of detergents. Photo © Mohamed Ghamizi





Dubost (1986) has calculated that 8-10 tonnes of salt accumulate per hectare on agricultural land per year in Algeria contaminate the surface waters via erosion.

Molluscicides

In the northern African Region the large scale use of molluscicides to destroy the intermediate snail host of *Schistosoma* (*Bulinus*, *Biomphalaria*) has been confined to Egypt. Brown (1994) states on this matter: 'More money has been spent on the use of molluscicides in Egypt than in any other African country and perhaps even in all other African countries combined. During the Egypt-49 Project in the Nile Delta, area-wide applications of molluscicides (mainly niclosamide) were made in canals and drains from 1963-70'. In Middle and Upper Egypt about 330,000 tonnes of niclosamide were used in the year 1984 alone (Brown, 1994). How many molluscan populations were destroyed in Egypt due to molluscicides is unknown, but there is no direct evidence that a species was exterminated. Due to the high costs, growing environmental concerns (niclosamide also kills fish and amphibians) and the rather unsatisfactory results, the intense campaigns were stopped in the early 1990s. While Van Damme (1984), based on records from 1960-80, noted that there was virtually no molluscan life in the Middle and Upper

Nile, Ibrahim *et al.* (1999) on the contrary describe an abundant and diversified fauna. Quite possibly this positive change is correlated with the reduced use of molluscicides.

Habitat loss due to construction of physical barriers for species

Large dams form migration barriers for fish and therefore for the ectoparasitic larvae of unionoids (*Mutela*, *Coelatura*, *Nitia*, *Unio*, *Potomida*, *Anodonta*, *Margaritifera*) that spread via fish. No case has yet been recorded of a northern African bivalve species that has become rare or extinct due to the erection of dams.

Nowadays, the Aswan Dam has a direct positive impact on the freshwater malacofauna of the Egyptian Nile and in particular of the Nile Delta due to the fact that the sediment load carried by the river is greatly diminished and the water volume is regulated. Marine water no longer encroaches on Delta lakes such as Lake Mariut as it did previously during the dry season. A future problem is that the degree of erosion presently surpassed the degree of sedimentation in the Delta and consequently the stretch of sand bars that separates the delta lakes from the sea may vanish. In other words, the Delta is likely to shrink in the future.

A team of Moroccan and Spanish malacologists aided by local youngsters collecting *Margaritifera marocana* in the Oued Abid (Morocco). After tissue samples were taken, the animals of the last viable population of this species were placed back. Photo ©Mohamed Ghamizi



Introduced invasive species

In the Palaearctic part of the northern African Region the only introduced molluscan species appears to be the pulmonate snail *Physa acuta*, which probably came from North America and is now found all over Africa. Trials have been carried out in Egypt to introduce two American species, the ampullariid *Marisa cornuarietis* and the planorbid *Helisoma duryi*, as competitors of intermediate hosts of schistosomes. These species appear to remain highly localized and attempts have not been particularly successful. The rumour that *Biomphalaria glabrata*, a Neotropical intermediate host of schistosomes had escaped from a laboratory in Cairo and was spreading along the Nile has not been substantiated by subsequent genetic investigations. Finally, the Nearctic *Lymnaea columella*, presently found all over the world, has been introduced incidentally in Egypt around 1944, but does not seem to be particularly common. There are hence no introduced molluscan species in the northern African region that constitute a threat to the indigenous species. The introduction of a number of European and American fish, e.g., molluscivores such as domestic carp, in Moroccan and Algerian lakes during the second half of the 20th century probably did have significant negative effects on the malacofauna, but this impact was never studied.

Collecting

Probably due to their increasing scarcity, shell collectors' interest for freshwater molluscs, particularly for unionoids, has increased in the last years. Several shell dealers presently offer Mediterranean freshwater molluscs for sale, mainly from Morocco, Portugal and Spain, also occasionally from Italy, Israel and Turkey. The genera *Melanopsis* and *Theodoxus* appear to be the most popular. The trade in freshwater molluscs is still far less intense than in marine and terrestrial shells and it still remains a highly specialized market. An estimate of *Melanopsis* specimens sold per year is probably ca. 150. However, while negligible in comparison to the vast amounts of marine shells traded, it should be taken into account that some Maghrebian freshwater species have been reduced to small relict populations due to pollution and water abstraction. Extinction by over-collecting may therefore pose a threat in synergy with the other dangers, particularly if collectors' interest in freshwater molluscs keeps rising. Unfortunately the present taxonomic chaos in northern African species, e.g., in species complexes such as *M. praemorsa* (LC), *M. magnifica* (EN) and *M. scalaris* (DD) make it difficult to assess the impact of collecting on a number of populations which may be distinctive species (and are sold as such) but presently are not 'officially' recognized by scientists.

4.5 Conclusions and conservation recommendations

The present IUCN survey on northern African molluscs has in the first instance revealed that the species richness of north-western Africa has been severely underestimated and that the Atlantic and Mediterranean region from Morocco to Libyan Arab Jamahiriya is a true malacological hotspot with a surprisingly high amount of endemic molluscs in surface waters as well as in underground waters. Sadly, the present study has also revealed that a large number of species are on the verge of extinction and that due to the taxonomic disarray and lack of investigation we can only roughly guess at how many species there are and how many are threatened. There seems to be no reason for optimism, because freshwater resources in this region, with its steep demographic growth, modernized industry and agriculture, are being severely depleted and both surface and ground waters are being polluted. The trend of increasing aridity and global warming strongly aggravates the already severe human impact on the aquatic ecosystems.

In Egypt, on the contrary, the molluscan populations in the Nile seem to be in good condition, having extended their range over the whole Egyptian Nile. This is possibly partly due to the decrease in seasonal turbidity and water velocity since the building of the Aswan Dam and partly by the fact that large scale use of molluscicides has been stopped in Middle and Upper Egypt.

The most urgent conservation recommendations are:

- Inventory of species and taxonomic research of freshwater populations in the Maghrebian countries;
- Protection of still relatively unpolluted headwaters of rivers in the Atlas, Middle Atlas and Anti-Atlas;
- Protection of quality and quantity of aquifers;
- Protection of coastal wetlands;
- Complete ban on introduction of non-indigenous molluscivore fish.

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Chapter 5. The status and distribution of dragonflies

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5.1 Overview of the regional fauna

The Odonata of northern Africa are mainly of Eurasian and tropical origin but the region houses a few additional south-west Asian species. There are marked differences in the dragonfly fauna within distinct areas of the region which reflect past and current climates and topography. Three distinct ecoregions (the mountain ranges of Morocco, the coastal wetlands of Numidia in north-east Algeria and the Nile Delta in Egypt) providing a refuge to different sets of species have been identified within northern Africa.

Records spanning over a century and a half are used to map the spatial distribution of northern African Odonata. A total of 83 species has been recorded with 6 now believed to be Extinct. One species is only a migrant and is therefore classified as Not Applicable. A complete list of these species can be found in Appendix 3. The number of recorded species for each country/territory within northern Africa is given in Table 5.1 (doubtful records and/or vagrant specimens such those of *Erythromma najas* and *Lestes sponsa* in the Maghreb, *Sympetrum depressiusculum* in north-east Algeria and *Urothemis edwardsii* in Tunisia are not included here). The greatest concentration of species is found in the Maghreb: Algeria, Morocco and Tunisia (Table 5.1).

Oued Seybouse near Guelma, northeast Algeria. Photo © Boudjéma Samraoui



Table 5.1 Number of Odonata species within the area of northern Africa involved.

Countries	Number of recorded species
Algeria	63
Morocco	62
Tunisia	53
Egypt	33
Libyan Arab Jamahiriya	27
Mauritania	8
Chad	4
Mali	0
Niger	0
Sudan	0

Tunisia shares the majority of its species with Algeria whereas Morocco and Algeria have a number of distinct species. *Lestes dryas*, *Pyrrhosoma nymphula*, *Pseudagrion sublacteum*, *Oxygastra curtisii*, *Cordulegaster princeps*, *Libellula quadrimaculata* and *Zygonyx torridus* are found in Morocco but not in Algeria, while *Lestes numidicus*, *Pseudagrion hamoni*, *Gomphus lucasii*, *Lindenia tetrphylla*, *Cordulia aenea*, *Orthetrum sabina*, *Acisoma panorpoides*, *Urothemis edwardsii* and *Rhyothemis semihyalina* are, or were, found in Algeria but not in Morocco. *Orthetrum ransonnetii*, *Selysiothemis nigra* and *Sympetrum sinaiticum* were until recently believed not to be present in Morocco, but all three have now been found in this country in several places and/or years, sometimes at emergence, supporting local reproduction (Boudot 2008, Boudot *et al.* 2009, Juillerat and Monnerat 2009).

The Blue Basker *Urothemis edwardsii* (Critically Endangered), an Afrotropical relict species. Photo © Boudjéma Samraoui



Two suborders occur in northern Africa: the Zygoptera (damselflies) include up to 35 species spanning four families (Calopterygidae, Lestidae, Coenagrionidae and Platycnemididae), and the Anisoptera (dragonflies) include 48 species belonging to six families (Aeshnidae, Gomphidae, Cordulegastridae, Macromiidae, Corduliidae and Libellulidae). The percentage of endemic species is

Table 5.2 Number of endemic species and total number within each Odonata family.

Suborder	Family	Number of species	Number of endemic species
Zygoptera	Calopterygidae	3	1
Zygoptera	Lestidae	6	1
Zygoptera	Coenagrionidae	24	2
Zygoptera	Platycnemididae	2	1
Total – Zygoptera (damselflies)		35	5
Anisoptera	Aeshnidae	8	0
Anisoptera	Gomphidae	8	1
Anisoptera	Cordulegastridae	2	1
Anisoptera	Macromiidae	1	0
Anisoptera	Corduliidae	2	0
Anisoptera	Libellulidae	27	0
Total – Anisoptera (dragonflies)		48	2
Total – Odonata		83	7

higher among the damselflies (14.3%) compared to the dragonflies (4.2%), reflecting the higher dispersal power of the latter. In this report, the word “dragonflies” is used for both suborders.

As early as the mid-nineteenth century, the dragonflies of northern Africa attracted the interest of naturalists and this attraction was sustained and has not abated to this day, making the Odonata the best known insect group in the region. Systematic records were initiated with the “Exploration scientifique de l’Algérie” by Lucas (1849), which followed in the wake of the French colonisation of Algeria. Lucas was the first to visit the El Kala area, where he managed to collect a set of most interesting species such as *Rhyothemis semihyalina*, *Urothemis edwardsii*, *Lindenia tetraphylla* (Selys in Lucas 1849).

The male of the Blue Hawker, *Aeshna cyanea* (Endangered). This species is very common in Europe but in Africa it is a glacial relict which is confined to small areas in the coastal mountains of the Maghreb. Photo © Jean-Pierre Boudot



Oued Ziatine in Tunisia. This kind of sandy river favours Odonata with burrowed larvae like Gomphidae. Here, a large population of *Paragomphus genei* is settled and emerge almost all round the year. Photo: © Jean-Pierre Boudot





A string of papers of one of the most prominent odonatologists followed, covering mainly Algeria but also Morocco and Tunisia and spanning the whole of the second half of the 19th century (Selys 1865, 1866, 1871, 1902; Selys and Hagen 1850). During the same period and in the early 20th century, a whole array of distinguished odonatologists visited the area or examined material collected by ardent naturalists (Kolbe 1885, McLachlan 1889, 1897; Martin 1901, 1910; Morton 1905; Ris 1909-1919, 1913; Navás 1913, 1922, 1928, 1934).

The turn of the century also coincided with the French penetration of the Sahara, which opened uncharted territories to naturalists and diverted their attention to the desert (Le Roi 1915, Kimmins 1934, Reymond 1952; Nielsen 1956). The second half of the 20th century witnessed many efforts focused first in Morocco (Schmidt 1957, 1960; Aguesse 1958; Aguesse and Pruja 1957, 1958) and then in Tunisia and Algeria (Dumont 1977, 1978a). Much progress was made in furthering our knowledge of the fauna of Morocco by Liefinck (1966), Dumont (1972) and Jacquemin and Boudot (1999). Recent additions were due to Boudot (2008) and new important discoveries included here have just been published (Juillerat and Monnerat 2009).

The male of the Atlas Goldenring, *Cordulegaster princeps*, a Moroccan endemic (Near Threatened). This species is confined to the western and central parts of the High and Middle Atlas, where it exists sometimes in flourishing populations. However, it is extinct in former localities impacted by urbanization and agriculture, due to water overconsumption. Photo © Jean-Pierre Boudot



The female of the Holarctic Emerald Spreadwing *Lestes dryas* (Vulnerable). This species is widespread in northern and central Europe but is generally confined to mountainous areas in southern Europe. In Africa, it is a glacial relict limited to the Rif and Middle Atlas mountains in Morocco. Photo © Jean-Pierre Boudot



Similarly, two major surveys of Odonata in Algeria and Tunisia were independently carried out by Samraoui and Menai (1999) and Jödicke *et al.* (2000) respectively, clarifying the status of most species in these two countries. Over the last thirty years, the Odonata of northern Africa have been under intense scrutiny (Dumont 1976, 2007; Carchini 1981; Lavergne-Viala and Thiery 1983; Jacquemin, 1984, 1985, 1987a, 1987b, 1991, 1994; Jacquemin and Aguesse 1987; Jacquemin and Boudot, 1986, 1990; Lohmann 1990; Ocharan 1992; Samraoui *et al.* 1993, 2002, 2003; Jödicke 1995; Samraoui and Corbet 2000a, b; Jödicke *et al.* 2004; Samraoui 2009).

Elements of the dragonfly fauna of Egypt have been known since Selys (1887), but this country (Navás 1909, Ris 1912, Andres 1928, Morton 1929, Kimmins 1950) and the neighbouring Libyan Arab Jamahiriya (Ris 1911; Navás 1932; Nielsen 1935a, 1935b, 1959) were mainly explored by odonatologists in the first half of the 20th century. More efforts were made by Dumont on the fauna of Egypt in the second half of the same century (Dumont 1973, 1974, 1980, 1991; Dumont and Fossati 1990). An update and revision of the Odonata from the Libyan Arab Jamahiriya, with important additions, is found in the recent Atlas of the Mediterranean and North Africa (Boudot *et al.* 2009).

The Odonata of Mauritania were not known until the mid-twentieth century when they were first studied by

Fraser (1952) and Aguesse and Pruja (1958), before Dumont (1976, 1978b) added much to our knowledge of this taxon from this part of the world.

There is little data about Odonata south of the lower Drâa valley in Morocco and the Mauritanian borders, and from the part of Mali, Niger, Chad and Sudan involved in this report (Dumont 1976, Navás 1936). All were recently synthesized in the recent “Atlas of the Odonata of the Mediterranean and North Africa” (Boudot *et al.* 2009).

An immature male of *Mesocnemis robusta* (Critically Endangered). This African species is known only from the Nile system in Egypt and Sudan and from western Africa in Ghana and Benin. Recent records in northern Africa are very rare and are localized in the lower Nile Valley and Delta.. Photo © Jean-Pierre Boudot



The female of the West-Palearctic Southern Damselfly, *Coenagrion mercuriale* (Endangered). This species is widely distributed in France and in the Iberian Peninsula but is steadily decreasing in Italy and in large parts of the Maghreb. In the latter area the largest known populations stand in the Middle Atlas and the species either remains scattered or is lacking in other regions. Photo: © Jean-Pierre Boudot





5.2 Conservation status (IUCN Red List Criteria: Regional scale)

Within the 82 dragonfly species assessed, almost a quarter (24.4%) are threatened with extinction: 7.3% of these are Critically Endangered, 8.5% Endangered and 8.5% Vulnerable (see table 5.3). Whilst 43 species (52.4%) are classified as Least Concern, 8 taxa (9.8%) are classified as Near Threatened (*Boyeria irene*, *Coenagrion scitulum*, *Pyrrhosoma nymphula*, *Cordulegaster*

boltonii algerica, *C. princeps*, *Gomphus simillimus maroccanus*, *Onychogomphus costae* and *Zygonyx torridus*), 5 species (6.1%) as Data Deficient (*Enallagma cyathigerum*, *Ischnura evansi*, *I. senegalensis*, *Lestes numidicus* and *Orthetrum ransonnetii*). The circumtropical species *Pantala flavescens* is a vagrant species in northern Africa and is therefore considered as Not Applicable for this regional assessment (1.2%). A total of 6 species (7.3%) have been assessed as Regionally Extinct (see Table 5.3, Figure 5.1, 5.2 and Table 5.4).

Table 5.3 The number of dragonfly species in each Red List Category in the northern African region.

	IUCN Red List Category	Number of Species (%)	Number of regional endemics (%)
Threatened categories	Regionally Extinct (RE)	6** (7.3%)	0 (0%)
	Critically Endangered (CR)	6 (7.3%)	0 (0%)
	Endangered (EN)	7 (8.5%)	1 (14.3%)
	Vulnerable (VU)	7 (8.5%)	1 (14.3%)
	Near Threatened (NT)	8 (9.8%)	1 (14.3%)
	Least Concern (LC)	43 (52.4%)	3 (42.9%)
	Data Deficient (DD)	5 (6.1%)	1 (14.3%)
	Total number of taxa assessed*	82 (100%)	7 (100%)

* Excluding taxa considered Not Applicable.

** *Agriocnemis sania* was recently discovered on the Nile River banks and Delta marshes during the last IUCN Pan African workshop in Cairo, in May 2009. This means also that the single old record of *A. exilis* from the Delta marshes, based on a defective specimen, was a misidentification and referred really to *A. sania*, which is closely related and was not formerly described.

Figure 5.1 The proportions of dragonfly species in each regional Red List category in the northern African region.

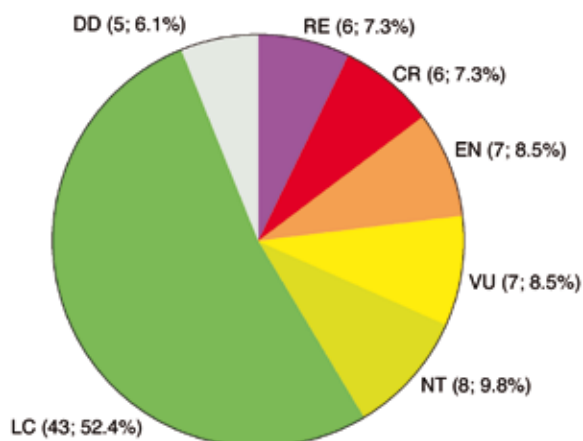


Figure 5.2 The proportions of endemic dragonfly species in each regional Red List category in the northern African region.

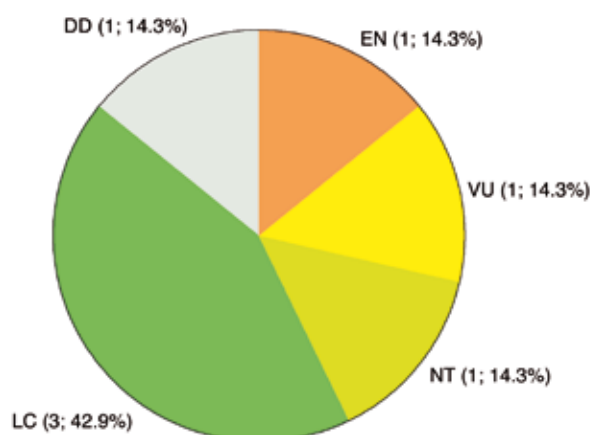


Table 5.4 Threatened Odonata species of the northern African region.

Family	Scientific name	Common name	IUCN Red List Category (northern Africa)	Endemic to the region?
CALOPTERYGIDAE	<i>Calopteryx virgo meridionalis</i>	Southern Beautiful Demoiselle	CR	
COENAGRIONIDAE	<i>Pseudagrion sublacteum</i>	River Sprite	CR	
CORDULIIDAE	<i>Oxygastra curtisii</i>	Orange-spotted Emerald	CR	
GOMPHIDAE	<i>Lindenia tetraphylla</i>	Bladetail	CR	
LIBELLULIDAE	<i>Urothemis edwardsii</i>	Blue Basker	CR	
PLATYCNEMIDIDAE	<i>Mesocnemis robusta</i>	-	CR	
LIBELLULIDAE	<i>Acisoma panorpoides</i>	Grizzled Pintail	EN	
AESHNIDAE	<i>Aeshna cyanea</i>	Blue Hawker	EN	
CALOPTERYGIDAE	<i>Calopteryx exul</i>	Glittering Demoiselle	EN	Yes
COENAGRIONIDAE	<i>Coenagrion mercuriale</i>	Southern Damselfly	EN	
LIBELLULIDAE	<i>Nesiothemis farinosa</i>	Black-tailed False-skimmer	EN	
COENAGRIONIDAE	<i>Pseudagrion niloticum</i>	Nile Sprite	EN	
COENAGRIONIDAE	<i>Pseudagrion nubicum</i>	Nubian Sprite	EN	
AESHNIDAE	<i>Aeshna affinis</i>	Blue-Eyed Hawker	VU	
AESHNIDAE	<i>Aeshna isoceles</i>	Green-eyed Hawker	VU	
COENAGRIONIDAE	<i>Pseudagrion hamoni</i>	Maroon Sprite	VU	
GOMPHIDAE	<i>Gomphus lucasii</i>	Algerian Clubtail	VU	Yes
LESTIDAE	<i>Lestes dryas</i>	Emerald Spreadwing	VU	
LIBELLULIDAE	<i>Sympetrum sanguineum</i>	Ruddy Darter	VU	
LIBELLULIDAE	<i>Libellula quadrimaculata</i>	Four-spotted Chaser	VU	

The female of the Afrotropical River Sprite, *Pseudagrion sublacteum* (Critically Endangered). This Afrotropical species shows a continuous range south of the Sahel in Africa and two disjunct areas in Morocco and in the Levant. The latter are regarded as relicts of a former Pan African continuous distribution realized during past pluvial periods, more than 6,000 years ago. The species is very rare in Morocco and all its present localities is threatened through pollution, water overconsumption and rainfall deficit. Photo © Jean-Pierre Boudot





The male of the African Grizzled Pintail, *Acisoma panorpoides* (Endangered). This threatened species shows a string of relict localities from north-east Algeria to the Egyptian Western Desert. No recent information is available about the status of the two Libyan populations (last record in 1936), but the species is still flourishing, although very localized, in Algeria and north-western Egypt (post IUCN workshop tour, Siwa oasis, May 2009). Photo © Jean-Pierre Boudot



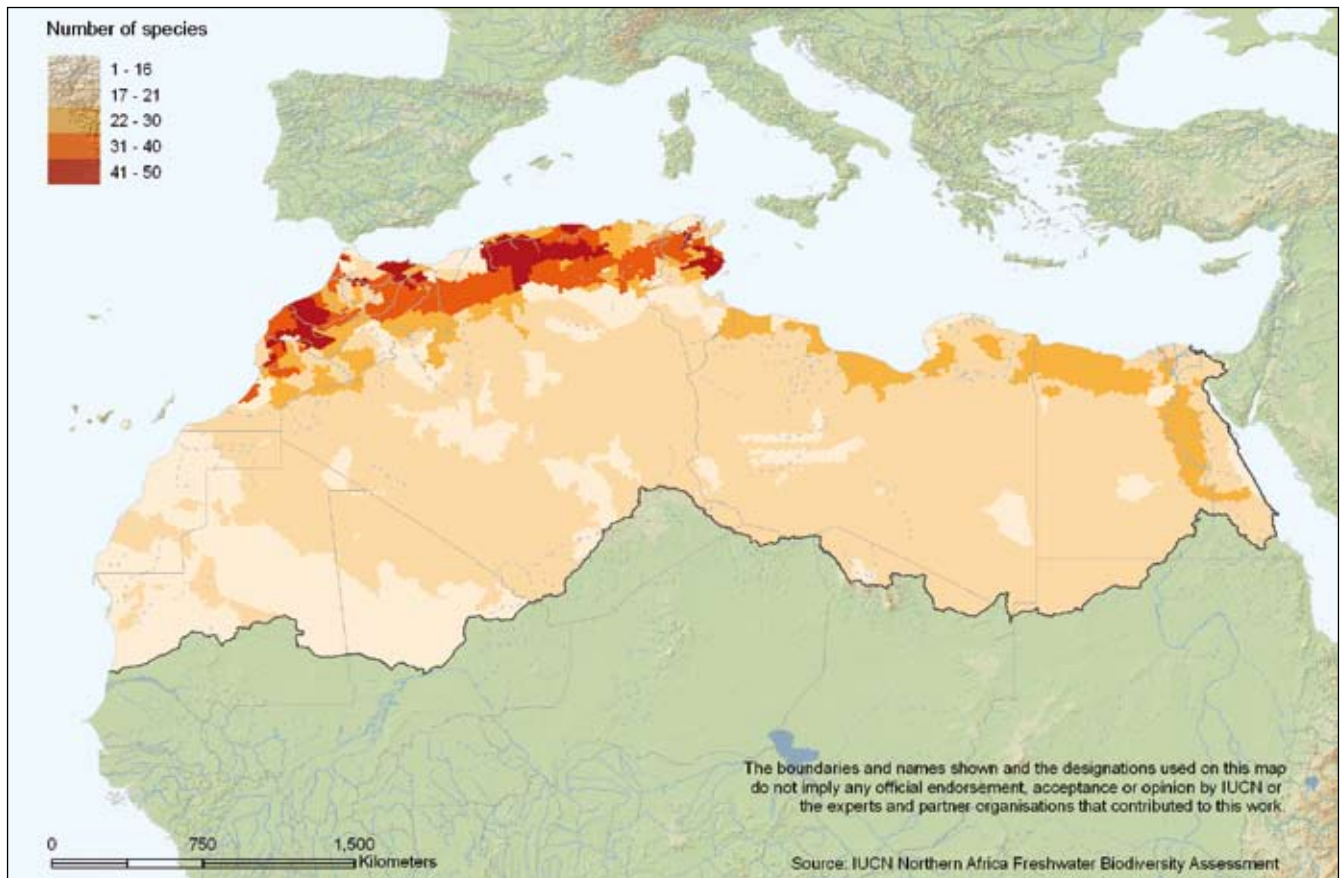
5.3 Patterns of species richness

5.3.1 All species

In the Maghreb, the high mountain range of Morocco is unique in housing a set of Holarctic (*Lestes dryas*, *Enallagma cyathigerum*, *Libellula quadrimaculata*) and Eurosiberian (*Pyrrhosoma nymphula*) species. In contrast with the Maghreb which possesses a dragonfly fauna mainly composed of Palearctic species, the Odonata of Egypt are dominated by Afrotropical species owing to the key role of the Nile River, which facilitates the crossing of the Sahara Desert.

Many Oriental species, found in Algeria and Tunisia, for the time being, have not been recorded in Morocco. This may be explained by dispersal with species having failed so far to extend their range to the west. In contrast, Moroccan species not found in Algeria are mainly Holarctic and Eurosiberian taxa confined to high altitude sites, and endemics (Figure 5.3).

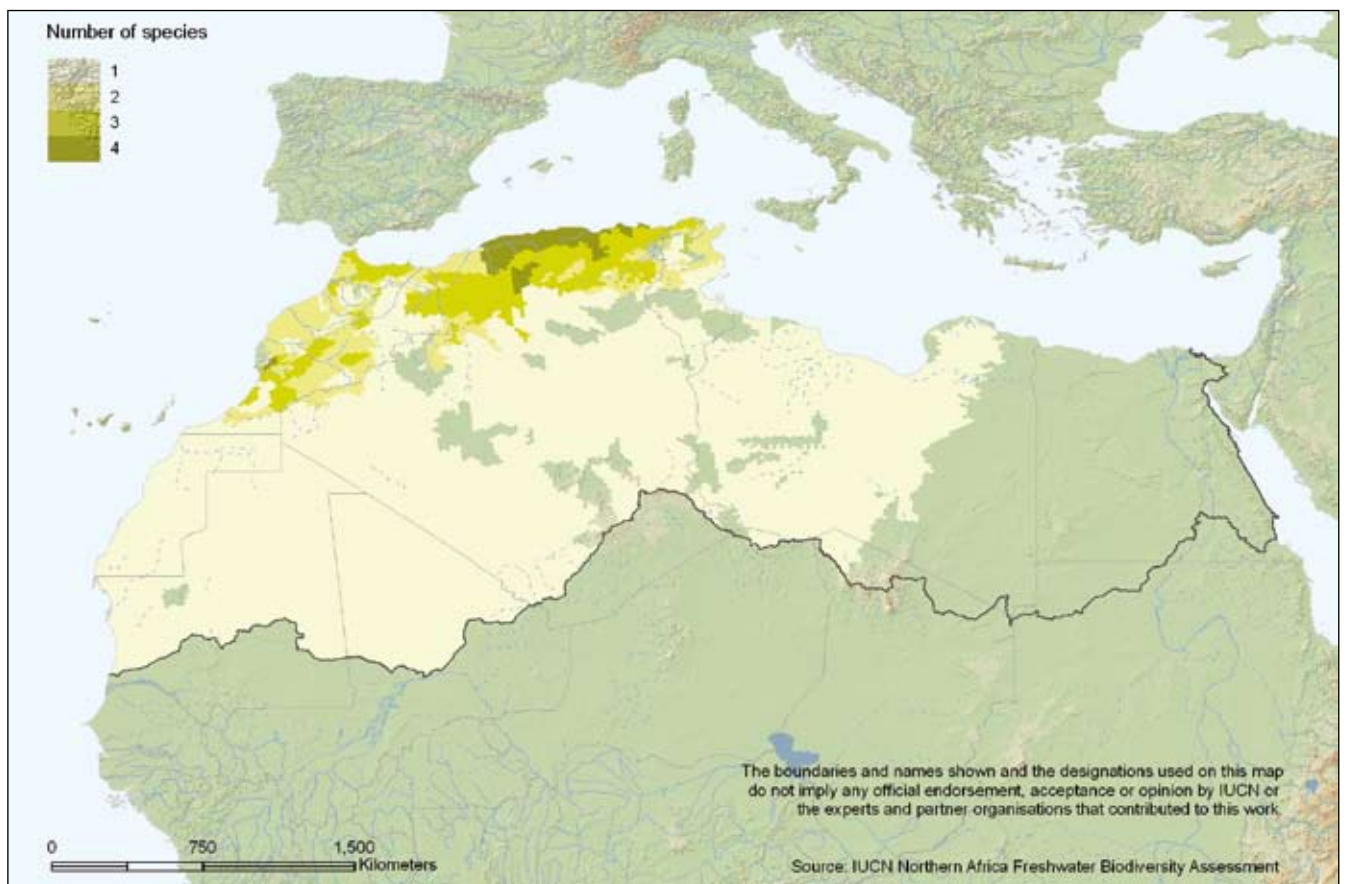
Figure 5.3 Distribution of Odonata species in the northern African region, showing the highest number of species in the northern Maghreb.



The female of the Holarctic Four-spotted Chaser, *Libellula quadrimaculata* (Vulnerable). This species is very common in Eurasia but is confined to cold waters generally in mountainous areas in northern Africa, where it is restricted to Morocco. Photo © Jean-Pierre Boudot



Figure 5.4 Distribution of endemic species of Odonata, illustrating the high degree of endemism in the northern Maghreb, particularly in Algeria.





5.3.2 Threatened species

The highest number of threatened species is in the north of the Maghreb and in the Nile Valley. Two of the Critically Endangered species (*Calopteryx virgo meridionalis* and *Lindenia tetraphylla*) are already deemed extinct in Algeria. Another Critically Endangered species, *Urothemis edwardsii*, found in a single locality in north-east Algeria, is teetering on the verge of extinction (Figure 5.5).

5.3.3 Endemic Odonata

There are 7 northern African endemic species and among these, two (*Calopteryx exul* and *Gomphus lucasii*) are assessed as threatened, one (*Cordulegaster princeps*) as Near Threatened, another (*Lestes numidicus*) is Data Deficient and 3 (*Ischnura saharensis*, *Enallagma deserti*, *Platycnemis subdilatata*) are judged as Least Concern (Tables 3 and 4). The northern Maghreb is the area which shows the highest number of these northern African endemics (Figure 5.4).

5.3.4 Extirpated species

Six species (7.3%) were first assessed as Regionally Extinct (Table 5.5). Since then, one of them (*Agriocnemis sania*) was discovered in the lower Nile valley and delta during the Cairo Pan African workshop, so that this species will have to be reassessed in the future, most likely qualifying for Endangered category. Moreover, that means that the old record of *A. exilis* in the Nile Delta, based on a defective museum specimen at a time where *A. sania* was not still described, was a misidentification and referred indeed to *A. sania*. Accordingly, only four species should be maintained as Regionally Extinct (4.9%). Two of them (*Ceriagrion glabrum* and *Phyllomacromia picta*) were recorded in the past from the Nile Valley, where new investigations are urgently needed. The two others (*Cordulia aenea* and *Rhyothemis semihyalina*) are clearly extinct in north-eastern Algeria where they were formerly known as Eurosiberian and Afrotropical relicts from the last glacial and past pluvial period, respectively).

Figure 5.5 Distribution of threatened species of Odonata in the northern African region, showing the highest number of threatened species in the North of Maghreb, followed by the Nile Valley.

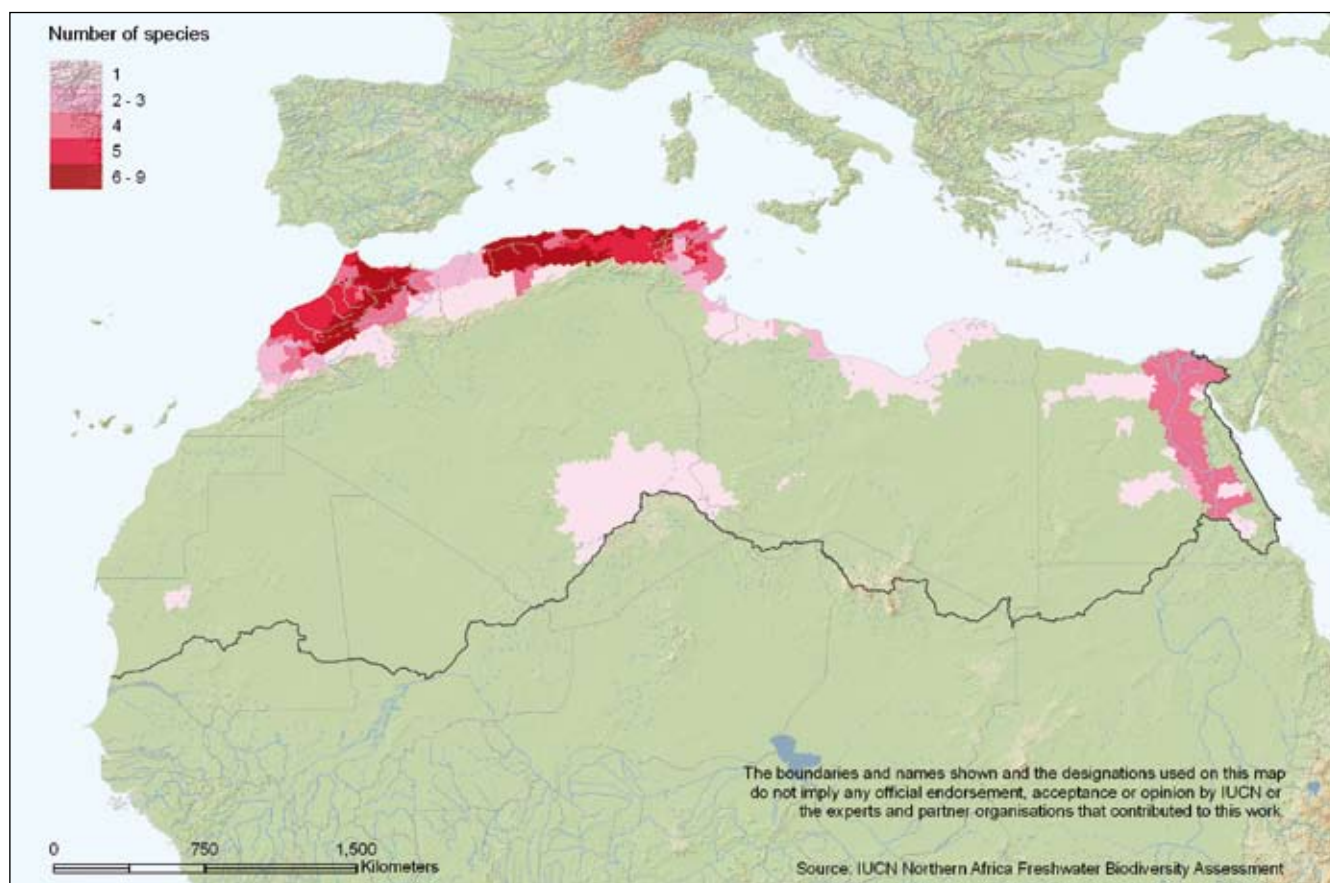




Table 5.5 Regionally Extinct Odonata species of the northern African region.

Family	Scientific name	Common name	IUCN Red List Category (northern Africa)*
COENAGRIONIDAE	<i>Agriocnemis sania</i> *	-	RE (to be reassessed)
COENAGRIONIDAE	<i>Agriocnemis exilis</i> *	Little Whisp	RE (to be reassessed)
COENAGRIONIDAE	<i>Ceriagrion glabrum</i>	Common Pond Damsel	RE
MACROMIIDAE	<i>Phyllomacromia picta</i>	Darting Cruiser	RE
CORDULIIDAE	<i>Cordulia aenea</i>	Downy Emerald	RE
LIBELLULIDAE	<i>Rhyothemis semihyalina</i>	Phantom Flutterer	RE

* *Agriocnemis sania* was just rediscovered in Africa and the old record of *A. exilis* from the Nile Delta should be turned to *A. sania* (see text).



The Common Pond-damsel, *Ceriagrion glabrum* is considered as Regionally Extinct in northern Africa. Photo © Elisa Riservato (Socotra, Yemen)



5.3.5 Data Deficient species

Five species (6.1%) were assessed as Data Deficient, namely, *Enallagma cyathigerum*, *Ischnura evansi*, *I. senegalensis*, *Lestes numidicus* and *Orthetrum ransonnetii*. *Enallagma cyathigerum* is a Eurasian species which is known from only 3 localities in the Moroccan Middle Atlas. It looks like very similar to the Maghrebian endemic *E. deserti*, and can be hardly identified in the field so may be more widespread in the Middle and High Atlas than currently believed. In any case, it is a last glacial relict in Africa and is probably absent elsewhere.

Ischnura senegalensis is a typical Afrotropical species which crosses the north of Africa thanks to the Nile valley, from where it extends to the Near-East. It is also widespread in India and Asia up to Japan. In addition, it is present in scarce remote oases and gueltas in the Egyptian Western Desert, Libyan Arab Jamahiriya and Mauritania as remnant of a former more continuous range dating from the ancient pluvial periods of the post-glacial times, 6,000-10,000 years ago. Although its distribution is well understood, population size and trend in northern Africa is poorly documented, so that the species was assessed as Data Deficient. However, a recent field trip during and after the last IUCN Pan African workshop in Cairo (May 2009) showed that this species is widespread and very common on the lower Nile river banks and delta, so that the species has to be reassessed, probably as Least Concern, in the future. The present status of the species remains unknown in Libyan Arab Jamahiriya (Kufra area) and Mauritania.

Lestes numidicus has been differentiated from other members of the *L. virens* group only in north-east Algeria. No information exists about its possible occurrence in other areas. *Ischnura evansi* is an Arabian near endemic** typical from desert, semi-desert and steppe areas from west Iran to north-west Egypt. No recent information was available at the time of the northern African assessment about its present status in Africa. However, a recent field trip after the last IUCN Pan African workshop in Cairo (May 2009), showed that this species remains widespread and common in the Siwa oases area, its main distribution centre in Africa. It will have to be reassessed, either as Near Threatened or Least Concern, in the future, depending on landscape management in this area. *Orthetrum ransonnetii* is an uncommon and poorly known Irano-Turanian species which was believed until

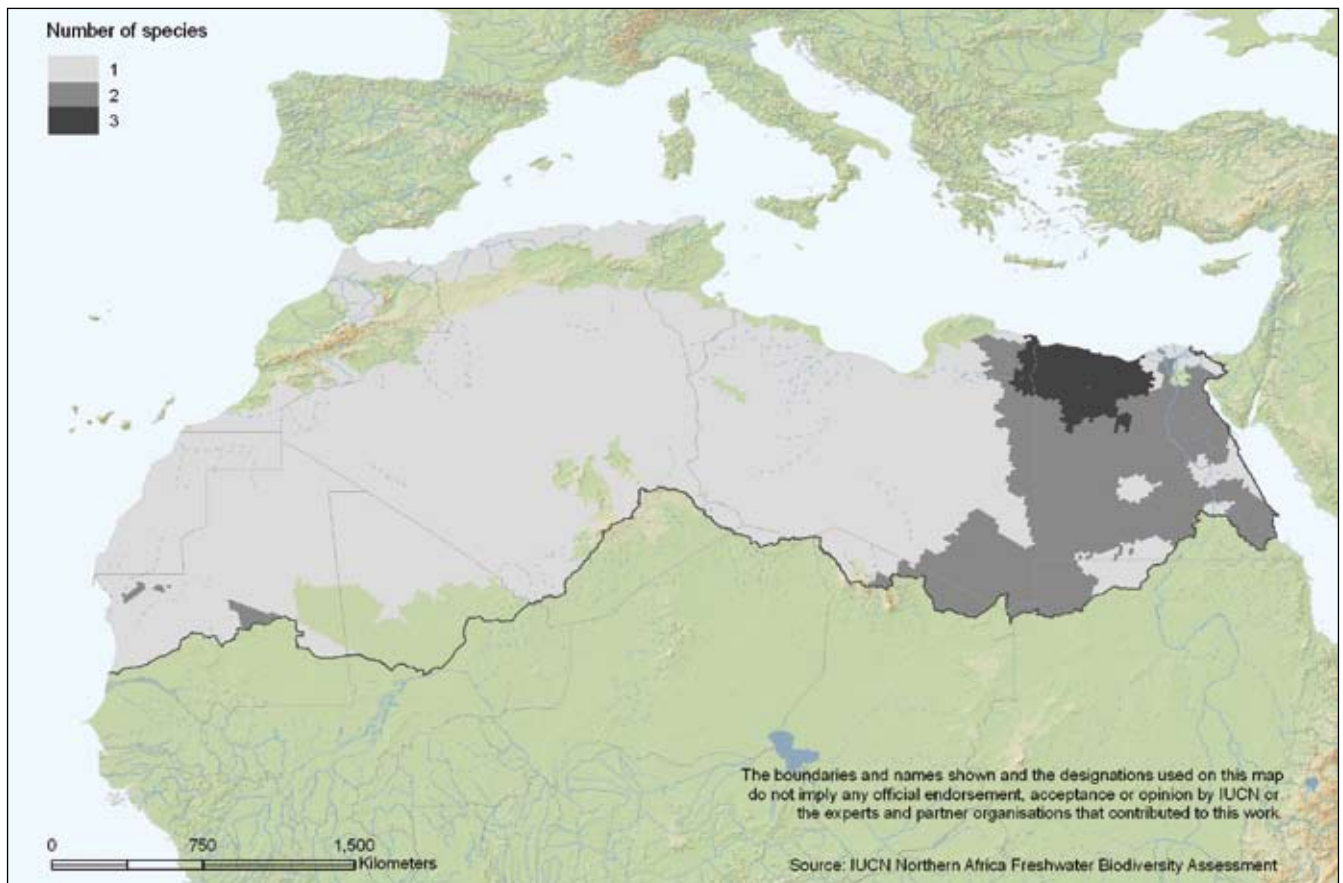
A copula of the Arabian Evans Bluetail, *Ischnura evansi* (Data Deficient). This species is restricted to the Arabian Peninsula and surrounding countries. Egyptian populations are restricted to the north-west (Siwa area) and to the Sinai. An additional African record is on the Red Sea coast in Sudan. No recent information was available during the elaboration of the African Red List, but further findings in the Siwa area shows that the species is presently flourishing in north-west Egypt (post IUCN workshop tour, may 2009). Photo: © Jean-Pierre Boudot



recently to be confined to scarce remote mountains in Central Sahara, Arabia and south-west Asia up to Afghanistan. However, it may be easily overlooked due to its global resemblance in the field with other *Orthetrum* species. Recent findings show that *O. ransonnetii* occurs also in western Morocco on the Saharan fringe (Juillerat and Monnerat 2009), in the High Atlas (J.P. Boudot, in prep.) and in western central Tunisia (B. Kunz *et al.* in prep.). Similar discoveries in Saudi Arabia (Lambret and Boudot 2009) and in the UAE (Feulner *et al.* 2007) show that this species remained largely overlooked and undocumented in the past due to its global pattern and to its localisation in poorly investigated areas with limited access. Due to significant direct human impacts on its preferred habitats (water consumption and pollution, overgrazing) and due to present climate change (rainfall deficit), it may be expected that a future reassessment will include it in a more or less threatened category (either NT or VU) (See Figure 5.6).

** *Ischnura evansi* is confined to the whole Arabian Peninsula but shows some peripheric localities close to this Peninsula border and therefore cannot be considered as strictly endemic to the northern African region

Figure 5.6 Distribution of Data Deficient dragonfly species assessed for the northern Africa region.



The male of the Eurasian Common Bluet, *Enallagma cyathigerum* (Data Deficient). This common Eurasian species is known only from three single localities in Africa (Middle Atlas, Morocco). As it can be easily misidentified as *E. deserti*, a large uncertainty remains with respect to its true distribution in the Maghreb. Photo © Jean-Pierre Boudot





A young female (left), and male (right) of the African Bluetail, *Ischnura senegalensis* (Data Deficient). This widespread African species cross the Saharan belt thanks to the Nile River. Although no recent information was available during the elaboration of the African Red List, further findings shows that the species is common along the lower Nile River and Delta (post IUCN workshop tour, May 2009). Photo © Jean-Pierre Boudot



5.4 Major threats to Odonata

Major threats to northern African species include habitat degradation, water pollution, water extraction, dam construction, exotic fish introduction and drought. Clearly, there is a need for northern Africa to establish a framework for the protection of inland surface waters (temporary ponds, freshwater and salt lakes, wadi and estuaries, ground water and coastal waters) similar to the Integrated River Basin Management (IRBM) implemented within the European countries. Global warming can be an impetus for northern African countries to take steps towards a rational management of water resources.

Coastal sand dune systems are especially species rich but they are equally vulnerable to anthropogenic pressures

like water extraction and tourism. Odonata have complex life cycles which need aquatic as well as terrestrial habitats. Both dunary slacks and alder carrs, which play a crucial part in the life history of many northern African species, are being degraded at a fast pace in Algeria and urgent protective actions are needed to avert the loss of threatened species. Intensive coast urbanisation for tourism is ongoing in Morocco, destroying coastal marshes, and similar projects exist in Tunisia. In Egypt, fish farming development in the delta is at risk of impacting coastal lakes and marsh systems which harbour restricted range species like *Agriocnemis sania*. Throughout the region, present climate change and related rainfall deficit lead to increased irrigation and river damming which results in the desiccation of streams.

Figure 5.8 Summary of the most important threats to Odonata in northern Africa.

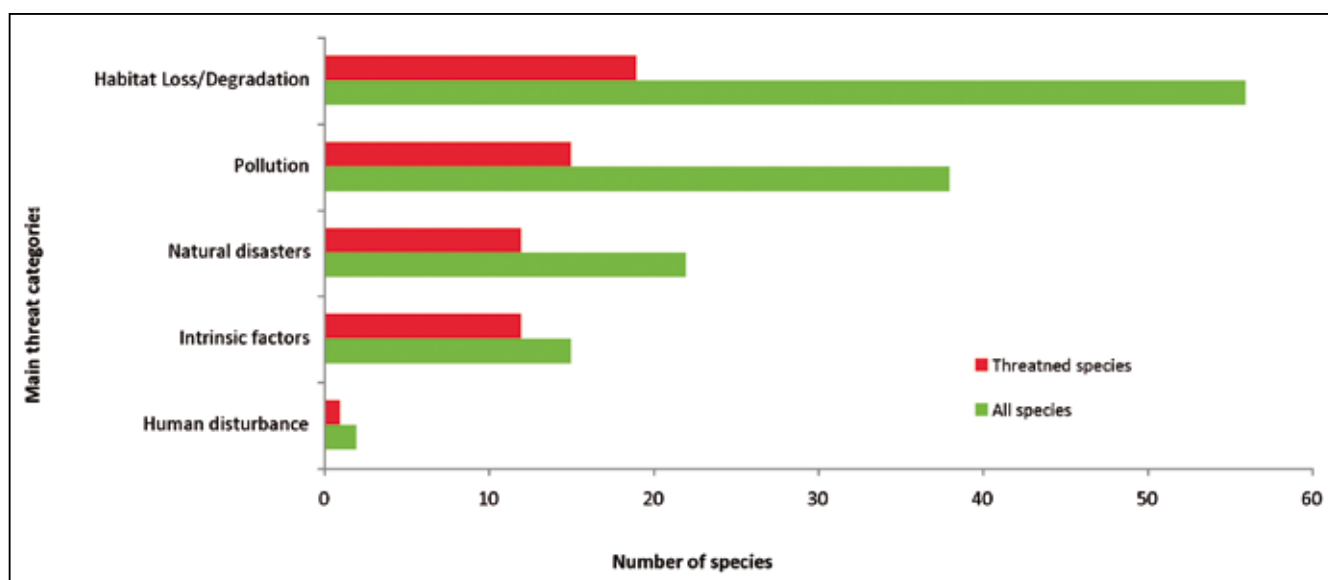


Table 5.6 Main threats and conservation status of the northern African endemic species.

Family	Species	Main threats	Red List Category
Calopterygidae	<i>Calopteryx exul</i>	Water pollution, drought, habitat degradation	EN
Lestidae	<i>Lestes numidicus</i>	Water extraction, deforestation	DD
Coenagrionidae	<i>Ischnura saharensis</i>	Drought	LC
Coenagrionidae	<i>Enallagma deserti</i>	Drought	LC
Platycnemididae	<i>Platycnemis subdilatata</i>	Water pollution	LC
Gomphidae	<i>Gomphus lucasii</i>	Water pollution, drought, habitat degradation	VU
Cordulegastridae	<i>Cordulegaster princeps</i>	Water extraction, drought, habitat degradation	NT

Gravel pitting in backwater systems destroys larval habitats. Za in Larbaa, Morocco. Photo © Jean-Pierre Boudot



5.5 Conclusions and conservation recommendations

The Odonata and their habitats are part of the world's natural heritage and this insect order encompasses, worldwide, around 6,000 species and subspecies (Grand and Boudot 2006). Although the number of species present in northern Africa represents less than 2% of the world total, the fauna encompasses 7 endemic species and shows a number of subspecies and distinct populations exhibiting a range of adaptations to local climate and habitats (Samraoui *et al.* 1998a, Samraoui and Corbet

2000b, Samraoui 2009). Their main threats and conservation status are summarized in Table 5.6.

The proportion of threatened species in northern Africa is higher (24.4%) than the 10% of the assessed so far worldwide species (Clausnitzer *et al.* 2009).

The number of threatened species is divided almost evenly among Anisoptera (11 species) and Zygoptera (9 species). There is also the same share of threatened species among running water and standing water habitats (10 species each).



The difference in the Afrotropical elements between distinct geographic areas may indicate two different ancient dispersal pathways. In Algeria, an Afrotropical relict pocket is found in the north-east in Numidia (Samraoui *et al.* 1993, Samraoui *et al.* 1998b), and to a lesser extent in Central Sahara, suggesting that Afrotropical elements were able in the past, namely during the Early Holocene Pluvial Period, 6,000 - 10,000 years ago, to move north along major watered wadi (Tafassasset and the presently fossil Igharghar) and to cross the Central Sahara. The latter acted as a water tower enabling aquatic species to move from Lake Chad to the Saharan Atlas in the north (Samraoui and Samraoui 2008). In contrast, Afrotropical elements in Morocco moved up probably along the Atlantic coast (Dumont 1982). Further in the east, in Egypt, the Nile River acted as an important highway allowing Afrotropical elements to reach the Mediterranean shores, during the ancient times but probably also more recently, after the arid period which it underwent at the end of the Neolithic and which is believed to have eliminated most of the Palearctic species that should have been in existence in Egypt since the previous pluvial period (Dumont 1980, 1982).

The conservation status of Odonata, as well as other taxa (Samraoui and Samraoui 2008), is a useful indicator for assessing the ecological status of northern African ecosystems (whether protected or not) and it can be an important tool in priority-setting tasks for action plans. This assessment is fundamentally a first step towards resource management, highlighting the importance of some areas for biological diversity and facilitating decisions about development proposals. Effective ecosystem management can ensure that biological diversity will be maintained, thus providing the foundation for sustainable development.

Raising awareness of the population is clearly insufficient in northern Africa, where current behaviour is far from conservation orientated. Overgrazing, water over-consumption, chemical pollution, eutrophication, anarchic and careless refuse abandonment, accumulation and stocking, gravel pitting in the main water beds have greatly increased during the last decades. Raising awareness from childhood is often lacking and should be established at a large scale to stop the degradation of the northern African countries. Such population education has just been initiated at Moroccan beaches in recent

Lac Tonga, a freshwater marsh within the El Kala National Park, Algeria. Photo © Boudjèma Samraoui



years but as this is not a natural trend, results remain presently low.

Within northern Africa, the Maghreb has a high level of endemism. Pressure on freshwater habitats is increasing, largely in relation to increased demography [x 2.5 in Morocco, x 3.1 in Algeria and x 2.3 in Tunisia from 1961 to 2003 (FAOSTAT 2004 - 2005)]. There is a need to develop monitoring for any biodiversity issue, as the latter is strongly impacted. The distribution and status of dragonflies are fairly well understood in both Morocco and Tunisia, thanks to various important publications. However, similar knowledge could not be accumulated in Algeria, except in the north-east, due to the local political situation. Other northern African countries, Egypt and even more Libyan Arab Jamahiriya remain poorly investigated. Most data are rather old to very old, present investigations are rare, in part due to some insecurity and/or difficulty to go freely anywhere, and any field search give rapidly important records. Local competence should be developed through appropriate relations with odonatologists from other countries in order to increase significantly the amount of information available. Accumulating data and determining trends at the middle and long term is an urgent need in these countries to preserve biodiversity. Desert and semi-desert areas south of the Drâa valley on the west, northern Chad, Niger and Mauritania produced information on Odonata only during scientific expeditions which is not open access. Monitoring is quite impossible in these countries, although this would be useful in the Saharan mountains.

To our knowledge, with the exception of Algeria, no specialist is present in northern Africa, so that no true monitoring is currently done elsewhere than in north-east Algeria. There is a need to favour an increase in local capacity in biodiversity monitoring through the network

Here you enter a protected area in the Toubkal National Park (Morocco, High Atlas). Photo © Jean-Pierre Boudot



of Universities and through relations with specialists from other countries. This will also increase contact between people working on freshwater issues in northern Africa.

A freshwater action plan for the Maghreb is highly desirable. It should include an overview of the protected areas and the evaluation of the efficiency of the protection, and both can be used to determine the main gaps in the network of freshwater protection. A species action plan for the most endangered species is needed as well, including all Critically Endangered (CR) and Endangered (EN) species. A general legislation derived from the recent European environmental laws is presently initiated in those of these countries which are trying to develop stronger economic relations with Europe. This should be accelerated and generalized in all northern African states.

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Chapter 6. The status and distribution of freshwater crabs

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6.1 Overview of the regional fauna

The northern African region from Morocco to Egypt is home to three species of freshwater crabs that belong to two genera, *Potamon* Ortmann, 1896, and *Potamonautes* MacLeay, 1837. These are assigned to two families (the Potamidae Ortmann, 1896, and Potamonautidae Bott, 1970, respectively) (Cumberlidge 1999). All of these species have recently been revised, and they now have a stable taxonomy (used here) whereby both families are included in the superfamily Potamoidea Ortmann, 1896 (Brandis *et al.* 2000, Cumberlidge 2009).

The Potamidae is the largest of all freshwater crab families, and includes 95 genera and more than 505 species distributed throughout the southern Palearctic and Oriental zoogeographical regions from Morocco as far east as Japan, and as far south as Indonesia (Cumberlidge *et al.* 2008, Yeo *et al.* 2008). The northern African representative of this family, *Potamon algeriense* Bott, 1959, from Maghreb, is included in the subfamily Potaminae Ortmann, 1896, whose members are found around the Mediterranean, the Middle East, and the Himalayas. In fact, *P. algeriense* in northern Africa represents the westernmost extension of this subfamily. *Potamon algeriense* is found in the temperate rivers of Maghreb and in seasonally arid freshwater bodies where crabs tend to be semi-terrestrial and live in burrows (Bott 1967, Brandis *et al.* 2000).

The Potamonautidae is a predominantly Afrotropical family that is represented by 18 genera and 133 species (Cumberlidge 1999, Cumberlidge *et al.* 2008, Cumberlidge *et al.* 2009). The presence of members of this family outside the Afrotropical region in northern Africa is due to the presence of two species in the Nile River that flows north from eastern Africa to the Mediterranean Sea (Palearctic region) (Bott 1955, Cumberlidge 1999). More than 70 species of *Potamonautes* are found throughout continental Africa, but only two of these are present in the northern African region in northern Egypt. These two species of *Potamonautes* are predominantly riverine in habit and do not leave the Nile River and its tributaries to forage on land (Bott 1955; Cumberlidge 1999, 2009).

The low species richness and diversity of freshwater crabs in northern Africa reported on here is probably valid because it is based on large numbers of specimen records from throughout the region that have been collected over the past 100 years. Despite this, the distribution data used here are likely to be incomplete, and further

collections are necessary to understand the actual distribution of these northern African taxa. Nevertheless, it is clear that freshwater crabs are absent from the more arid regions of the Sahara including Libyan Arab Jamahiriya, and the desert regions of Morocco, Algeria, and Egypt. It is also clear that northern Africa's freshwater crab fauna is also dramatically impoverished compared to that of western Africa (29 species, 7 genera) (Cumberlidge, 1999), eastern Africa (35 species, 3 genera) (Bott 1955; Cumberlidge 1997, 1998; Corace *et al.* 2001; Cumberlidge and Vannini 2004; Reed and Cumberlidge 2004, 2006), central Africa (24 species, 5 genera) (Bott 1955, Cumberlidge *et al.* 2002, Cumberlidge and Boyko 2000; Cumberlidge and Reed 2004), southern Africa (19 species, 1 genus) (Cumberlidge and Daniels 2008), and Madagascar (only 15 species, but 7 genera) (Cumberlidge *et al.* 2008, Cumberlidge and Meyers 2009).

The three species of northern African freshwater crabs are similar in terms of their breeding strategy (they all have direct development from egg to hatchling crabs, and they

Oued Zegzel in the Moulouya River basin in Morocco, habitat of the freshwater crab *Potamon algeriense* Photo © Jean-Pierre Boudot



all lack larval stages) but they differ in their choice of habitat within freshwater ecosystems (Cumberlidge 1999). These freshwater crabs are omnivores that mostly consume plant matter and scavenge detritus, and are found wherever year round water is present. Freshwater crabs also form an integral part of the food chain in river systems because they are vital components of the diet of a number of natural piscine, amphibian, reptilian, avian and mammalian predators (Collen *et al.* 2008, a Cumberlidge *et al.* 2009).

6.1.1 Crab Distribution and Ecoregions

Freshwater crab distribution patterns, whereby one or more species are endemic to an ecoregion, do not conform closely to the majority of the six ecoregions found in northern Africa (Thieme *et al.* 2005, Abell *et al.* 2008). *Potamon algeriense* is the only freshwater crab species that is endemic to northern Africa, and this species is found only in the northwest Mediterranean ecoregion. Both *Potamonautes niloticus* and *P. berardi* are found in the Lower Nile ecoregion but the distributional range of each of these species extends south and includes other Afrotropical ecoregions in the Nile River basin (Thieme *et al.* 2005, Abell *et al.* 2009, Cumberlidge 2009).

6.2 Conservation status (IUCN Red List Criteria: Regional Scale)

Although there is a need to collect more comprehensive information, the available data were sufficient to make valid assessments of the conservation status of most species. All three species of freshwater crabs found in northern Africa have a wide extent of occurrence, and are all found in more than one country. For example,

The freshwater crab *Potamon algeriense* is endemic to the streams and rivers of Morocco, Algeria and Tunisia. It is Least Concern and affected by human induced threats such as habitat loss and degradation linked to population growth and industrial and agrarian development. Photo © Jean-Pierre Boudot



Potamon algeriense occurs in Morocco, Algeria, and Tunisia, *Potamonautes niloticus* occurs in Egypt, Sudan, Ethiopia, Uganda, Rwanda, and Kenya, and *P. berardi* occurs in Egypt, Sudan, Ethiopia, Uganda, and Kenya (Cumberlidge 2009).

The conservation status of each of the three species of freshwater crabs found in northern Africa is summarized in Table 6.1 and 6.3 and is discussed briefly below.

6.2.1 Case Studies

1. Algerian River Crab *Potamon algeriense* (Bott, 1967) (LC)

Potamon algeriense is a medium-sized species of river crab that occurs in temperate streams and rivers of northern Africa that drain into the Mediterranean Sea. Its distribution includes three countries: Morocco (in Kenitra

Table 6.1 The number of crab species in each regional Red List Category in the northern African region (Cumberlidge *et al.* 2009).

	IUCN Red List Category	Number of Species (%)	Number of regional endemics (%)
Threatened categories	Critically Endangered (CR)	0	0
	Endangered (EN)	0	0
	Vulnerable (VU)	0	0
	Near Threatened (NT)	0	0
	Least Concern (LC)	3	1
	Data Deficient (DD)	0	0
	Total number of taxa assessed*	3	1

* Excluding species that are considered Not Applicable.

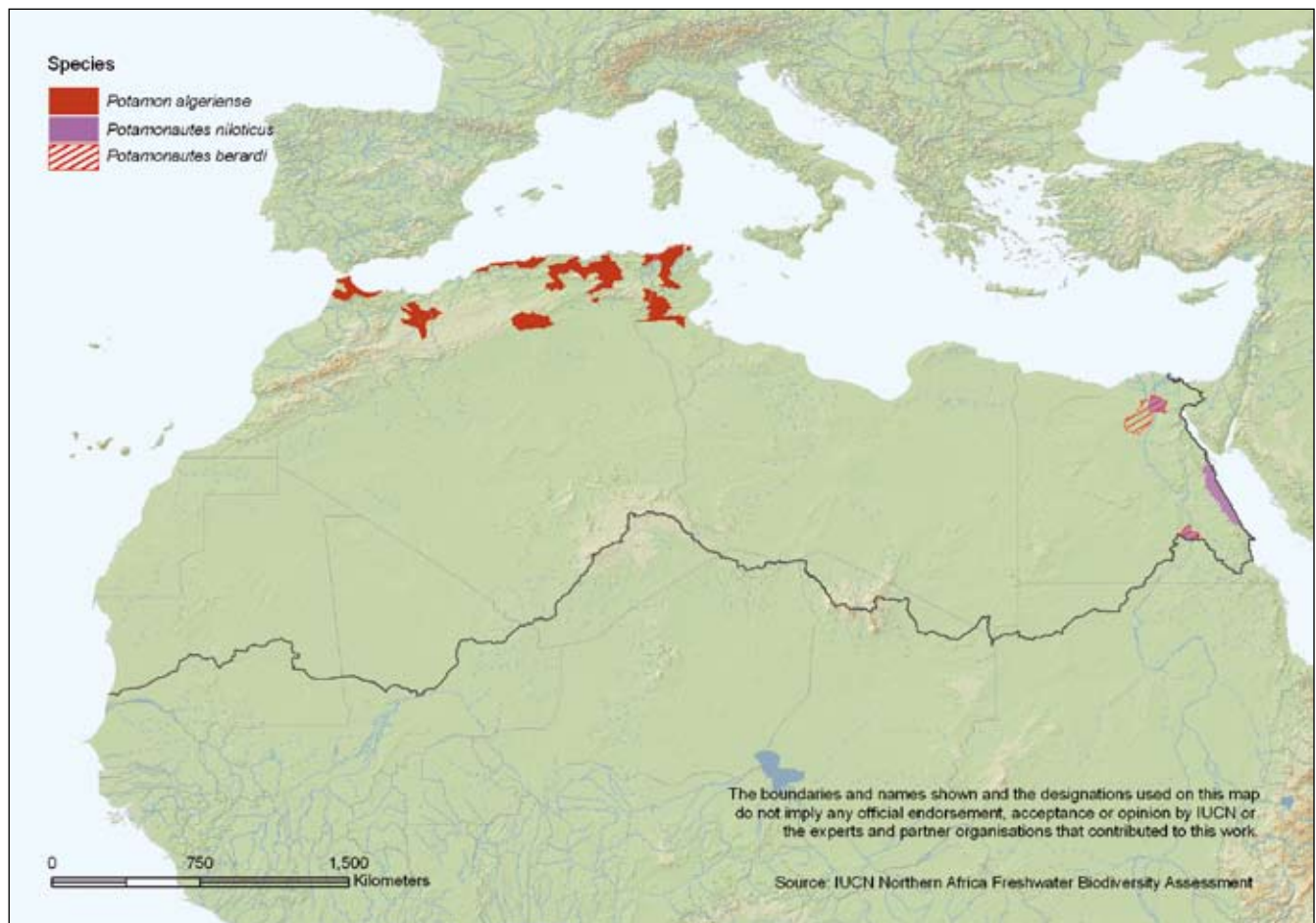


and Fes Provinces), Algeria (in Algiers, Lemdiyya, and Bejaia Provinces), and Tunisia (in Jenduba, Beja, Kairouan, and Gafsa Provinces). This species is neither found in the Libyan Arab Jamahiriya nor in Egypt (or elsewhere in the Mediterranean region) and it is endemic to the Maghreb of northern Africa (Bott 1967, Brandis *et al.* 2000). The past distributional range of this species has been uncertain because of its unstable taxonomy whereby past authors considered it to be a subspecies of the eastern Mediterranean species *P. fluviatilis* that is found in Italy and Greece (Bott 1967, Pretzmann 1976). *Potamon algeriense* was not recognized as a valid species until relatively recently (Cumberlidge 1998, Brandis *et al.* 2000). The present population levels of *P. algeriense* are estimated to be stable based on the relatively high number of localities (more than 30) in the three countries where this species is known to occur. However, despite its relatively wide distribution many of these localities are discontinuous and fragmented and there may be cause for concern for the future stability of some of its isolated subpopulations. For example, in parts of its range (such as Fez and Kenitra Provinces in Morocco) *P. algeriense* has not been seen for many years, and here it might be

threatened (or may even be in danger of extirpation). The Sebou River in Fez and Kenitra Provinces is the most polluted river in all of Morocco due to water pollution from industrial and domestic sources, and might be described as a dead river from a biological point of view. These rapid anthropogenic changes that affect habitat (such as water diversion, drainage, habitat disturbance, and pollution), are especially hard on those crab populations found near centres of human population. *Potamon algeriense* was collected in 2009 from several localities in the Moulouya catchment (by the project UICN/ABHM) where it is threatened by water diversion (as at Zegzel), water pollution (as at l'Oued Zebra), or by violent floods and mud slides (as l'oud Za). (pers. comm. from Mohammed Melhaoui, University Mohamed I, Morocco)

Despite the local extirpation of *P. algeriense* in parts of Morocco, healthy populations of this species have been found recently in a number of new localities in other regions of that country. For example, *P. algeriense* has been collected from the from Oued Zegzel (Beni Snassen) from Branche south west, Arougene, Zaoui, My Ahmed,

Figure 6.1 Distribution map of the freshwater crabs *P. bernardi*, *P. niloticus* and *P. algeriense* in the northern African region.



My Idriss, and Grotte Chameau, Tazaghine (Bas Zegzel), and from Oued Cherraa (Zegzel at Berkane). It has also been reported to occur recently in the Bassin de l'Oued Za (haut plateaux) from the southern affluents of Oued Za (Melga El Widan, Oulad Lefkir) near the confluence with the Moulouya River and its tributaries, as well as Oued Za (Guefait), Ammont Oued Za; and Oued Charef (from the spring at Ain Bni Mathar). Additional recent localities include the basin of the Moulouya River (Oued Zebra, from a small affluent of the Moulouya River, and from near Zaio (Mohammed Melhaoui pers comm.). Other records from the literature include the basin of the Oued Laou (Rif) in a small Oued near Chefchaouen, as well as from the basin of the Oued Oum Rbia (Middle Atlas), and near the road to Khénifra 4 km before El-Borj (Middle Atlas) (Aymerich 2002).

This species is also found at high altitudes in the Middle Atlas from two localities: (1) Lac Ouiouane, 68 km from Khénifra, at 1,600 m asl, and (2) near Oued Oum Rbia close to lake Bin El Widan (Middle Atlas south of Meknes)

in a region rich in water resources that includes the origins of the rivers that drain into the Mediterranean Sea and the Atlantic Ocean; this species is also present in the region of Khénifra where it has colonized small watercourses (Figure 6.1).

2. Nile River Crab *Potamonautes niloticus* (H. Milne Edwards, 1837) (LC)

Potamonautes niloticus is a large and conspicuous river crab found in the Nile River in Egypt. This species is easily recognized by a row of distinct spines along the anterior margins of its carapace. Its presence in the Lower Nile in Egypt represents the northern-most extension of the range of this species, which has a wide distribution throughout the entire length of the Nile and its tributaries and is known to occur in more than 60 localities in six countries (Egypt, Sudan, Ethiopia, Uganda, Kenya, and Rwanda). *Potamonautes niloticus* is endemic to the Nile River basin and it has never been found outside this system and has not been reported to occur in Tanzania, despite its presence in Lake Victoria (Reed and

Potamonautes niloticus is an African endemic freshwater crab found in the streams and rivers of the Nile River from Cairo in Egypt to Rwanda in East Africa. Although this species is assessed as Least Concern in northern Africa, it is possible that populations near centres of human settlements might be in the future threatened by water diversion, pollution and over-harvesting for food. Photo © Neil Cumberlidge





Cumberlidge 2006, Cumberlidge 2009) (Figure 6.1). *Potamonautes niloticus* occurs in a range of aquatic habitats including the major channels of the Nile itself and its lowland tributaries, in small and large lakes associated with the river basin, as well as in small clear fast-flowing mountain streams with rocky beds, and sluggish warm lowland streams with muddy bottoms (Bott 1955; Williams 1964; Cumberlidge 1997, 1998). This species is completely dependent on aquatic habitats and it never leaves the water whether it is found in streams, rivers, or lakes. In the southern parts of its range in Kenya and Uganda, *Potamonautes niloticus* serves as a host for the aquatic larvae of the biting blackfly, *Simulium* sp., that are the vectors of *Onchocerca volvulus*, the parasite that causes river blindness in humans (Crosskey 1990). There is no evidence that *P. niloticus* is associated with this disease in the northern part of its range in Egypt and the Sudan. *Potamonautes niloticus* is listed as Least Concern (LC) in view of its wide distribution (it is known to occur in more than 60 localities and in six countries), estimated stable population size and abundance (it supports small-scale local fisheries in Lake Victoria in Uganda and Kenya), and the lack of known widespread threats. Crab populations may nevertheless be under threat in the future from rapid anthropogenic changes affecting their habitat such as water diversion, pollution, and it could also suffer population declines from over-harvesting in Lake Victoria. Recent surveys of freshwater ecosystems in Egypt in the Nile River from Cairo to Aswan failed to find either *Potamonautes niloticus* or *P. berardi* and it is of some concern that our only records of the presence of these species in Egypt are now over 90 years old. These specimens were collected at a time before the Aswan Dam and cataracts on the Nile River, and before the human population of the country increased to its present levels with its accompanying demands for water and farmland that may both impact freshwater habitats negatively.

3. Berard's River Crab *Potamonautes berardi* (Audouin, 1826) (LC)

Potamonautes berardi is a common river crab recognized by its uniform brown colour, its small size at maturity, and the smooth margins of its anterior carapace. This species is widely distributed throughout the basin of the Nile River and its tributaries in Egypt and south along the Nile River basin in Sudan, Ethiopia, Uganda, Tanzania, and Rwanda (Williams 1976; Cumberlidge 1997, 1998). *Potamonautes berardi* is endemic to the Nile River basin and it has never been found outside this system (Cumberlidge 2009). *Potamonautes berardi* was listed as Least Concern (LC) in view of its wide distribution (it is known to occur in more than 21

Potamonautes berardi is endemic to the African continent and classified as Least Concern due to its wide distribution throughout the basin of the Nile River in Egypt, Sudan, Ethiopia, Uganda, and Tanzania. The major and future threats to this species include habitat loss and degradation due to industrial and agrarian development. Photo © Neil Cumberlidge



localities in five countries), estimated stable population size and abundance, and the lack of known widespread threats. Crab populations may nevertheless be under threat in the future from rapid anthropogenic changes affecting its habitat such as water diversion, drainage, habitat disturbance, and pollution, especially those crab populations found near centres of human population in Egypt (Figure 6.1).

6.3 Patterns of species richness

The Nile River basin in northern Egypt is where two common and widespread Afrotropical species (*P. berardi* and *P. niloticus*) come into close proximity with (but are not sympatric with) the widespread Palearctic species *Potamon potamios*, which is an eastern Mediterranean taxon whose range extends south into the Sinai Peninsula (Brandis *et al.* 2000). Because of this juxtaposition the freshwater crab species list for Egypt includes three species in two genera and two families (but none is endemic to that country), and although this list is short, it is the richest in northern Africa (Cumberlidge *et al.* 2009). However, *P. potamios* is not discussed here because the Sinai Peninsula lies outside of the northern African region as defined in the present work.

Only one of the species dealt with in the present study (*P. algeriense*) occurs exclusively in northern Africa (from Morocco to Tunisia). The other two species in northern Africa are on the northern end of a wider distributional range that extends into Egypt. The range of each of the two potamonautid species extends south along the Nile River basin into east Africa. The taxonomic diversity of northern Africa (two genera, three species) is lower than that of the Mediterranean region as a whole (two genera and 12 species), and lower than the whole of the rest of continental Africa (five genera, 120 species) and Madagascar (7 genera, 14 species). Species diversity within the northern African region clearly depends on the availability of permanent surface water and the low

Table 6.2. Number of species of freshwater crabs per country that occur in the northern African region*

Country	No. Species	Family	Species
Morocco	1	Potamidae	<i>Potamon algeriense</i>
Algeria	1	Potamidae	<i>Potamon algeriense</i>
Tunisia	1	Potamidae	<i>Potamon algeriense</i>
Egypt	2(3)	Potamonautidae	<i>Potamonautes niloticus</i> , <i>Potamonautes berardi</i> <i>Potamon potamios</i> (not discussed here)

* Northern African countries with no freshwater crabs are not displayed in this table. The number in parentheses is total number of species found in Egypt

number of species of freshwater crabs found there is typical of arid ecosystems such as those found in northern Africa. The distributional data indicate that there is a low degree of endemism in northern Africa's freshwater crab fauna at the species level (1 out of 3, 33%), but not at the genus and family levels (0 out of 2 (0%) (Cumberlidge *et al.* 2008). The majority of species (2 out of 3, 66%) occur in Egypt, only 33% of the region's species are found in Morocco, Algeria and Tunisia, whereas Libyan Arab Jamahiriya completely lacks freshwater crabs (Table 6.2).

The generally low species richness in the countries of northern Africa is not entirely unexpected because these countries include vast areas of arid land in the form of sahel and desert ecosystems. Nevertheless, it is still likely that at least some of the apparent species poverty reported on here may be due to under-sampling. For example, the lack of records of any species of freshwater crabs below the Draa River basin and Libyan Arab Jamahiriya may be real or it may equally be an artefact resulting from under-collection. Further exploration is needed throughout northern Africa where it is probable that the species-

count for the freshwater crab fauna of the region will increase as taxonomic discrimination improves and collection efforts intensify.

6.3.1 Extirpated species

No species of freshwater crab from the northern African region is known to have been extirpated and none are Extinct (EX) or Extinct in the Wild (EW).

6.4 Major threats to crabs in northern African freshwater ecosystems

Threats to crabs in northern African freshwater ecosystems include habitat destruction driven by increasing agriculture and industrial development, the alteration of fast flowing rivers for the creation of hydroelectric power, and the drainage of wetlands for farming and other uses (Collen *et al.* 2008, Cumberlidge *et al.* 2009). In addition, excessive water abstraction leaves rivers with little or no flow in the drier months, and sedimentation associated with farming activities further decreases habitat quality. Potential future threats to aquatic

Table 6.3. Summary of the Red List categories and the distribution of the species of freshwater crabs found in northern Africa. **

Species	RL Category	Range (km ²)	# Loc	PA	Zone
<i>Potamonautes niloticus</i>	LC	> 1,000,000	> 60	Y	NILE
<i>Potamonautes berardi</i>	LC	> 1,000,000	> 21	Y	NILE
<i>Potamon algeriense</i>	LC	> 500,000	> 23	N	MAGR

** Range = estimation of species distribution range based on distribution polygon of all known specimens; #Loc = Number of discontinuous localities from which the species was collected; PA = found in a protected area; Y = yes, N = no, NILE = Nile River basin, MED = Mediterranean region, MAGR= Maghreb. See text for taxonomic authorities.



communities in rivers associated with cities and towns tend to be polluted by sewage, industrial and general waste, and agricultural pesticides used by farmers may prove to be lethal to freshwater crabs once more research has been carried out. All of the above combine to increase the overall level of threat to range-restricted endemic species of freshwater crabs, and the careful management of water resources in the future will have the biggest impact on their survival.

6.5 Conservation recommendations

None of the three species of freshwater crabs from northern Africa are currently assessed as threatened, and the region's freshwater crab fauna does not appear to be in immediate trouble when compared with other assessed freshwater groups, such as fish, molluscs, and dragonflies, found in the same freshwater habitats. The three northern African freshwater crabs assessed as Least Concern have a wide distribution in the lowland rivers and wetlands of the region and so far have proved to be relatively tolerant to changes in land-use affecting freshwater ecosystems. The persistence of these more adaptable species in lowland rivers and streams that are already disturbed and visibly polluted in parts is encouraging. Loss of natural vegetation and pollution as a result of land development and agriculture is, however, likely to affect the lowland rivers, and many of the wholly aquatic species that live here could be vulnerable. Even species assessed as LC could suffer catastrophic declines should there be abrupt changes in land development, hydrology, or pesticide-use regimes. The on-going human-induced loss of habitat in many parts of the region is a primary cause for concern for the long-term survival of this fauna.

Significant areas of this region still remain insufficiently explored and new species of freshwater crabs are sure to be discovered as collection efforts in the remote areas intensify and taxonomic skills become more refined. Although taxonomic knowledge has advanced considerably in recent years and museum collections of freshwater crabs have improved, a great deal of work still needs to be done. There is a need for surveys to discover new species, refine species distributions, define specific habitat requirements, describe population levels and trends, and identify specific threats to northern Africa's important freshwater crab fauna.

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Chapter 7. Status and distribution of aquatic plants

Rhazi, L.¹ and Grillas, P.²

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7.1 Overview of the regional flora

Northern Africa is known for the richness (approximately 8,000 species), taxonomic diversity and high number of endemic species of its flora (Maire 1952-1987, Médail and Quézel 1997; Médail and Myers 2004). This richness is due to geographical position and to the history of its geology and climate. At the crossroads between the Euro-Siberian and tropical regions, northern Africa contains floristic elements of both regions (see for example Raven 1973, Quézel 1983, Quézel and Médail 1995, Médail and Myers 2004). Northern Africa is also a major contributor to the Mediterranean Basin hotspot (Mittermeier *et al.* 2004) as it contains 4 of the 11 regional biodiversity hotspots (Médail and Quézel 1997): the Moroccan High and Middle Atlas, the Betico-Rifan complex, the Cyrenaica coastal region of Libya (Médail and Quézel 1997) and the Kabylia–Numidia–Kroumiria region, stretching from the Algerian sector to the Tunisian border (Véla and Benhouhou 2007). There is a high level of specific and sub-specific endemism in northern Africa (Fennane and Ibn Tattou 1998, Neffati *et al.* 1999, Véla and Benhouhou 2007, Boulos 1995), particularly in regions of plate collision (mountain ranges and large tectonic fault lines), due to population isolation caused by barriers to dispersal, and to the climatic and geological record of the region (Quézel 1983; Pons and Quézel 1985; Médail and Quézel 1997, 1999; Blondel and Aronson 1999).

The Pond Water-Crowfoot *Ranunculus peltatus* is a species of the Ranunculaceae family that is widely distributed in northern Africa and listed as Least Concern in the region. Photo © Serge Muller



In northern Africa, there is a good representation of aquatic and wetland habitats, very diverse in their size, hydrological regime, water quality, and position within catchment. They make a significant contribution to the regional flora and constitute a refuge for unusual plant species, with the addition of Euro-Siberian elements which have persisted beyond the last glacial period, the presence of aquatic environments compensating for the aridity of the climate.

Aquatic vascular plant inventories have been undertaken within the context of habitat conservation and wetlands

Temporary pool in Mamora forest (Salé, Morocco). Photo © Patrick Grillas



Temporary stream in Ben Abid forest (Rabat, Morocco). Photo © Patrick Grillas



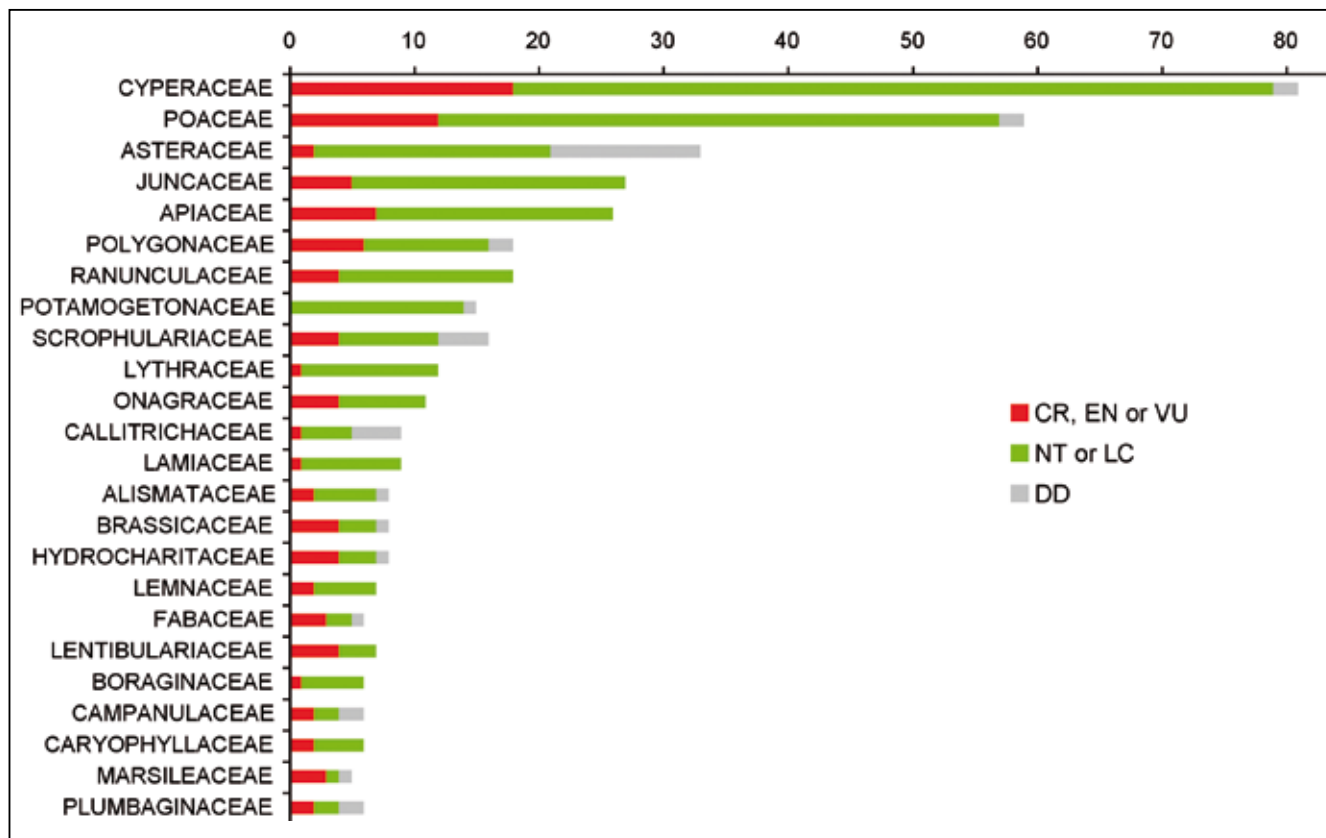
floristic biodiversity in northern Africa over the last ten years. The inventories focused on the vegetation of wetlands in Morocco (Hammada *et al.* 2002, Hammada *et al.* 2004), Tunisia (Ghrabi-Gammar *et al.* 2009) and eastern Algeria (Samraoui and de Bélair 1997, de Belair 2005). A list is available for Egypt (Boulos unpublished data), but no inventory has been done for aquatic plants in Libyan Arab Jamahiriya.

For the northern African Freshwater Biodiversity Assessment project, 645 species and sub-species of

aquatic plants (Cook 1996) have been listed in northern Africa, based on catalogues, monographs, flora from the different countries and existing publications. The list includes 31 species of macro-algae from the Characeae family. A total of 521 aquatic plants have been assessed for northern Africa, including 12 non-indigenous taxa. These plants are predominantly perennials (72%), of which 70% are hemicryptophytes-geophytes and 2% are chamaephytes-phanerophytes; 28% are annuals. The main habitats on which these species depend are temporary and permanent marshes and rivers, as well as temporary ponds and permanent lakes. These aquatic plants belong to 67 families (Table 7.1), of which the most highly represented are the Cyperaceae (84 species), the Poaceae (59), the Asteraceae (33), the Juncaceae (28) and the Apiaceae (26) (Fig. 7.1). The number of threatened species (CR, EN and VU) is significant for the Cyperaceae (18), the Poaceae (12), the Apiaceae (7) and the Polygonaceae (6) (Fig. 7.1).

Of all the taxons assessed, 14% are endemic to northern Africa (i.e., 75 species). Nearly half (45%) of the endemic species belong to 5 families: Asteraceae, Apiaceae, Plumbaginaceae, Plygonaceae and Scrophulariaceae (Table 7.1).

Figure 7.1 Number of Threatened, Non-Threatened or Data Deficient aquatic plants for each Family in the northern African region. Families with the lowest number of species where excluded from the graph for simplification





Marsh with *Salicornia herbacea* (north of Sidi Boughaba reserve, Morocco). Photo © Serge Muller



Table 7.1 Total number of aquatic species, number of threatened species and of endemics per family

Family	Number of species	Number of threatened species	Number of endemic species
CYPERACEAE	84	18	1
POACEAE	59	12	1
ASTERACEAE	33	2	12
JUNCACEAE	28	5	2
APIACEAE	26	7	8
POLYGONACEAE	18	6	5
RANUNCULACEAE	18	4	3
POTAMOGETONACEAE	16	0	0
SCROPHULARIACEAE	16	4	4
LYTHRACEAE	12	1	0
ONAGRACEAE	11	4	3
CALLITRICHACEAE	9	1	1
LAMIACEAE	9	1	1
ALISMATACEAE	8	2	0
BRASSICACEAE	8	4	3
HYDROCHARITACEAE	8	4	0
LEMNACEAE	8	2	0
FABACEAE	7	3	2
LENTIBULARIACEAE	7	4	1
BORAGINACEAE	6	1	2
CAMPANULACEAE	6	2	2
CARYOPHYLLACEAE	6	2	2
MARSILEACEAE	6	3	1
PLUMBAGINACEAE	6	2	5

Family	Number of species	Number of threatened species	Number of endemic species
PRIMULACEAE	6	1	2
TYPHACEAE	6	0	0
GENTIANACEAE	5	0	1
ORCHIDACEAE	5	2	2
CONVOLVULACEAE	4	2	1
CRASSULACEAE	4	0	1
HALORAGACEAE	4	0	0
NYMPHAEACEAE	4	3	0
RUBIACEAE	4	1	0
VERBENACEAE	4	0	0
ZANNICHELLIACEAE	4	1	0
AMARANTHACEAE	3	0	0
ELATINACEAE	3	2	0
EUPHORBIACEAE	3	1	1
ISOETACEAE	3	1	0
JUNCAGINACEAE	3	0	0
MOLLUGINACEAE	3	0	1
PTERIDACEAE	3	3	0
SALICACEAE	3	0	0
CERATOPHYLLACEAE	2	0	0
IRIDACEAE	2	1	1
MENYANTHACEAE	2	2	0
PLANTAGINACEAE	2	2	1
PORTULACACEAE	2	0	0
ROSACEAE	2	0	1
SELLAGINELLACEAE	2	0	1
VAHLIACEAE	2	0	0
ADIANTACEAE	1	0	0
BLECHNACEAE	1	1	0
BUTOMACEAE	1	1	0
CHARACEAE	1	0	0
GUTTIFERAE	1	0	1
HYACINTHACEAE	1	0	0
ILLECEBRACEAE	1	0	0
OSMUNDACEAE	1	0	0
PARNASSIACEAE	1	0	0
PODOSTEMACEAE	1	0	0
RESEDACEAE	1	1	1
RHAMNACEAE	1	1	0
SALVINIACEAE	1	0	0
SAXIFRAGACEAE	1	1	0
TRAPACEAE	1	1	0
VIOLACEAE	1	0	1
Total	521	122	75



7.2 Conservation status (IUCN Red List criteria at Regional Levels)

Out of the 509 species assessed in northern Africa (excluding the 12 introduced species classified as Not Applicable), 122 (24%) are threatened at regional level (Table 7.1): 68 species (13.4%) are Vulnerable, 27 (5.3%) are Endangered and 27 (5.3%) are Critically Endangered (Fig. 7.2; Table 7.4). Over half (65.7%) are not threatened, with 52.3% in the Least Concern category and 13.4% in the Near Threatened category (Table 7.2; Fig. 7.2).

7.2.1 Endemic species

75 species of aquatic plants assessed are endemic to northern Africa (14%). Nearly half of these endemic species (44%; 33 species) are threatened: 16 species (21%) are Vulnerable, 7 (9%) are Endangered and 10

The Critically Endangered *Pilularia minuta* is a small amphibious fern growing in Algeria, Morocco and Tunisia. Its populations are in decline in northern Africa as a result of its very small and fragmented area of distribution as well as due anthropogenic threats on its habitat, temporary pools. Photo © Serge Muller



Table 7.2 Number of aquatic plant species in each regional Red List Category in the northern African region

	IUCN Red List Category	Number of Species (%)	Number of regional endemics (%)
	Regionally Extinct (RE)	1 (0.2%)	0 (0%)
Threatened categories	Critically Endangered (CR)	27 (5.3%)	10 (13.3%)
	Endangered (EN)	27 (5.3%)	7 (9.3%)
	Vulnerable (VU)	68 (13.4%)	16 (21.3%)
	Near Threatened (NT)	68 (13.4%)	21 (28%)
	Least Concern (LC)	266 (52.3%)	12 (16%)
	Data Deficient (DD)	52 (10.2%)	9 (12%)
	Total number of taxa assessed	509 (100%)	75 (100%)

Figure 7.2 Proportion of plant species in each regional Red List Category in the northern African region

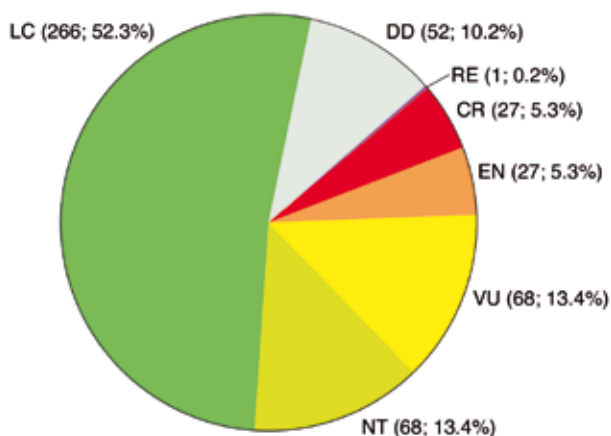
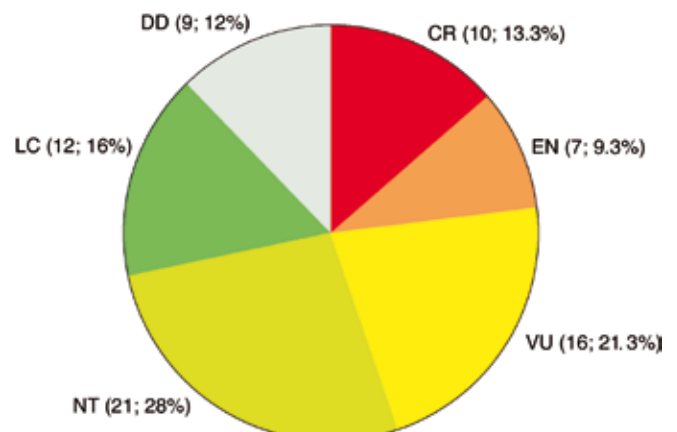


Figure 7.3 Proportion of endemic aquatic plant species in each regional Red List Category in the northern African region



(13%) are Critically Endangered (Table 7.2; Fig. 7.3). Most threatened endemics in the region occur in Morocco (29.3%; 21 species), which is characterised by a high number of strict endemics (i.e., 40 species occurring only in Morocco) (Table 7.3). The other threatened endemic species are found either in Algeria (4%; 3 species) or spanning the Moroccan-Algerian border (4%; 3 species) or the Algerian-Tunisian border (4%; 3 species) (Table 7.2).

The level of endemism in aquatic plants is much lower (14%, Table 7.1: 75/509) than that existing within the Mediterranean hotspot as a whole (52%, 11,700 out of 22,500) (Médail and Myers 2004). A lower level of endemism is expected in wetland plants because of the connectivity between sites and populations. The connectivity within river catchments is due to hydrochory, a common strategy in aquatic plants. Dispersal between river catchments by water birds is a very important process (Figuerola *et al.* 2002, Figuerola *et al.* 2005, Brochet *et al.* 2009), with millions of migrating water birds visiting wetlands of the African and Euro-Siberian continents twice a year (Berthold 1993).

The clover fern *Marsilea strigosa* grows in poorly mineralized temporary pools of Tunisia, Algeria and Morocco. It is Endangered in northern Africa, where it is facing several threats such as overgrazing, water extraction, and habitat loss due to changes in land-use related to agriculture and the construction of road infrastructures. Photo © Serge Muller



The Lesser Marshwort *Apium inundatum* is a perennial species that grows in the dayas of the siliceous mountains of Tunisia and less commonly in Morocco and Algeria. It is Vulnerable in northern Africa, and major threats are habitat loss and pollution due to agricultural development. Photo © Laila Rhazi





Waterbirds in an islet of *Typha angustifolia* in the Ramsar Site of Sidi Boughaba Reserve (Morocco). Photo © Patrick Grillas



The northern African species *Eryngium atlanticum* is Near Threatened and endemic to temporary pools on sandy substratum (dayas) of the Atlantic Moroccan region. Water pollution and extraction as a result of urban and agricultural development close to large cities are the main threats to this species. Photo © Laila Rhazi



7.2.2 Extirpated Species

One (0.2% of the total) of the aquatic species assessed, *Laurembergia tetrandra* (Haloragaceae), a tropical plant of central Africa and South America, has become extinct in the northern African region. In northern Africa, this species was only found in Algeria (in the Black Lake of the El Kala region). This lake was destroyed in 1990-1991 due to water extraction for agriculture; subsequent fires completed the destruction of the ecosystem, including the aquatic plants seed bank (de Bélair and Samraoui 1994).

Despite habitat loss in northern Africa (Blondel and Médail 2009), in particular the degradation of freshwater environments and wetlands, the extinction rate of aquatic plants remains low. It may be an under-estimate because of the lack of recent data in some regions. Moreover, the increasing pressure on freshwater resources (Nilsson *et al.* 2005) and on wetlands could rapidly increase this number, as many species are in a very precarious situation.

7.2.3 Data Deficient Species

Insufficient data was available (for example, on distribution, number of locations, and status of populations) to assess the conservation status of 52 species (10%). They were therefore assigned to the Data Deficient (DD) category. The high number of species with insufficient data underlines the current gaps in the knowledge of the

Table 7.3 Total number of strict endemic and endemic aquatic plants (i.e., occurring only in one country or shared between northern African countries) in each Red List category

	CR	EN	VU	NT	LC	DD	Number of Threatened endemic	% of Threatened endemic (CR,EN,VU)
Morocco	40	3	7	12	11	7	22	29,3
Algeria	3	3					3	4
Tunisia	1	1					1	1,3
Libya	2		1			1	1	1,3
Egypt	7					7	0	0
Morocco + Algeria	8		3	2	2	1	3	4
Algeria + Tunisia	7	3		4			3	4
Morocco + Algeria + Tunisia	5			4	1		0	0
Algeria + Tunisia + Libya	1				1		0	0
Algeria + Tunisia + Libya + Egypt	1				1		0	0
Total	75	10	7	16	21	12	33	44%

wetland vegetation and the need for further investigation. Amongst the species with insufficient data, 9 species are endemic to the northern African region and are characterised by a restricted distribution, placing them at greater risk of extinction; there are 7 species endemic to

Egypt (*Sonchus macrocarpus*, *Homognaphalium crispatum*, *Glinus runkewitzii*, *Rumex aegyptiacus*, *Persicaria obtusifolia*, *Primula boveana*, *Veronica kaiseri*), one endemic to Libyan Arab Jamahiriya (*Sedum bracteatum*) and one endemic to the Moroccan-Algerian region (*Limonium battandieri*).

Table 7.4 Threatened species of aquatic plants of the northern Africa region

Family	Species	Red List status	Endemic to the region? (northern Africa)
ASTERACEA	<i>Pulicaria flaginoides</i>	CR	Yes
CONVOLVULACEAE	<i>Convolvulus durandoi</i>	CR	Yes
CYPERACEAE	<i>Fimbristylis cioniana</i>	CR	
CYPERACEAE	<i>Schoenoplectus mucronatus</i>	CR	
CYPERACEAE	<i>Schoenoplectus triqueter</i>	CR	
ELATINACEAE	<i>Elatine alsinastrum</i>	CR	
FABACEAE	<i>Lotus benoistii</i>	CR	Yes
FABACEAE	<i>Vicia fulgens</i>	CR	Yes
HYDROCHARITACEAE	<i>Vallisneria spiralis</i>	CR	
IRIDACEAE	<i>Romulea antiatlantica</i>	CR	Yes
ISOETACEAE	<i>Isoetes setacea</i>	CR	
JUNCACEAE	<i>Juncus maroccanus</i>	CR	Yes
JUNCACEAE	<i>Juncus tingitanus</i>	CR	
LAMIACEAE	<i>Mentha cervina</i>	CR	
LENTIBULARIACEAE	<i>Utricularia minor</i>	CR	
MARSILEACEAE	<i>Marsilea minuta</i>	CR	
MARSILEACEAE	<i>Pilularia minuta</i>	CR	
MENYANTHACEAE	<i>Nymphoides peltata</i>	CR	
NYMPHAEACEAE	<i>Nymphaea caerulea</i>	CR	
NYMPHAEACEAE	<i>Nymphaea lotus</i>	CR	
ONAGRACEAE	<i>Epilobium numidicum</i>	CR	Yes
ORCHIDACEAE	<i>Serapias stenopetala</i>	CR	Yes
POACEAE	<i>Micropyropsis tuberosa</i>	CR	
POLYGONACEAE	<i>Rumex algeriensis</i>	CR	Yes
POLYGONACEAE	<i>Rumex tunetanus</i>	CR	Yes
PRIMULACEAE	<i>Lysimachia vulgaris</i>	CR	
RUBIACEAE	<i>Oldenlandia capensis</i>	CR	
APIACEAE	<i>Carum asinorum</i>	EN	Yes
BRASSICACEAE	<i>Rorippa amphibia</i>	EN	
BUTOMACEAE	<i>Butomus umbellatus</i>	EN	
CALLITRICHACEAE	<i>Callitriche mathezii</i>	EN	Yes
CONVOLVULACEAE	<i>Ipomoea sagittata</i>	EN	
CYPERACEAE	<i>Carex elata</i>	EN	
CYPERACEAE	<i>Carex laevigata</i>	EN	
CYPERACEAE	<i>Carex fissirostris</i>	EN	Yes
CYPERACEAE	<i>Carex illegitima</i>	EN	
CYPERACEAE	<i>Rhynchospora modesti-lucennoi</i>	EN	
FABACEAE	<i>Genista ancistrocarpa</i>	EN	
HYDROCHARITACEAE	<i>Hydrocharis morsus-ranae</i>	EN	
JUNCACEAE	<i>Juncus mogadorensis</i>	EN	Yes
JUNCACEAE	<i>Juncus sorrentini</i>	EN	
LENTIBULARIACEAE	<i>Pinguicula lusitanica</i>	EN	



Family	Species	Red List status	Endemic to the region? (northern Africa)
MARSILEACEAE	<i>Marsilea strigosa</i>	EN	
MENYANTHACEAE	<i>Menyanthes trifoliata</i>	EN	
ORCHIDACEAE	<i>Dactylophiza maurusia</i>	EN	Yes
POACEAE	<i>Glyceria fluitans</i>	EN	
POACEAE	<i>Leptochloa ginae</i>	EN	Yes
POACEAE	<i>Phalaris caesia</i>	EN	
POACEAE	<i>Spartina maritima</i>	EN	
PTERIDACEAE	<i>Thelypteris interrupta</i>	EN	
SCROPHULARIACEAE	<i>Bacopa monnieri</i>	EN	
SCROPHULARIACEAE	<i>Gratiola linifolia</i>	EN	
SCROPHULARIACEAE	<i>Scrophularia eriocalyx</i>	EN	Yes
TRAPACEAE	<i>Trapa natans</i>	EN	
ALISMATACEAE	<i>Baldellia repens</i>	VU	
ALISMATACEAE	<i>Damasonium polyspermum</i>	VU	
APIACEAE	<i>Apium inundatum</i>	VU	
APIACEAE	<i>Apium repens</i>	VU	
APIACEAE	<i>Carum lacuum</i>	VU	Yes
APIACEAE	<i>Eryngium corniculatum</i>	VU	
APIACEAE	<i>Eryngium variifolium</i>	VU	Yes
APIACEAE	<i>Oenanthe pimpinelloides</i>	VU	
ASTERACEAE	<i>Cirsium ducellieri</i>	VU	Yes
BLECHNACEAE	<i>Woodwardia radicans</i>	VU	
BORAGINACEAE	<i>Coldenia procumbens</i>	VU	
BRASSICACEAE	<i>Cardamine pratensis</i>	VU	Yes
BRASSICACEAE	<i>Lepidium violaceum</i>	VU	Yes
BRASSICACEAE	<i>Rorippa hayanica</i>	VU	Yes
CAMPANULACEAE	<i>Campanula alata</i>	VU	
CAMPANULACEAE	<i>Campanula mairei</i>	VU	Yes
CARYOPHYLLACEAE	<i>Spergularia doumerguei</i>	VU	Yes
CARYOPHYLLACEAE	<i>Spergularia embergeri</i>	VU	Yes
CYPERACEAE	<i>Blysmus compressus</i>	VU	
CYPERACEAE	<i>Carex acutiformis</i>	VU	
CYPERACEAE	<i>Carex maritima</i>	VU	
CYPERACEAE	<i>Carex paniculata</i>	VU	
CYPERACEAE	<i>Carex pseudocyperus</i>	VU	
CYPERACEAE	<i>Carex riparia</i>	VU	
CYPERACEAE	<i>Cyperus microbolbos</i>	VU	
CYPERACEAE	<i>Cyperus papyrus</i>	VU	
CYPERACEAE	<i>Eleocharis acicularis</i>	VU	
CYPERACEAE	<i>Mariscus hamulosus</i>	VU	
ELATINACEAE	<i>Elatine brochonii</i>	VU	
EUPHORBIACEAE	<i>Euphorbia nereidum</i>	VU	Yes
HYDROCHARITACEAE	<i>Najas horrida</i>	VU	
HYDROCHARITACEAE	<i>Najas pectinata</i>	VU	
JUNCACEAE	<i>Juncus subnodulosus</i>	VU	
LEMNACEAE	<i>Lemna trisulca</i>	VU	
LEMNACEAE	<i>Wolffia arrhiza</i>	VU	
LENTIBULARIACEAE	<i>Utricularia inflexa</i>	VU	
LENTIBULARIACEAE	<i>Pinguicula fontiqueriana</i>	VU	Yes

Family	Species	Red List status	Endemic to the region? (northern Africa)
LYTHRACEAE	<i>Lythrum baeticum</i>	VU	
NYMPHAEACEAE	<i>Nymphaea alba</i>	VU	
ONAGRACEAE	<i>Epilobium angustifolium</i>	VU	
ONAGRACEAE	<i>Epilobium atlanticum</i>	VU	
ONAGRACEAE	<i>Epilobium mirei</i>	VU	Yes
PLANTAGINACEAE	<i>Littorella uniflora</i>	VU	
PLANTAGINACEAE	<i>Plantago lacustris</i>	VU	Yes
PLUMBAGINACEAE	<i>Limonium duriaei</i>	VU	Yes
PLUMBAGINACEAE	<i>Limonium ornatum</i>	VU	Yes
POACEAE	<i>Agrostis tenerrima</i>	VU	
POACEAE	<i>Alopecurus aequalis</i>	VU	
POACEAE	<i>Catabrosa aquatica</i>	VU	
POACEAE	<i>Glyceria declinata</i>	VU	
POACEAE	<i>Molinia caerulea</i>	VU	
POACEAE	<i>Puccinellia convoluta</i>	VU	
POACEAE	<i>Puccinellia festuciformis</i>	VU	
POLYGONACEAE	<i>Persicaria bistorta</i>	VU	
POLYGONACEAE	<i>Persicaria lanigera</i>	VU	
POLYGONACEAE	<i>Polygonum amphibium</i>	VU	
POLYGONACEAE	<i>Rumex palustris</i>	VU	
PTERIDACEAE	<i>Pteris incompleta</i>	VU	
PTERIDACEAE	<i>Thelypteris palustris</i>	VU	
RANUNCULACEAE	<i>Ranunculus flammula</i>	VU	
RANUNCULACEAE	<i>Ranunculus lateriflorus</i>	VU	
RANUNCULACEAE	<i>Ranunculus penicillatus</i>	VU	
RANUNCULACEAE	<i>Ranunculus tripartitus</i>	VU	
RESEDACEAE	<i>Reseda battandieri</i>	VU	Yes
RHAMNACEAE	<i>Frangula alnus</i>	VU	
SAXIFRAGACEAE	<i>Chrysosplenium dubium</i>	VU	
SCROPHULARIACEAE	<i>Gratiola officinalis</i>	VU	
ZANNICHELLIACEAE	<i>Althenia orientalis</i>	VU	

Elatine brochonii is a small plant species whose growth is very dependant on high light levels and water availability. It is Vulnerable in northern Africa and present in Morocco and Algeria, where it is subjected to drainage, overgrazing, human disturbance for vehicles and grazing animals, and competition with woody plants. Photo © Patrick Grillas





7.3 Patterns of species richness

7.3.1 All aquatic plant species

The highest number of species is found in Morocco, with 388 species, 9 of which occur in the Saharan part of the country, and in Algeria (331). The numbers are lower in Tunisia (239), Egypt (226) and Libyan Arab Jamahiriya (133). The number of aquatic species found in the small areas of Mauritania and Sudan included in the project is very low and not significant (4 and 2 species respectively) (Table 7.5).

Table 7.4 Threatened species of aquatic plants of the northern Africa region*

Countries	Number of recorded species	%
Morocco	388	74.5 %
Algeria	331	65.0 %
Tunisia	239	47.0 %
Egypt	226	44.4 %
Libya	133	26.1 %

* Data from Mauritania and Sudan have been excluded due to lack of available information.

The spatial distribution pattern of species richness shows high species richness in the Mediterranean part of the region in Morocco, Algeria and Tunisia, in the Cyrenaica region of Libyan Arab Jamahiriya, the coastal area, and the Nile in Egypt (Fig. 7.4). The zones with very high species richness (between 78 and 196 species) are mainly the mountains and the littoral areas (Fig. 7.4): the Rif mountains, the Middle and High Atlas and the Atlantic plains of Morocco; the Oran area with the Tlemcen mountains, the mountains of Great and Little Kabylia and Numidia, the High Plateau of Constantine and the littoral plains of Algeria; the Kroumirie mountains, the Mogods, the north-east area, Cap Bon and the Medjerda valley in Tunisia; the Nile delta and the Upper Nile in Egypt (Fig. 7.4). In the southern and arid regions of these countries, close to the Sahara, species richness is low.

Aquatic plant species richness is governed by climate and biogeography. Species richness is largely dependent on rainfall and on the size of river catchments, which determine the extent of wetland habitat. These habitats are mostly found in the north of the Maghreb, where they are very varied (from lakes, rivers, and wetlands, to ponds and peat bogs), and in the Lower Nile Valley, but are rare in the Saharan zone (oases).

Temporary stream in Ben Abid forest (Rabat, Morocco) © Patrick Grillas



Figure 7.4 Distribution map of species richness for aquatic plants of the northern African region

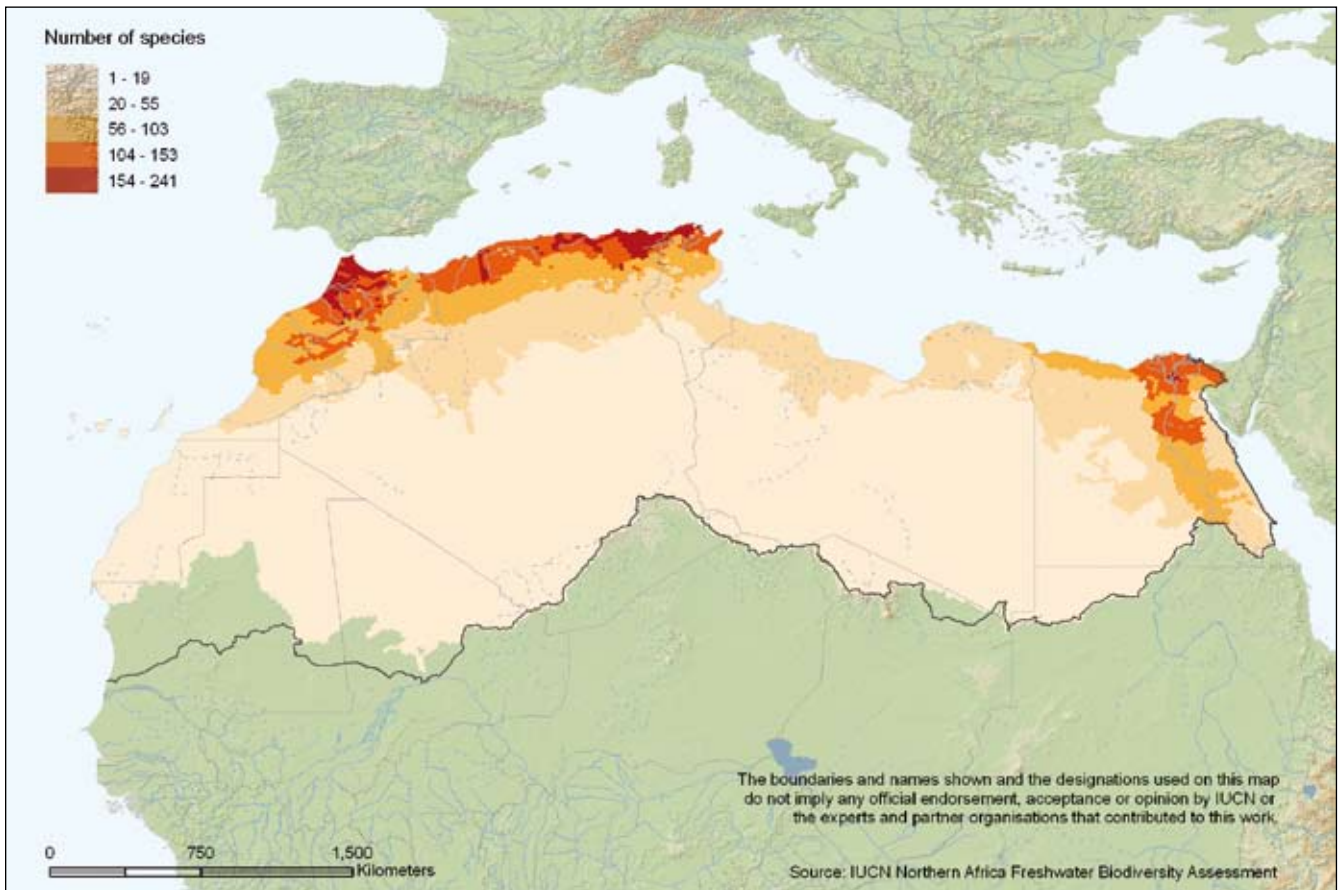
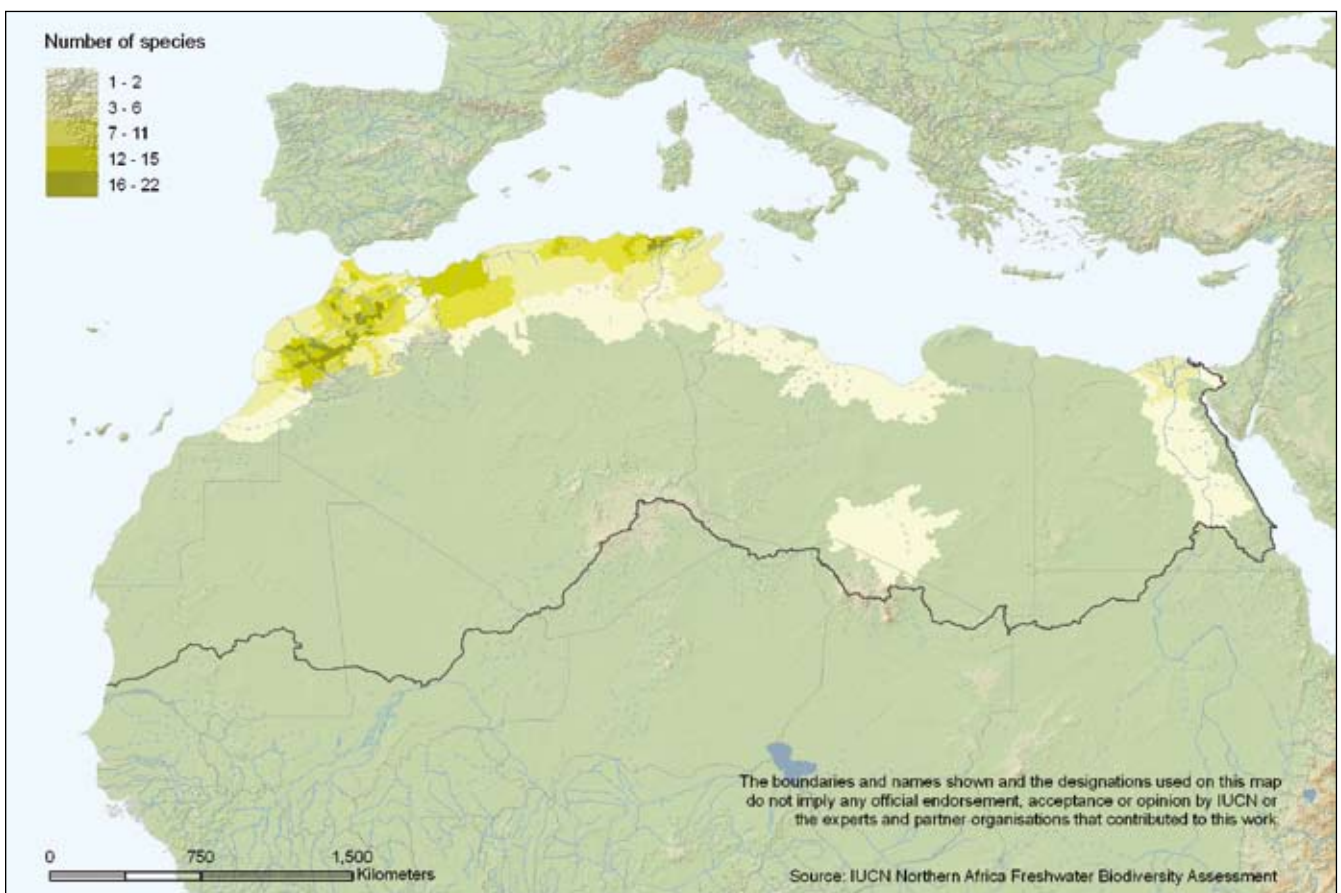


Figure 7.5 Distribution map of endemic species richness for aquatic plants of the northern African region





7.3.2 Endemic species

Endemic aquatic species (75) are found mainly in the Mediterranean part of the Maghreb, where their richness and abundance correspond well with the “biodiversity hotspots” (Verlaque *et al.* 1997, Médail and Quézel 1997, Vêla and Benhouhou 2007). They are concentrated in Morocco (Atlas range, Rif range), western Algeria and an area containing Tunisia and eastern Algeria (Kabylia–Numidia–Kroumiria). It seems there are no aquatic endemic species in the Libyan biodiversity hotspot (Cyrenaica). To the east and south of the study area, the number of endemic aquatic plants is very low (Fig. 7.5). Endemic aquatic plants are mostly confined to the high mountains of Morocco and Algeria (such as Jbel Toubkal, over 4,000 m high), which are absent from other northern African countries (Tunisia, Libyan Arab Jamahiriya, Egypt, Mauritania and Sudan). They have been found, but to a lesser extent, in the littoral plains with higher rainfall and in the Nile Delta.

7.3.3 Threatened species

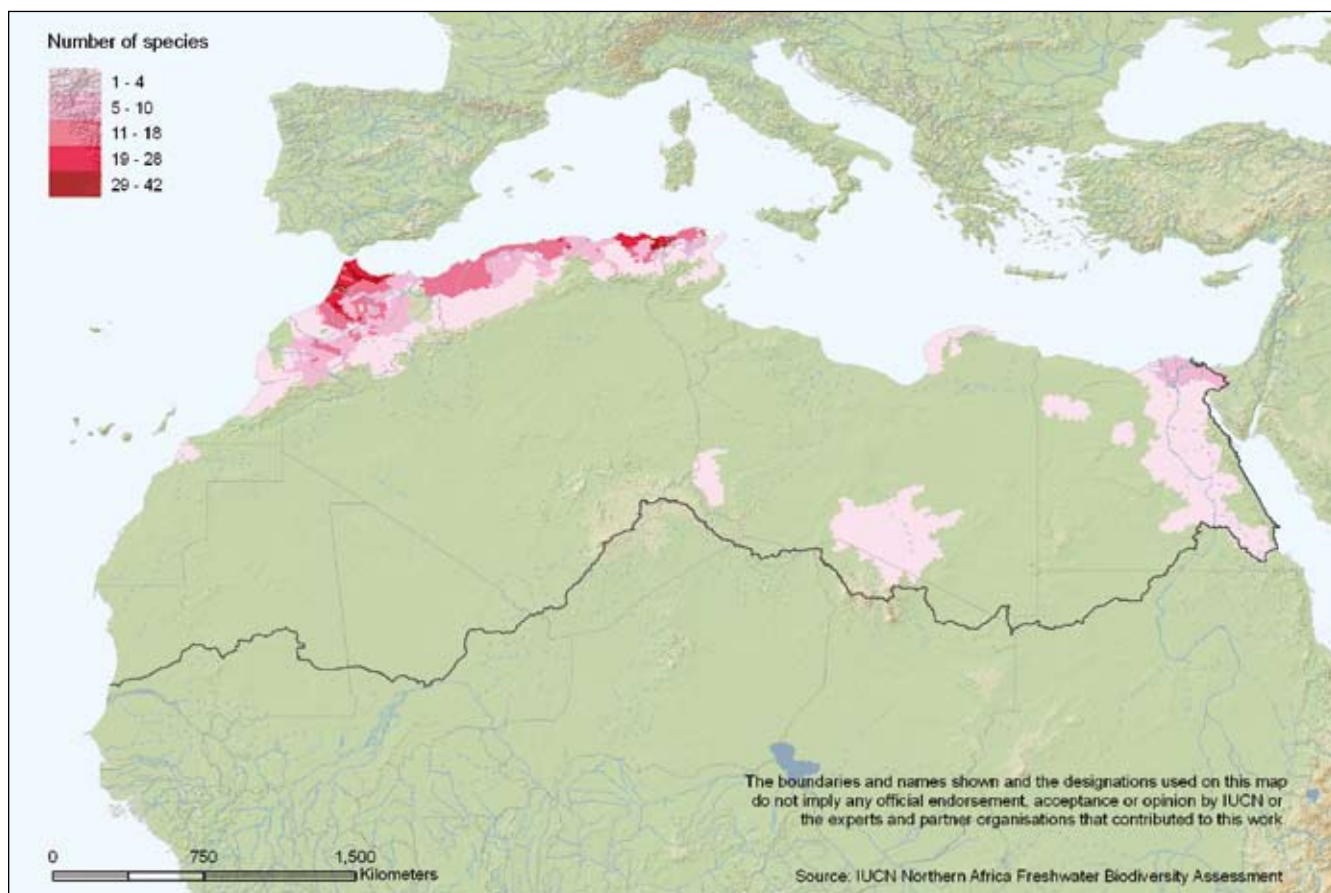
The most threatened aquatic species are found in the Mediterranean and Atlantic coastal zones, from north Morocco to Kroumiria. The level of threat is particularly

high in the north of Morocco (coastal plain and Rif) and to the east of the Maghreb. A dominant feature of these areas is the presence of temporary ponds, marshes, streams and lakes, all home to many threatened species, including a fairly high proportion of endemics (Fig. 7.6). In these areas, the major threats to aquatic plants are directly linked to land use (drainage of wetlands for agriculture,

Oldenlandia capensis is Critically Endangered in northern Africa, where it is present in Morocco and Algeria. It is under high risk of extinction due to the small size and number of its populations, which are severely fragmented and facing threats such as heavy trampling by people and cattle grazing as well as water pollution among others. Photo © Serge Muller



Figure 7.6 Distribution map of threatened species richness for aquatic plants of the northern African region



deforestation of river catchments, coastal urbanisation) and with the exploitation of water resources for agriculture.

7.3.4 Regional biodiversity hotspots for aquatic plants

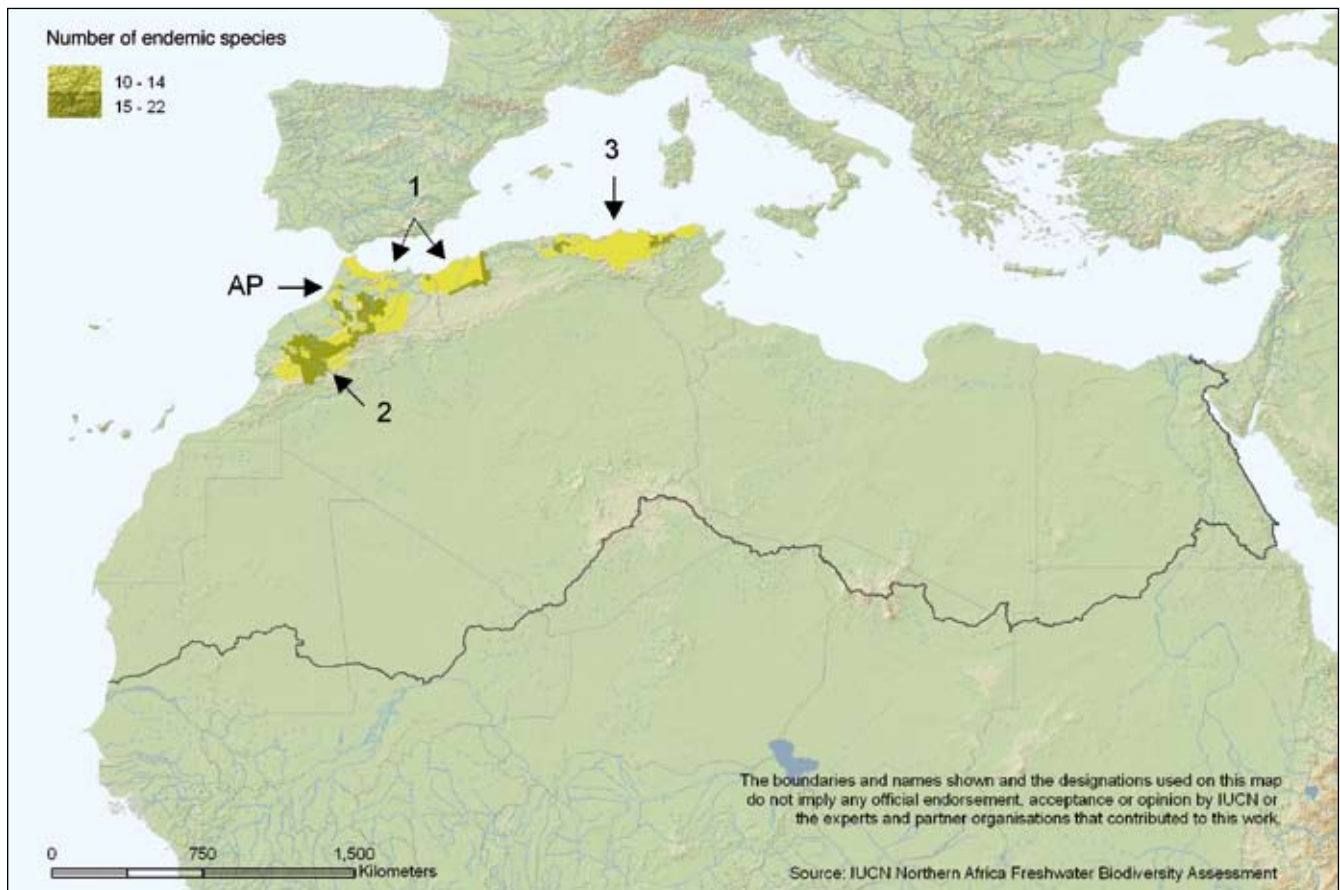
There are three identifiable aquatic biodiversity hotspots in northern Africa (Fig. 7.7), established on the basis of total aquatic plant species richness (Fig. 7.4) as well as endemic species richness (Fig. 7.5). These hotspots correspond to zones with high aquatic (>104) and endemic (>10) species richness; they should be prioritised in relation to regional biodiversity conservation. They are:

1. The Betico-Rifan arc, stretching across northern Morocco and western Algeria. It comprises the southern part of the Rif, the mountains of the Oriental region of Morocco and the Oran area with the Tlemcen mountains in Algeria;

2. The Middle Atlas and High Atlas mountains;
3. The Kabylia–Numidia–Kroumiria complex, which is vast and stretches from the Algerian sector (Mitidja) to the Kroumiria region in Tunisia.

These aquatic plant biodiversity hotspots correspond, on the whole, to those identified in this region by Médail and Quézel 1997 and Véla and Benhouhou 2007 for the whole vegetation. The difference lies in the absence of the hotspot in Mediterranean Cyrenaica (Libyan Arab Jamahiriya) (Médail and Quézel 1997), which is due to the low representation of wetlands in this region. There is a small area of endemic species richness in the Atlantic plains of Morocco (Fig. 7.7; AP), but this does not represent a biodiversity hotspot. This richness may be due to the abundance and diversity of wetlands in this region, particularly temporary ponds and species-rich marshes, and probably to populations spreading from the two neighbouring hotspots (the Atlas and the Rif).

Figure 7.7 Map of the three regional biodiversity hotspots for endemic aquatic plants in northern Africa. (1) the Betico-Rifan arc; (2) Middle and High Atlas; (3) Kabylia–Numidia–Kroumiria (AP: Atlantic plains of northern Morocco); this map has been obtained by combining the zones where aquatic species richness is greater than 104, of which 10 at least are endemic to northern Africa.





7.4 Major threats to aquatic plants of northern Africa

7.4.1 Major threats

Aquatic plants in the northern African region are threatened mainly by habitat loss and degradation, and more generally by the direct and indirect impact of human activities (Blondel and Aronson 1995). Species intrinsic factors, such as restricted distribution, low dispersal rate and low recruitment rate, are main factors in the conservation of aquatic plants. Similarly, natural disasters constitute a relevant threat (Fig. 7.8).

7.4.2 Specific threats to aquatic plants in northern Africa

Habitat loss and degradation

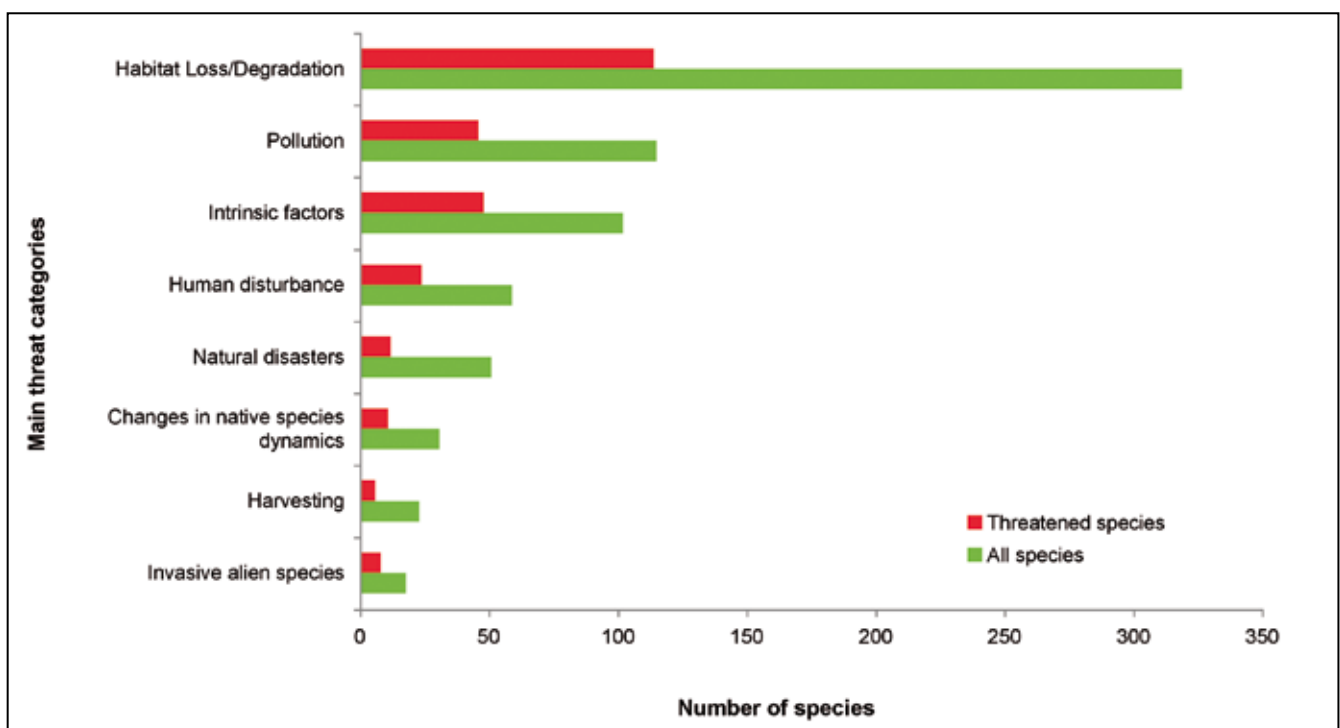
The main threat for 95% of the aquatic plants which have been assessed as threatened (CR, EN, VU) in the region is habitat loss and degradation, due to underground water extraction, pumping surface waters directly into wetlands, agricultural development and intensification, and infrastructure development. In northern Africa, anthropogenic pressure on freshwater resources and wetlands is high (Plan Bleu 2009), mainly due to population growth and the littoralisation of the population. Mediterranean rivers are among the most

engineered in the world (Nilsson *et al.* 2005), the demands made on freshwater resources in northern Africa are very high (Plan Bleu 2009, Halls *et al.* 2006), and the pressure is increasing (Plan Bleu Outlook 2025). As a result, there is a marked decrease in water resources available for wetlands and fluvial ecosystems. Agricultural water requirements play a large part in the pressure on water resources, using over 80% of the total share (Plan Bleu 2009). The overexploitation of underground and surface waters is the main threat to many aquatic plants assessed as threatened in the region. Excessive extraction (from the Black Lake in Algeria) was the main cause for the extinction at regional level of *Laurembergia tetrandra* (Haloragaceae). Water and soil pollution by pesticides

Filling of a temporary pool by building rubble in the area of Benslimane (Maroc). Photo © Laila Rhazi



Figure 7.8 Main threats to aquatic plants in the northern African region



and fertilisers is one of the main threats to some 52% of the species assessed as threatened in the region.

Aquatic habitats are also under heavy pressure from agricultural improvement, urbanisation (Morocco, Algeria and Tunisia, for example) and infrastructure development (roads, motorways, and tourism). These threats are causing the irreversible loss and degradation of aquatic habitats. Approximately 28% of the wetlands in Tunisia have disappeared during the past 100 years (Hughes *et al.* 1990); and some sites, such as Lake Burullus in Egypt, have greatly decreased in surface area (Meininger 1990).

Human disturbance

Leisure activities and tourism are the main forms of human disturbance, placing 39% of species assessed as threatened in the region at risk. The aquatic habitats most at risk from these activities are those found in coastal zones and mountains, where people enjoy going fishing, hunting and camping. Examples of this are two endemic orchid species (*Dactylorhiza maurusia*: EN; *Serapias stenopetala*: CR), which are commonly picked by people, and two species at the limit of their range in Morocco, threatened by the high level of tourist activity around Tangier (*Gratiola linifolia*: EN; *Littorella uniflora*: VU).

Intrinsic factors

Intrinsic factors of the population are considered a threat for many species (102, of which 48 have been assessed as threatened). These factors increase the risk of extinction. For example, some species are particularly vulnerable to stochastic extinction because their distribution is limited to a very small number of sites. They are, for example, endemics (*Lotus Benoistii*: CR; *Romulea antiatlantica*: CR; *Juncus maroccanus*: CR; *Plantago lacustris*: VU; *Epilobium numidicum*: CR; *Pulicaria filaginoides*: CR) and species at the limit of their range (*Juncus tingitanus*: CR ; *Isoetes setacea*: CR ; *Marsilea minuta*: CR), a low dispersal rate (*Nymphaea lotus*: CR), a low recruitment rate (*Serapias stenopetala*: CR ; *Genista ancistrocarpa*: EN) and large population fluctuations, are posing a threat to 48% of the species assessed as threatened in the region.

Natural disasters and climate change

Twelve species assessed as threatened in the region, including three endemics, *Epilobium numidicum* (CR), *Pulicaria filaginoides* (CR), *Scrophularia eriocalyx* (EN), are at risk from drought. It is likely that the increase in intensity and frequency of droughts is due to climate change. According to Plan Bleu 2009, northern Africa is the Mediterranean area the most vulnerable to the effects of climate change because of the decrease in rainfall and

Water extraction through pumping in one temporary pool in Benslimane cork oak forest (Morocco) . Photo © Laila Rhazi





The roots, stems, seed and leaves of *Phragmites australis* (Least Concern) have been used for human consumption, as well as for thatching roofs and for its medicinal properties. Photo © Faouzi Maamouri

The Water fern *Azolla filiculoides* is an invasive species, native to the American continent, affecting aquatic plant species of the northern African region. Photo © Patrick Grillas



increase in desertification. This is critical in the case of aquatic habitats and rare and endemic species populations. Annual species found in seasonal wetland habitats show resilience to drought because their persistent seedbanks can cushion its effects. But the impact of worsening droughts is not yet known. Perennial species of Euro-Siberian origin and “glacial relics” are particularly at risk from climate change; this is the case for *Nymphaea alba* (very rare in Morocco, Algeria and Tunisia) and *Menyanthes trifoliata* (only found in the peat bogs of the Rif mountains in Morocco).

Only one endemic species in Morocco, *Pinguicula fontiqueriana* (VU), which is found in very small populations, is threatened by frequent landslides in the Atlas Mountains.

Changes in vegetation dynamics of native species

Approximately 10% of aquatic species are threatened by the vegetation dynamics of other native species which, given certain ecological conditions, invade the area and become more competitive, thus preventing other species from growing. For example *Isoetes setacea* (CR), *Elatine brochonii* (VU), *Pilularia minuta* (CR), *Littorella uniflora* (VU), found in the regions temporary ponds, are being threatened by the spread of the helophytic *Bolboshoenus maritimus* and *Inula viscosa* (Grillas *et al.* 2004, Rhazi *et al.* 2009).

Trade

The trade in aquatic plants is not a major threat. Most of the species collected in the field are common perennials (LC) generally used for craft (*Juncus maritimus*, *Juncus acutus*, *Phragmites australis*, *Typha latifolia*) and decoration (*Ceratophyllum demersum* is used for aquariums). A few

species assessed as threatened at regional level are used locally for food (*Butomus umbellatus*: EN), for medicinal purposes (*Gratiola officinalis*: VU; *Persicaria bistorta*: VU; *Mentha cervina*: CR; *Bacopa monnieri*: EN), or for cultural reasons (*Trapa natans*: EN; *Genista ancistrocarpa*: EN).

Invasive species

Invasive exotic plant species are also a threat to aquatic plants. One Critically Endangered species, *Utricularia minor*, and three vulnerable species (*Najas horrida*, *Najas pectinata* and *Utricularia inflexa*) are threatened by invasive species (*Azolla filiculoides*; *Salvinia natans*). This is particularly noticeable in Egypt, where many invasive species from tropical countries in Africa enter via the Nile.

7.5 Recommendations for conservation

Wetland conservation is crucial to the long-term conservation of aquatic plants in northern Africa. Wetland conservation must address sustainable development, notably by the integrated management of habitats and natural resources, combining the rational use of resources, particularly water, with the preservation of wetland ecosystem services, and biodiversity. This can be achieved by each country applying its own existing legislation in order to reduce habitat loss (legislation on impact assessments and coastal legislation for example) and by strengthening existing protection measures (including increasing protected areas and the creation of micro-reserves). It also requires a better acknowledgment of the importance of wetlands, their ecosystem services and their biodiversity. This objective can only be achieved if the public and the decision-makers are aware of the issues. Identifying priorities also gives conservation more weight in negotiating with the main players in development.

Conservation should focus on the hotspots identified for their species-richness and levels of endemism, where the designation of Important Plant Areas (IPAs) can provide a basis for their management. Beyond the hotspots focusing on endemic species and species richness, all wetlands need better conservation to help maintain their function within the landscape.

The level of knowledge about northern African wetlands is currently insufficient to ensure their conservation. The gaps are numerous, and revision of data on taxonomy, species distribution and population status of plant species, particularly in Libyan Arab Jamahiriya and Algeria, but also more generally for the whole region is required. Further understanding of the links between ecosystem function and species demography is also necessary in order to obtain useful data for the rational management of habitats and species. To achieve this, research needs to be taken seriously; this requires decision makers responsible for development in relevant countries to understand its importance and the international community to support the increase in research capacity in many countries.

7.6 Conclusions

This assessment of the status of aquatic plants in northern Africa according to the IUCN Red List criteria is the first step towards their conservation. The main conclusions are:

- 24% (i.e., 122 species) of the aquatic flora in the region are under threat. This is an indicator of the condition of wetlands in the region.
- The level of endemism is 14% (75 species), and 44% of those (33) are threatened at regional level; their Red List conservation status corresponds to their extinction risk at global level because of the lack of geographical continuity beyond the region.
- There is a lack of information for 10% of the aquatic flora, 12 % of which consists of species endemic to the region. This highlights the need for more field investigations. Setting up a northern African observatory for aquatic plants would facilitate information sharing (species distribution, population

Centre for Environmental Education in the Sidi Boughaba (Morocco). Photo © Patrick Grillas





status, and threats) and remedy the information gaps. This applies particularly to Libyan Arab Jamahiriya and Egypt where none of the nine endemics recorded have been surveyed. Without surveys it is not possible to forecast the future decline or extinction of species and make adjustments to their conservation status.

- Habitat loss and degradation is the main threat for 95% of the aquatic species in the region. Yet the extinctions recorded remain low (0.2%); only one species has become extinct in the region, *Laurembergia tetrandra* (Haloragaceae). This is due to the resilience of aquatic plants to perturbation, and increases the chances of success of species restoration programmes in degraded habitats. Intensifying global changes may cause a rapid increase in threats to aquatic plants, due as much to climate change as to direct anthropogenic pressure.
- All the biodiversity hotspots for aquatic plants of northern Africa are found in Morocco, Algeria and the extreme north-west of Tunisia. It is therefore

critical that local and regional decision-makers and international bodies all work closely together for the successful conservation of the biodiversity of aquatic habitats.

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The Sidi Bou Ghaba Reserve is one of the 24 Ramsar sites of Morocco. Photo © Patrick Grillas



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Chapter 8. Regional synthesis for all data

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This chapter is a synthetic analysis of the regional assessments of the entire set of freshwater species evaluated - freshwater fish, molluscs, crabs, dragonflies and selected aquatic plants. The objective of presenting these results is to provide updated knowledge on the status of the freshwater biome at the regional level. Dissemination of this information to decision makers, resource managers and scientists will allow them to better understand the status of biodiversity in their region. It should be taken into consideration in environmental conservation and development planning for wetland ecosystems at regional, national and site levels in the future.

8.1 Patterns of species richness

Out of the 896 taxa considered in the region, 19 were not assessed because they are introduced or wandering species. Among the 877 remaining species and subspecies that were evaluated, 247 (28%) are categorized as threatened with extinction, out of which 61 (7%) are Critically Endangered (CR), 72 (8%) are Endangered (EN) and

114 (13%) are Vulnerable (VU). Of the total number of taxa assessed, 9% is Near Threatened (NT), while 42% is Least Concern (LC) (Table 8.1). A relatively high percentage of species (14%) are classified as Data Deficient (DD), which means that due to insufficient available knowledge on these species, they were not assigned to any of the Red List Categories. These species might qualify for a threatened category when more data become available and few of them, especially among the molluscs, are thought to be already extinct in the region.

At the level of the northern African freshwater biome, 45% of the regional freshwater molluscs, 27% of the freshwater fishes, 24% of the dragonflies and 24% of the aquatic plants are under risk of extinction (See Table 8.1 and chapters 3 to 7 for more information about each taxonomic group).

The number of Extinct and Regionally Extinct species should be noted, the taxonomic groups most affected by regional extinction are the freshwater molluscs, fish and

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plants. In total, 18 (2%) of the species which are native to northern Africa are already extinct at the global level, and 32 (around 4%) are no longer present at the regional scale. If these data are compared to similar evaluations in eastern Africa (Darwall *et al.* 2005), where less than 1% of the freshwater species were found to be extinct, or in the case of southern Africa (Darwall *et al.* 2008) where no extinction was recorded; northern Africa is the region with the highest known rate of extinction of freshwater species in the continent. These results are directly related to the high concentration of human activities in the area (and to the lack of adequate management) as well as to the limited dispersal capacity of some freshwater groups such as the molluscs, which are often restricted to a single catchment or lake. In addition, an important number of Regionally Extinct freshwater fish have areas of distribution restricted to the Nile River, and are therefore threatened by the changes in the hydrological regime associated with the construction of the Aswan Dam in Egypt. Future studies may demonstrate that the freshwater crab species *P. niloticus* and *P. berardi* in the northern African region may need to be reassigned from LC to one of the IUCN categories of threat, as the presence of these species in the Nile River north of the Aswan dam is based on museum material collected between 1830 and 1922. The absence of present records for either one of these species in this region correlates with expanding habitat

disturbance and increased pollution associated with growing human populations. Crab populations in the Nile may have also been impacted by the introduction of North American crayfish species (*Procambarus clarkii* and *P. zonangulus*) into the river basin in Cairo in the 1980s and by the subsequent spread of crayfish as far south as Qena (*pers. com.* Prof. Mohamed Reda Ali Fishar, National Institute of Oceanography and Fisheries, Egypt).

It should be noted that the majority of the 124 freshwater species assessed as Data Deficient (DD), due to lack of information, are aquatic plants (52 species; 6% of the regional total), freshwater fish (41 taxa; 5%), and freshwater molluscs (26 taxa; 3%) compared to the odonata and the crabs, which are the well known group with only 5 and none species listed as Data Deficient, respectively. In addition, the relatively small number of freshwater crab species found in the region is confirmed (3 species that belong to 2 genera and 2 families), but with some uncertainty about their continued presence in some parts of their known distributional range.

23% of the species (199 species) are endemic to the northern Africa region, i.e., they do not exist anywhere else in the world, and therefore their regional Red List status corresponds also to their risk of extinction at the global level. Almost half of these endemic species (94

Table 8.1 Summary of Red List Category classifications for all northern African freshwater species at the regional scale by taxonomic groups.

Taxon	EX	RE	CR	EN	VU	NT	LC	DD	NA	Total species* (%)	Number of threatened species (%)
Fish	1	23	1	8	26	2	26	41	0	128 (15%)	35 (27%)
Molluscs	17	2	27	30	13	5	35	26	6	155 (18%)	70 (45%)
Dragonflies	0	6	6	7	7	8	43	5	1	82 (9%)	20 (24%)
Crabs	0	0	0	0	0	0	3	0	0	3 (0%)	0 (0%)
Aquatic plants	0	1	27	27	68	68	266	52	12	509 (58%)	122 (24%)
Total species	18	32	61	72	114	83	373	124	19	877 (100%)	247 (28%)

IUCN Red List Categories: EX – Extinct (worldwide), RE – Regionally Extinct, CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, LC – Least Concern, DD – Data Deficient, NA – Not applicable (e.g. vagrant species not normally resident in the region).

* Excludes those species classified as Not Applicable (NA).

Table 8.2 Summary of Red List Category classifications for endemic northern African freshwater species at the regional scale by taxonomic groups.

Taxon Endemics	EX	EW	CR	EN	VU	NT	LC	DD	NA	Total species (%)	Number of threatened species (%)
Fish	1	0	1	2	7	2	12	6	0	31 (16%)	10 (32%)
Molluscs	15	0	22	20	7	2	1	18	0	85 (43%)	49 (58%)
Dragonflies	0	0	0	1	1	1	3	1	0	7 (4%)	2 (29%)
Crabs	0	0	0	0	0	0	1	0	0	1 (2%)	0 (0%)
Aquatic plants	0	0	10	7	16	21	12	9	0	75 (38%)	33 (44%)
Total Endemics	16	0	33	30	31	26	29	34	0	199 (100%)	94 (47%)

IUCN Red List Categories: EX – Extinct (worldwide), EW – Extinct in the Wild, CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, LC – Least Concern, DD – Data Deficient, NA – Not applicable (e.g. vagrant species not normally resident in the region).

species) are threatened with extinction: 33 (17%) are Critically Endangered; 30 (15%) Endangered and 31 (16%) are Vulnerable at global level (Table 8.2).

The regional Red List status of all species assessed that are compiled in this report can be found on the website <http://iucnredlist.org/initiatives/freshwater>.

8.1.1 Centres of species richness

River basins containing the highest species richness across the five taxonomic groups (freshwater fish, molluscs, aquatic plants, dragonflies and freshwater crabs) were identified by mapping species distributions to create the corresponding distribution maps. A small number of Data Deficient species could not be mapped and were, therefore, excluded from the analysis.

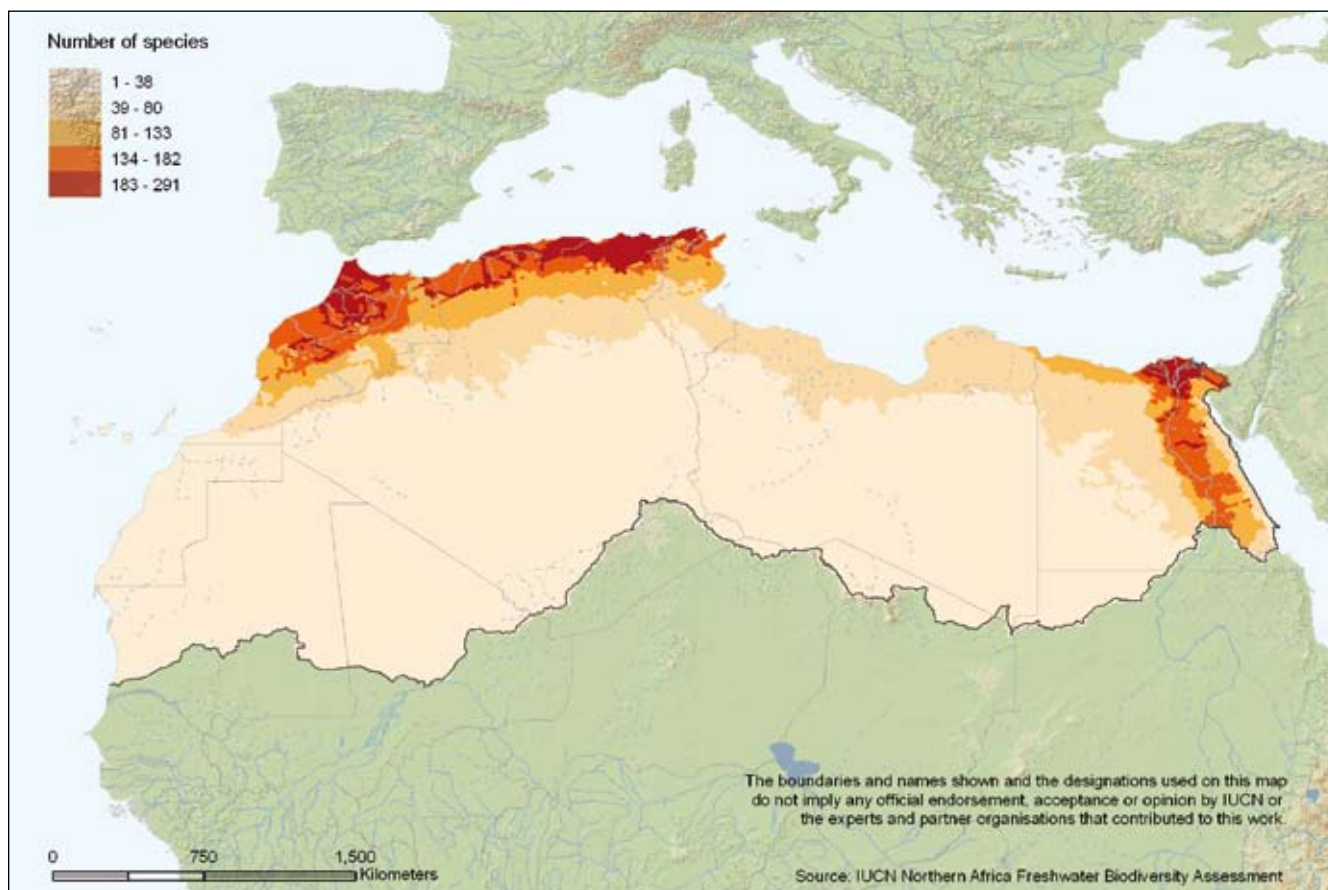
The most important areas that can be highlighted as having the highest numbers of freshwater assessed species are: *The Middle and High Atlas, and the Rif mountains* to the northeastern lowlands and estuaries of Morocco, *Subtropical Numidia* at the eastern

Mediterranean coast of Algeria and Tunisia, including the surrounding areas from Kabylia to Kroumirie, and the *Nile River basin* in Egypt, predominantly the Lower Nile (Figure 8.1).

Area 1: The Middle and High Atlas, and the Rif mountains to the northeastern lowlands and estuaries of Morocco. The Rif and Atlas Mountains in Morocco together with their Atlantic draining river system support an estimated 55 species of dragonflies (67% of the regional total*), 283 species of aquatic plants (56% of the regional total), 38 taxa of freshwater molluscs (24% of the regional total) 8 fish (6% of the regional total) and 1 crab (33% of the regional total).

Area 2: Subtropical Numidia at the eastern Mediterranean coast of Algeria and Tunisia, including the surrounding areas from Kabylia to Kroumirie, support an estimated 52 species of dragonflies (63% of the regional total), 261 species of aquatic plants (51% of the regional total), 1 crab species (33% of the regional total), 24 freshwater molluscs (15% of the regional total) and 6 fishes (5% of the regional total).

Figure 8.1 Distribution of river basins according to the level of biodiversity they contain in fish, molluscs, odonata, aquatic plants and freshwater crabs



* Regional total refers to the total number of taxa for each group within the northern Africa assessment region.

Area 3: The **Egyptian Nile River**, especially the Lower Nile, supports an estimated 2 species of crabs (67% of the regional total), 28 species of dragonflies (34% of the regional total), 170 species of aquatic plants (33% of the total), 37 species molluscs (24% of the regional total) and 31 of freshwater fish (24% of the regional total).

8.1.2 Distribution of threatened species

On the western side of the Mediterranean basin, the *Mediterranean and Northern Atlantic coasts of Morocco*, as well as *the Rif* and parts of the *High and Middle Atlas Mountains*, are the most important areas in terms of the number of freshwater threatened species present. More to the east, the areas that reach a similar level of species richness are *the east of Algeria* (Numidia), and *the north of Tunisia* (Kroumirie, north of the Medjerda river), in addition to the Egyptian *Nile River Basin* on the eastern side of the region, with Lake Nasser just downstream (that is located outside the study region) (Figure 8.2).

Area 1: The **northern Morocco and the Atlas Mountains** support a 53% of the regionally threatened freshwater taxa (130 species and subspecies), including 81 aquatic

plants, 35 freshwater molluscs, 10 odonates and 4 freshwater fish.

Area 2: The **northern coasts of Algeria and Tunisia** support a 25% of the threatened taxa (61 species and subspecies), including 44 plants, 9 odonates, 6 molluscs and 2 freshwater fish.

Area 3: The **Nile River basin**, in the southeast part of the assessment region, supports a 13% of the threatened taxa (32 species and subspecies), including 21 freshwater fish, 6 aquatic plants, 1 mollusc and 4 odonates.

8.1.3 Distribution of endemic species

Endemicity in the region is strongly linked to aquatic plants, freshwater molluscs, and freshwater crabs, which are the groups with the highest proportions of unique species. Most northern African endemic species are located in the *Middle and High Atlas* and, generally to a lower degree, in *the Betico-Rifan arc* in Morocco, *the Kabylia-Numidia region* in Algeria and *the Kroumiria Mountains* in Tunisia (Figure 8.3). 54% of the freshwater species endemic to the northern Africa region are present in these areas together: 36 molluscs, 51 aquatic plants, 9 odonata, 11 fish and 1 crab.

Figure 8.2 Distribution map showing concentrations of threatened species of the fish, molluscs, odonates and aquatic plants taxonomic groups

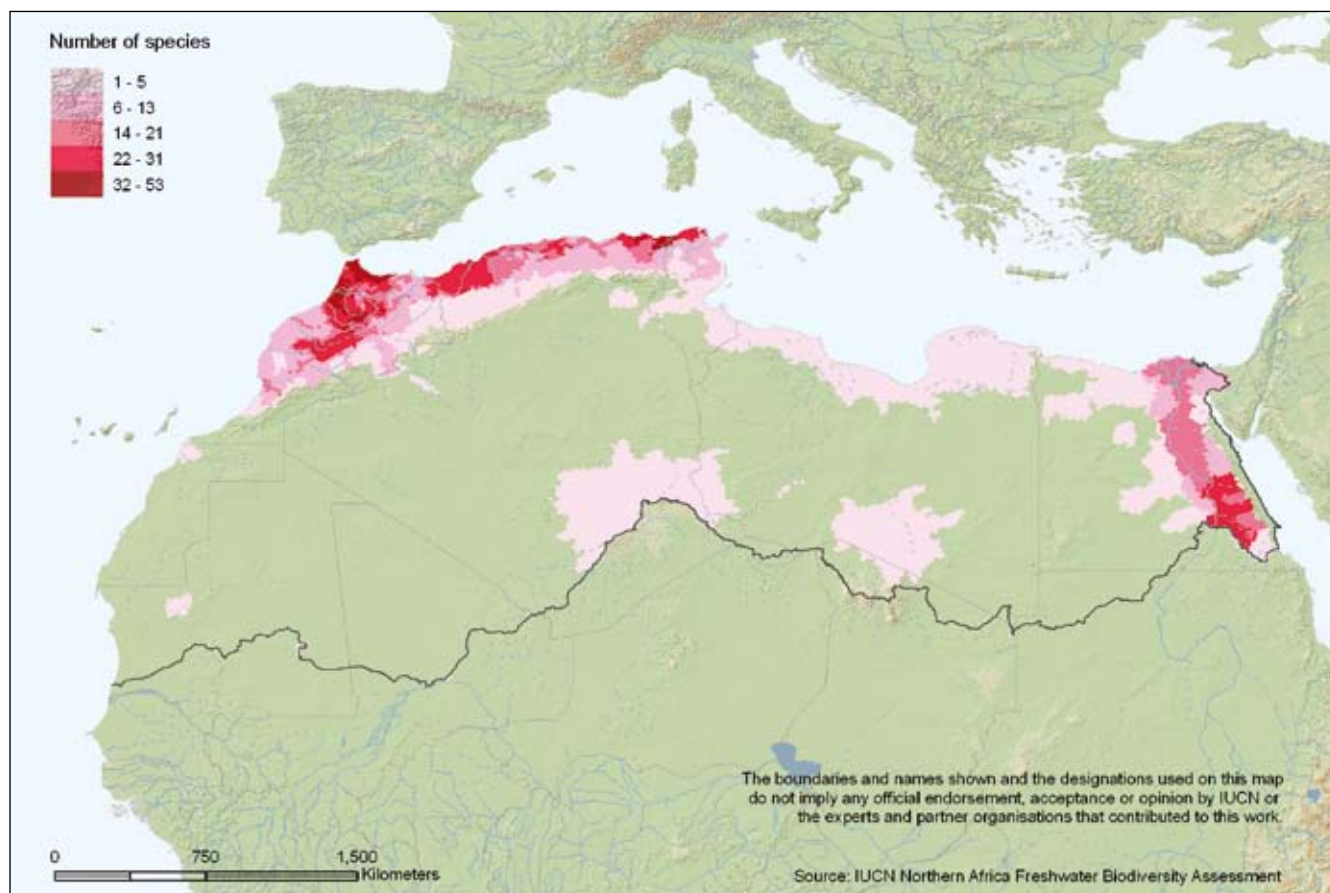


Figure 8.3 Distribution map showing areas of high endemicity of the fish, molluscs, odonates, aquatic plants and freshwater crabs

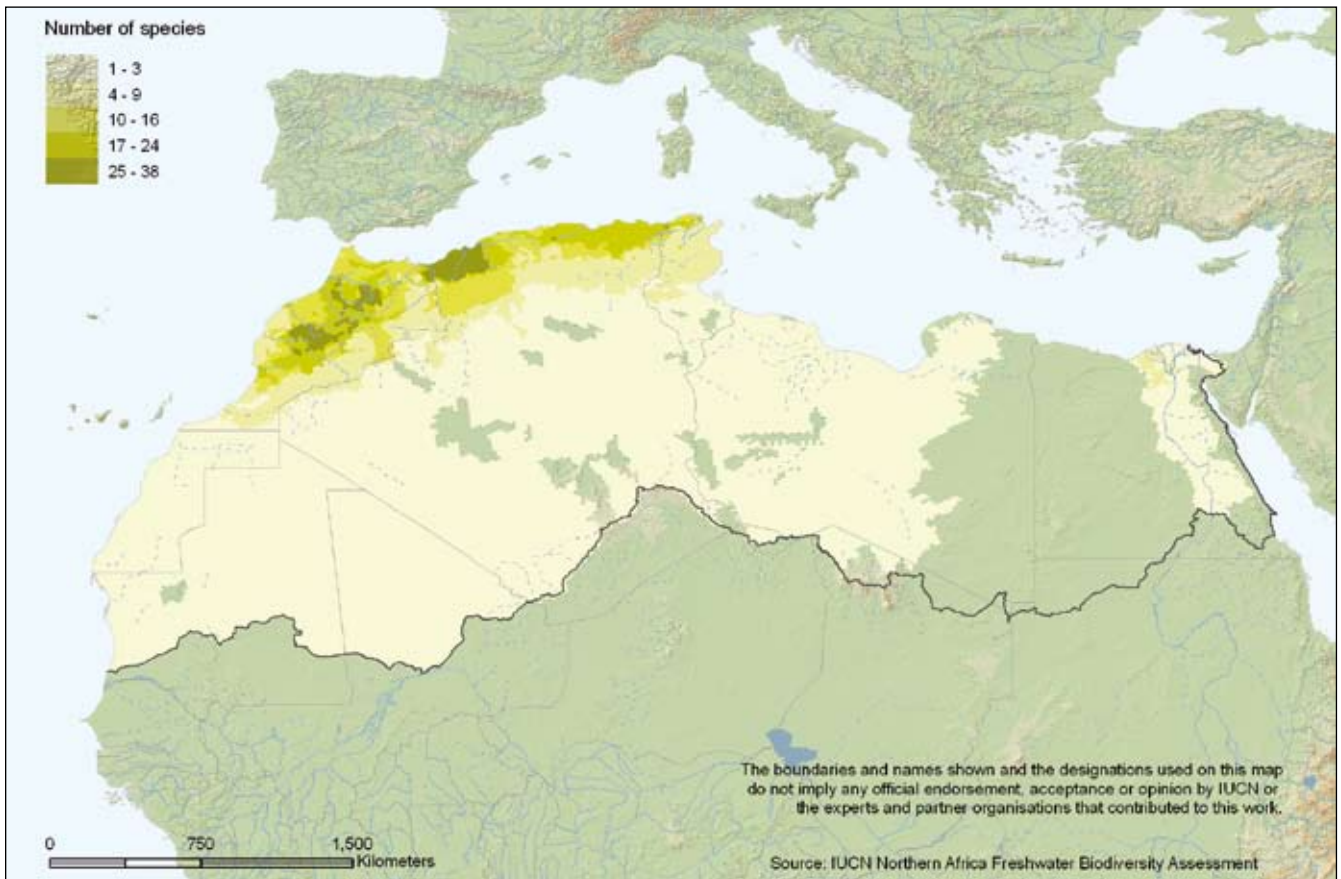
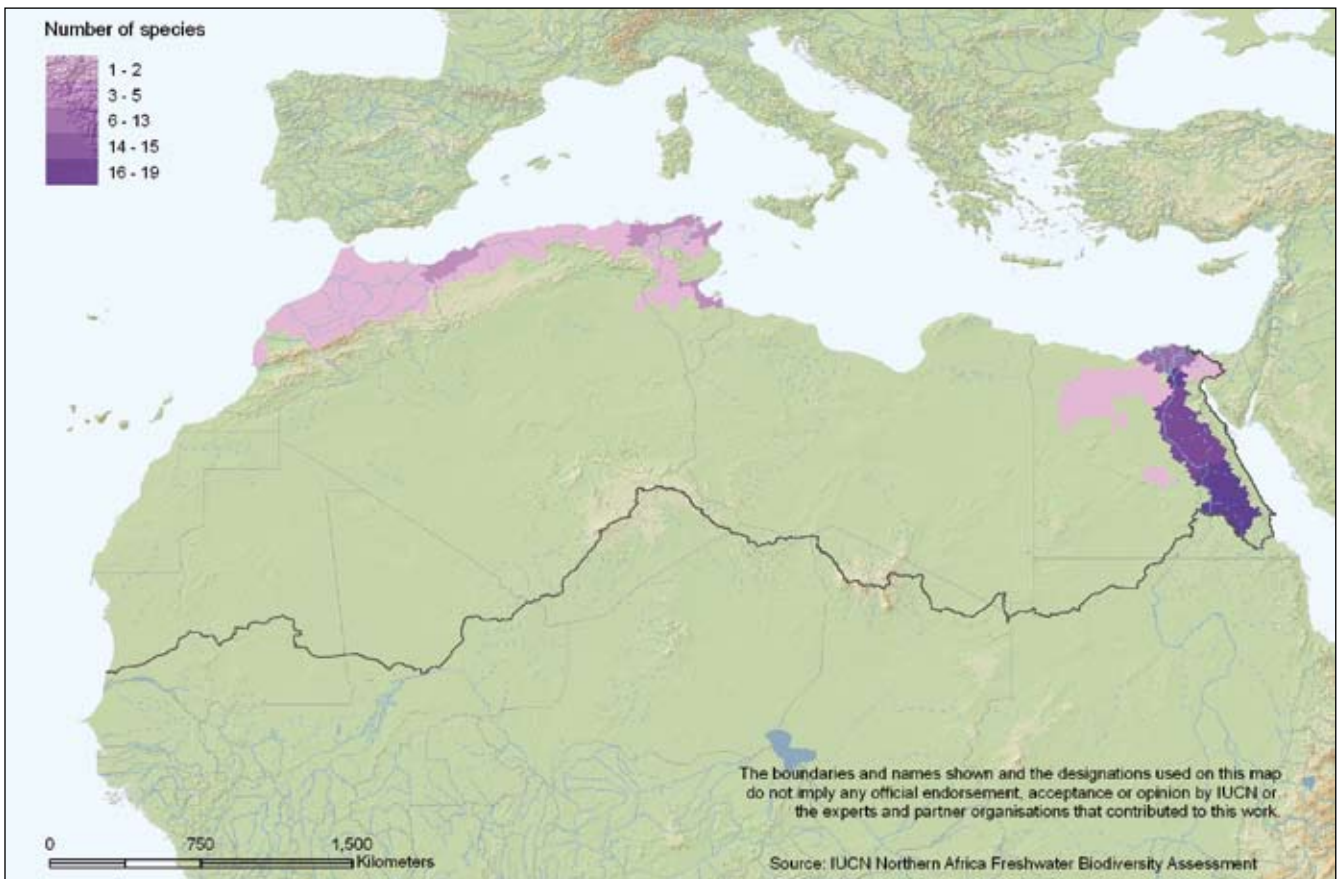


Figure 8.4 Distribution map showing areas of high number of Extinct or Regional Extinct species of freshwater fish, molluscs and odonates



A significant part of these areas were theoretically placed under protection during the recent decades thanks to the creation of National Parks and Natural Reserves [Toubkal (High Atlas), Talassemtane (Rif), Tazekka and Ifrane (Middle Atlas), El-Kala National Park, Biosphere Reserve, several Ramsar sites (Numidia), amongst others]. Practically, the protection is often low and the degradation may be very strong due to over irrigation in some areas, swamp fires and destruction, over-grazing and water pollution. As a result, species like the African *Urothemis edwardsii* (Odonata), which has a single breeding site in Numidia is now on the verge of extinction after the degradation of Lake Oubeïra and the destruction of Lac Noir (de Bélair and Samraoui 1994). Similarly, the Maghrebian endemic, *Calopteryx exul* (Odonata), is highly endangered due to the alteration of river systems throughout northern Africa due to pollution and the dessication of rivers as a result of water over-extraction for agricultural and domestic use.

8.1.4 Distribution of Extirpated species

The River Nile basin stands out for being the region where more northern African species have gone extinct (Figure 8.4). In total, 28 species have been recorded as

Extinct or Regionally Extinct in this area, including 23 freshwater fish, 3 odonata and 2 molluscs.

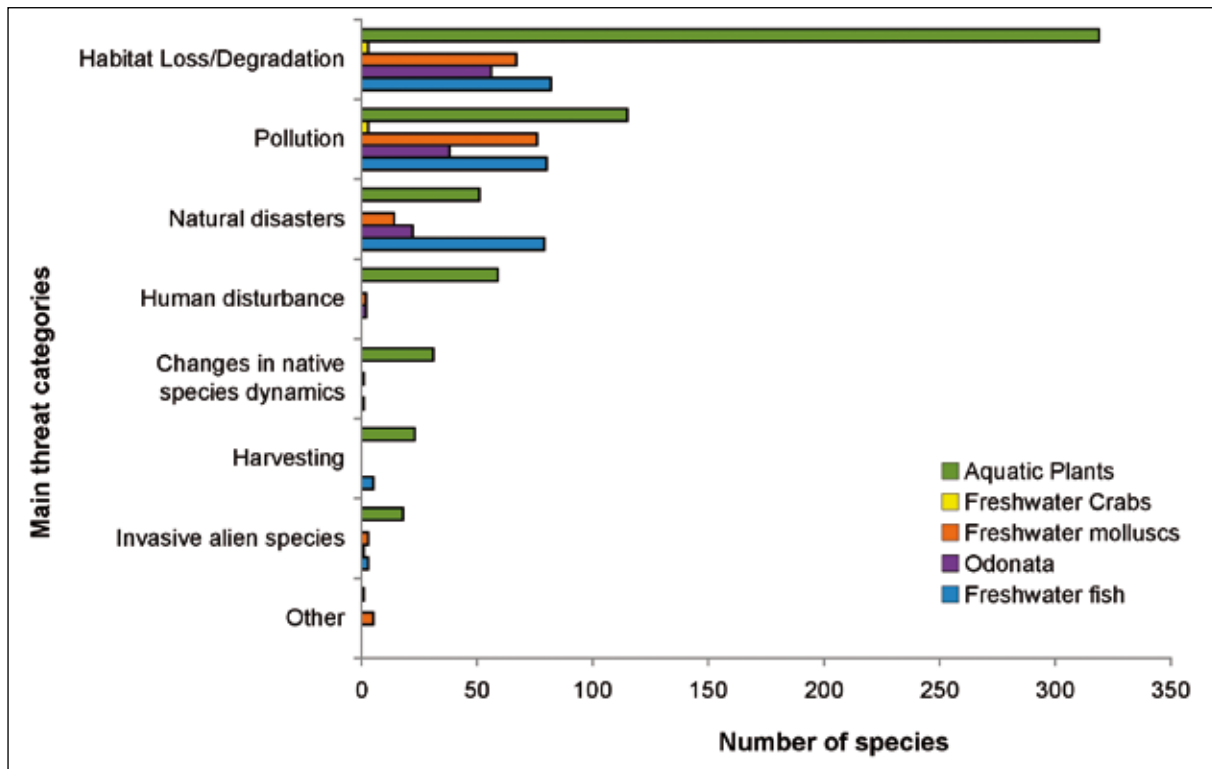
8.2 Regional Threats

Threats to freshwater species in northern Africa are similar to those in other regions of the continent for the same biome. These analysis reveal that the freshwater biome is also strongly threatened not only at the regional scale, but also at the global scale. All taxonomic groups were evaluated by specialist groups, who took into consideration the past, ongoing and future impacts leading to species extinctions and agreed on the main causes of decline for freshwater dependant species at the regional level. At the northern African scale, habitat loss and degradation induced by human activities appeared to be the most important threat, together with pollution. In addition, natural disasters (especially drought and strong highflow events) are known to be severely affecting freshwater species and have a direct effect on populations. This threats are expected to worsen in the future due to the increasing effects of climate change. Other threats of relevance are human disturbance, changes in the native species dynamics, harvesting, invasive alien species and intrinsic factors.

Centre for Environmental Education in Sidi Boughaba (Morocco). Photo © Patrick Grillas



Figure 8.5 Major threats to freshwater species in northern Africa



8.2.1 Habitat loss and degradation

Habitat loss and degradation are by far the main threats to freshwater biodiversity in northern Africa. The two main factors leading to habitat loss and degradation are related to excessive water abstraction for domestic, industrial and agricultural use and to the development of infrastructure. The habitat of lowland species is particularly affected by the intensification of agriculture, with its increased demand for water (in particular for irrigation) as well as the drainage of most of wetlands in the region. Overuse of underground water has resulted in an increase of underlying saline waters and led in many occasions to the disappearance of surface water bodies. Numerous permanent rivers and lakes are thus now becoming seasonal and are no longer suitable for most species that require a constant availability of water for their survival. Although there is a relatively small number of large river systems in the region, many of these are highly regulated by dams, as shown in the Figure 8.6. The construction of dams blocks migratory routes and modifies the hydrological landscapes (such as the flow and level control, water temperature, oxygen content and sediment load). This is particularly critical at certain times of the year (during the reproduction period for example) or in certain areas (spawning zones, habitat refuges, etc.). Amongst the northern African freshwater fish considered, dams are a major cause of decline for threatened species,

Palm trees inundated as a result of the construction of a dam in the Middle Atlas, Morocco © Pedro Regato

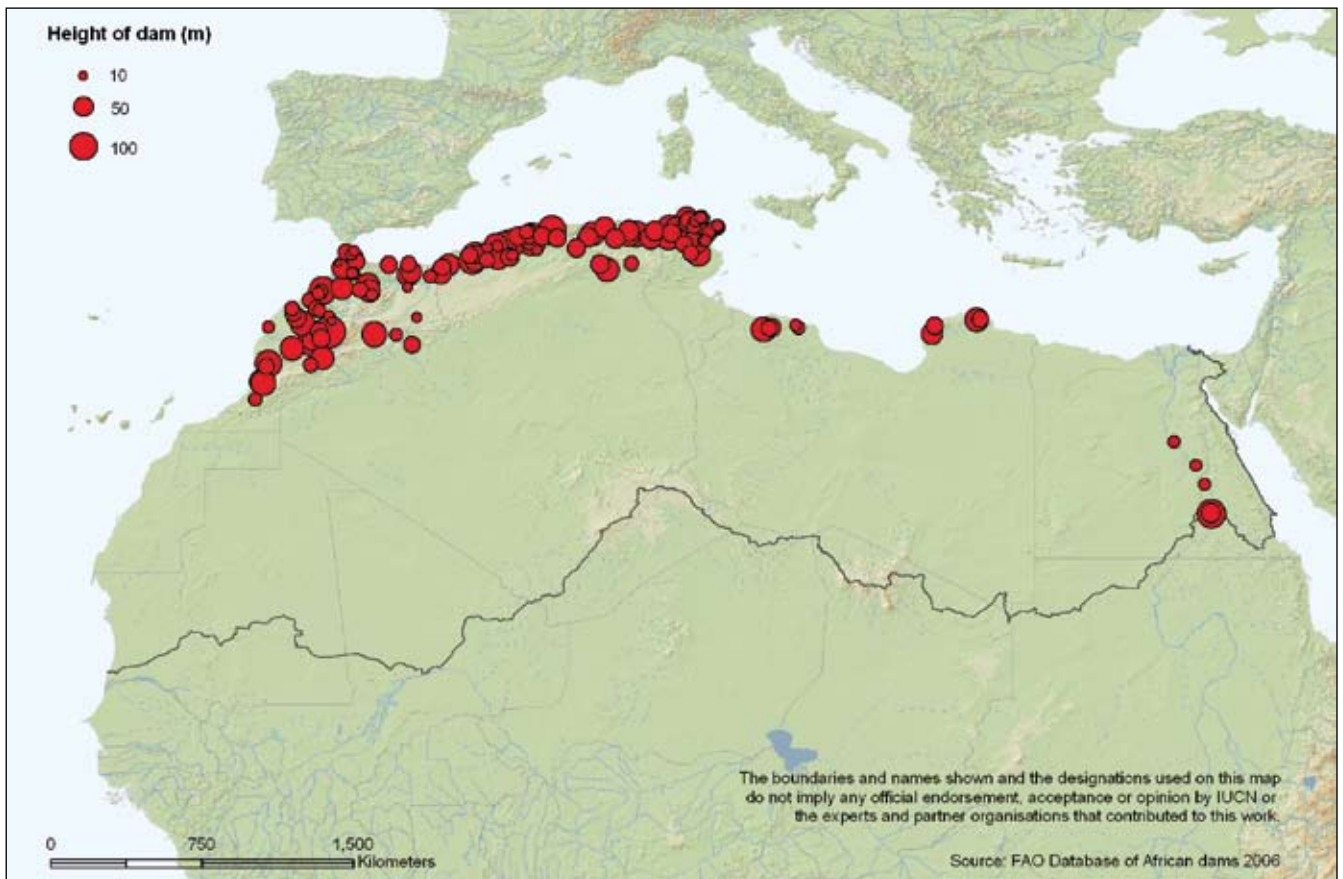


affecting almost 14% (122 sp.) of the freshwater species assessed, including 26 regionally threatened fish, 3 odonates, 3 molluscs and 2 aquatic plants.

Unfortunately, the changes in biodiversity caused by dams are invariably uniform for the majority of the groups, ultimately resulting in common species replacing rare ones. For example, when dams are built on wadis that feed salt lakes, more bird species such as coots, moorhens, mallards and little grebes are present. These common freshwater species are replacing salt lakes specialists like Slender-billed Gulls, Avocets, Shelducks and Gull-billed Terns, showing an assumed increase in “biodiversity” that hides a real decline in “natural” biodiversity.



Figure 8.6. Location of large and secondary dams in the northern Africa region. Source: FAO Aquastat (2007).



However, there are known exceptions for other taxonomic groups such as Odonata. For these species, the construction of dams may lead to the local extinction of lotic species (living in running waters) if a reserved water flow is not maintained downstream of dams, whereas the dam lake itself may favour the settlement of lentic species (those that develop in steady waters). In this particular case there would be a change of species presence and distribution in the region favouring common Odonata species disappearance and rare species development.

In total, 207 threatened freshwater taxa are at risk of extinction due to habitat loss and degradation in northern Africa - 114 plants, 49 molluscs, 32 fish and 12 Odonata. Threatened Odonata, such as the Maghrebian endemic *Calopteryx exul*, are highly endangered due to the alteration of river systems through pollution and desiccation of rivers as a result of water over extraction for agricultural and domestic use throughout northern Africa.

In the Maghreb, large-scale river habitat destruction due to excessive water abstraction for domestic, industrial and agricultural use is a threat that has reached catastrophic proportions. The human population has grown along the riparian corridors and the intensification of agriculture has led to habitat loss due to groundwater extraction for irrigation. This has been found to affect 34% of the threatened freshwater species. In addition to this threat, other main factors affecting northern African threatened species related to habitat degradation are infrastructure development and agricultural practices, affecting about 50% and 43% of the total threatened species respectively.

8.2.2 Pollution

Pollution was identified as the second most important cause of freshwater species extinction in the region. In total, more than half of the regionally threatened freshwater fauna and flora assessed (52 molluscs, 41 aquatic plants, 31 fish and 15 Odonata) were found to be threatened by water pollution. This alteration of freshwater quality is a negative result directly related to uncontrolled waste disposal from agricultural, industrial and domestic human activities that, in the majority of the cases, are also linked to soil pollution. In areas where the impact is higher, worsening of the freshwater quality has led to heavy pollution and eutrophication of surface and ground waters. New standards of legal thresholds of fertilizers should be applied in northern Africa to reduce the effect of chemicals on groundwater pollution (UNEP

2006). These legal thresholds should be re-evaluated in most northern African countries and adapted to the actual knowledge and technologies. Human populations are increasing along freshwater systems and so is the degree of contamination: high concentrations of detergents from washing clothes and sheep wool end up in the rivers. Furthermore, a massive amount of polluted soil is eroded and pollutants are leached from surrounding arable lands, contributing as well to the high levels of pollution.

8.2.3 Natural Disasters

Droughts are becoming more frequent and their severity and extent are increasing in the region, already the most affected by water scarcity of the entire African continent (UNEP 2006). On the other hand, important flooding episodes are also becoming more common in the region, carrying enormous amounts of sediment and destroying the aquatic habitats. These trends will only worsen with climate change in the northern African region, especially on the borders of the Sahara, which is considered one of the most vulnerable areas to desertification (Blue Plan 2009). As a matter of fact, the distribution of several species, especially the molluscs, already shows a tendency to move northwards. These species might soon reach the physical limit of the Mediterranean Sea that will prevent them from continuing their movement, subjecting them to possible extinction. Up to 26% of the threatened species assessed are currently affected by drought, a tendency that is likely to continue in the future with the expected rise of temperatures in this region due to climate change.

It should be noted that alarming climatologic events have been occurring more frequently in recent years in the region. Some examples are the spread of the summer drought to December of 2009 in the Sous valley (western Morocco between the high Atlas and the Anti-Atlas) as well as the succession of catastrophic rainfall and highflow events in eastern Morocco and Algeria in the winter and spring of the same year, leading to the destruction of many orange orchards (Boudot, pers comm.).

8.2.4 Human disturbance

Human disturbance as a result of tourism and outdoor recreational activities was identified as a relevant cause of threat affecting 24 aquatic plant species (11% of the regional total threatened species of this group): for example, the endemic plant *Serapias stenopetala*, assessed as Critically Endangered was found in the Brabtia Animal



Park within the El Kala National Park (Algeria), where it is threatened by associated recreation and tourism activities.

Some threatened endemic species are directly affected by the increasing number of visitors to the sites where species grow through infrastructures (building of paths, tracks and roads). This is, for example, the case of the freshwater plants *Dactylophiza maurusia* (EN), *Carex fissirostris* (EN), *Rorippa hayanica* (VU) and *Carum lacuum* (VU), and a newly discovered underground freshwater snail. On the other hand, some species are more vulnerable to human disturbance as they can easily be destroyed by trampling and disturbance of dune systems even if there is no construction, like the aquatic plant *Limonium duriaei*, a Vulnerable species only found in salt marshes of Algeria and Morocco.

8.2.5 Changes in native species dynamics

Due to changes in certain ecological conditions, some native aquatic plant species might not be favoured when

in competition with other native species. This could result in the reduction of their distribution from areas where they were previously found. The European eel, *Anguilla anguilla*, the freshwater mollusc, *Margaritifera marocana*, and 11 aquatic plant species, are threatened by this ecological pressure. This stress predominantly affects aquatic plants, which live on the ground being therefore more likely to compete for space, light and soil nutrients. For example, *Isoetes setacea* (CR), *Elatine brochonii* (VU), *Pilularia minuta* (CR), *Littorella uniflora* (VU), found in temporary ponds, are being threatened by the spread of the helophytic *Bolboschoenus maritimus* and *Inula viscosa* which are now favoured by changes from traditional to more modern land uses (Grillas *et al.* 2004, Rhazi *et al.* 2009).

8.2.6 Harvesting (over-exploitation)

Over-fishing for food is threatening at least 5 species of freshwater fish in the region, some of them are commercialized at local and national level but others, such as the European eel *Anguilla anguilla* (EN), are

exported. In addition, the Nile robber *Alestes dentex* (VU), the Nile perch *Lates niloticus* (DD), the Tiger fish *Hydrocynus forskahlii* (LC) and the barbell *Barbus bynni bynni* (LC) are affected by over-exploitation. Enforcement of the control measures to ban over-fishing or illegal practices (such as ban exploitations during closed season and the use of illegal techniques) is strictly needed.

In addition, 23 aquatic plants are threatened by over-harvesting (4% of the regional total), and amongst them 6 threatened species: *Mentha cervina* (CR), *Bacopa montinneri* (EN), *Gratiola officinalis* (VU) and *Periscaria bostorta* (VU) are collected for medicinal purposes; *Butomus umbellatus* (EN) for food; *Genista ancistrocarpa* (EN), collected locally for food; and the two Data Deficient (*Anacamptis palustris* and *Anacamptis laxiflora*).

8.2.7 Invasive alien species

Invasive alien species have a considerable impact on some indigenous species, through competition for resources (for example, the CR *Aphanius saourensis* is affected by the introduction of the North American mosquitofish *Gambusia holbrooki*), predation (for example, the CR Moroccan endemic *Anodonta pallaryi* is affected by the introduction of the invasive molluscivore fish Louisiana red crayfish *Procambarus clarkii* that is rapidly spreading through Mediterranean Europe), as well as food competitors or hybridisation (for example, the DD *Salmo macrostigma* is affected by hybridisation with an introduced trout species). Amongst the aquatic plants, *Utricularia inflexa* (VU), is threatened by competition with exotic plants (e.g., *Azolla filliculoides*, *Salvinia natans*), in addition to invasive competitors (e.g., *Paspalum*

paspalodes), which are a problem in parts of the range of *Eleocharis acicularis*. More specific threats affecting northern African freshwater species are commented on in each of the taxonomic group's chapters.

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Freshwater fish of the *Lepomis* genus, and introduced alien species in the northern African region



Chapter 9. Conclusions and recommendations

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Even if the northern African region is not exceptional in terms of the number of species of its freshwater fauna and flora, the importance of this report relies in highlighting the high level of threat and endemism of the freshwater species present in this region.

Freshwater habitats are under great pressure in northern Africa, due to the increasing water demands for agriculture, industrial development and drinking. This is clearly reflected in the high proportion of freshwater species under threat. As a matter of fact, 28% of all the species assessed at the regional scale is currently threatened with extinction. When compared with the percentages of the taxonomic groups that have been comprehensively assessed at the global level (such as birds - 12% threatened, mammals - 23% threatened, amphibians - 32% threatened) (Baillie *et al.* 2004), this figure is very high, stressing the fact that freshwater species are facing serious challenges and therefore requiring special conservation actions.

Furthermore, northern African freshwater biodiversity displays a high concentration of distinctive species, especially of molluscs and aquatic plants, which cannot be found in any other place of the world. However, this valuable natural patrimony is at high risk, as one fifth (21%) of its freshwater species is facing serious risks of extinction highlighting the responsibility of northern African countries to develop and implement conservation actions for these irreplaceable species.

The alarming status of freshwater species in the region is an indicator of the degraded status of their habitat urging for an integrated management plan that will guarantee the survival of these resources. This chapter describes the main conservation priorities identified by the experts for all the taxonomic groups assessed in this project during the review workshop held in Porto (Portugal) in October 2007.

9.1 Integrated River Basin Management (IRBM) and environmental flows

River basins are closed systems where biotic and abiotic parts are interrelated and interact. Thus, activities directly related to human development, such as water and gravel extraction or pollution have direct consequences on the quality of the fauna and flora of the freshwater bodies. It is therefore essential to consider the ecological requirements of the freshwater species when planning and managing the hydrological resources ensuring by this the maintenance of goods and services that those ecosystems provide.

Integrated River Basin Management (IRBM) is a key measure to ensure the future of rivers and wetlands in northern Africa. The process of IRBM aims at integrating the conservation of water and land resources within the management of freshwater ecosystems. There is an essential need to carry out joined multidisciplinary actions among stakeholders aiming at conserving, developing

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and restoring their natural resources, and in parallel providing beneficial outcomes at the social level enhancing livelihoods in the region. The basic principles of IRBM are explained along with a number of example case studies at: <http://www.gwptoolbox.org/>

Environmental flows refer to “the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated” (Dyson *et al.* 2003). Environmental flows are another important process that provides critical contribution to river health, economic development and poverty alleviation. They ensure the continued availability of the many benefits that healthy river and groundwater systems bring to society.

Dam authorities should be encouraged to provide this continuous “reserved flow” or “environmental flow” for the river up and downstream.

According to this concept, habitat restoration of spawning areas below dams and the construction of fish ladders and pathways for migratory species are highly recommended providing the means to complete their life cycles in addition to some additional assistance of some critical stocks to move over dams.

9.2 Sustainable agricultural techniques and waste/sewage management

Reducing water pollution relies mainly in diminishing the use of fertilisers and pesticides in agriculture, which are currently used at very high levels in northern Africa harming its fauna and flora. This problem is only resolved when linked to a change in the legislation applied to these practices. In addition, future initiatives should be taken to increase the waste water treatment facilities available and to ensure that their capacity and action are adapted to the needs.

In relation to water overexploitation, more efficient irrigation techniques such as the use of drip instead of sprinklers, and practices such as night irrigation as an alternative to reduce evaporation are recommended to prevent depletion and continuous reduction of the water table resources.

9.3 Enforce legislation

Enforcement of the current legislation is urgent, in particular preventing over-harvesting of fish stocks by

avoiding the use of illegal fishing techniques and ensuring the compliance with the current closed season obligations. In addition, legislation to protect threatened freshwater species (such as dragonflies or molluscs) and their critical habitats must be reinforced to prevent these highly threatened species to disappear, causing major losses of fundamental ecosystem services, like water purification.

9.4 Habitat and species conservation

Key Biodiversity Areas, i.e., areas with a high number of threatened and endemic species (Langhammer *et al.* 2007). should be identified and protected and management plans should be developed and implemented, in order to prevent the decline in species under high threat of extinction and in habitat quality. These actions will help in habitat restoration as wetlands react relatively well and quickly to conservation actions.

As an exceptional mean for selected highly threatened species, it would be recommended to promote captive breeding projects and translocation of populations/subpopulations to similar habitats where conditions are favored.

9.5 Raising awareness through biodiversity information

Freshwater ecosystems are vital to the livelihood and economies of the northern African countries. However, their importance is often largely under-estimated, by local people as well as by decision makers, and they are often considered as “waste” areas. Raising awareness campaigns to invert this tendency and to promote the sustainable use and management of northern African wetlands are crucial for the future of these vulnerable ecosystems.

Effective educational programmes with special focus on children need to be implemented in order to raise awareness about the importance of freshwater species, their habitats’ conservation and the threats increasingly faced by this biome. Moreover, educational projects oriented to all the population levels about the value of water and the need of more efficient techniques for the utilization of this resource are needed. Due to the rapid development of the region, it is fundamental to provide politicians, legislators and other relevant stakeholders with key biodiversity information about the status of freshwater ecosystems and the importance of its integration in short and long term decision-making and planning.



9.6 Data deficiency and research

This effort to produce IUCN Red List assessments for northern African freshwater species has confirmed that there is a significant lack of information on the status of many species in the region. Fourteen percent of species assessed were categorized as Data Deficient, indicating that there is not enough information to enable accurate assessment of their extinction risk. This is often due to a lack of research, or because species are (or have become) rare, or have a limited geographic distribution. Therefore, they may be especially vulnerable to anthropogenic threats.

Research efforts focusing on species for which there is currently little knowledge must be dramatically increased. A Data Deficient listing does not mean that these 124 species are not threatened. In fact, as knowledge improves, such species are often found to be amongst the most threatened (or suspected as such from available evidence). It is therefore essential to direct research efforts and funding towards these species as well as those in threatened categories (Cavanagh and Gibson 2007).

As a result, research is needed in order to improve the knowledge on freshwater species, in particular regarding taxonomy, population trends, distribution range and threats. Genetic studies should be encouraged as numerous sub-species in the region might in fact prove to be true species, endemic to the region and facing a high degree of threat than what was previously thought. There is a significant proportion of the region that is still lacking reliable information, notably in Algeria and the Libyan Arab Jamahiriya. This fact should be taken into consideration together with the results of the present evaluation. A conservation measure that appears essential to all taxonomic groups is to support new research projects on mid-term investigation as a mean to predict future species decline or extinction and to evaluate the impact of the conservation actions implemented.

9.7 References

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The Moulouya River Basin Case Study

Integrating biodiversity information to define the downstream flow needs from river regulation infrastructure (hydropower and irrigation dams) that would be required to maintain downstream biodiversity values and ecosystem functions. The project was carried out in close collaboration with the Moulouya River Basin Agency (ABHM), and regional partners (University of Oujda) and stakeholders. Some of the main outcomes are:

- Raise awareness and understanding on the state of biodiversity of the Moulouya through the event “Moulouya Caravan”, an itinerary exhibition that ran along different localities of the river basin targeting local decision makers, schools, universities, and NGOs, including the dissemination of field guides on the freshwater flora and fauna present in the Moulouya region.
- Training of the local freshwater experts and managers involved in the Moulouya Basin on the use of GIS techniques;
- Carry out regional freshwater biodiversity assessment in collaboration with the IUCN Dragonfly Specialist Group;
- Publication of a document with recommendations from scientific findings to the integration of this biodiversity knowledge in environmental planning and share findings and recommendations of the project with regional freshwater biodiversity experts and decision makers;
- Put in place of a monitoring network for the biodiversity in the region .



Appendix 1. Red List status of northern African freshwater fish

Order	Family	Scientific name	IUCN Red List Category (Northern Africa)	IUCN Red List Criteria	Endemic to the region?
ANGUILLIFORMES	ANGUILLIDAE	<i>Anguilla anguilla</i>	EN	A4bd	
ANGUILLIFORMES	OPHICHTHIDAE	<i>Dalophis boulengeri</i>	DD		
CHARACIFORMES	ALESTIIDAE	<i>Alestes baremoze</i>	RE		
CHARACIFORMES	ALESTIIDAE	<i>Alestes dentex</i>	VU	B2ab (ii,iii,v)	
CHARACIFORMES	ALESTIIDAE	<i>Brycinus macrolepidotus</i>	RE		
CHARACIFORMES	ALESTIIDAE	<i>Brycinus nurse</i>	DD		
CHARACIFORMES	ALESTIIDAE	<i>Hydrocynus brevis</i>	RE		
CHARACIFORMES	ALESTIIDAE	<i>Hydrocynus forskahlii</i>	LC		
CHARACIFORMES	ALESTIIDAE	<i>Hydrocynus vittatus</i>	DD		
CHARACIFORMES	ALESTIIDAE	<i>Micralestes acutidens</i>	RE		
CHARACIFORMES	CITHARINIDAE	<i>Citharinus citharus citharus</i>	VU	B2ab (i,ii,iii)	
CHARACIFORMES	CITHARINIDAE	<i>Citharinus latus</i>	VU	B2ab (iii)	
CHARACIFORMES	CITHARINIDAE	<i>Distichodus engycephalus</i>	RE		
CHARACIFORMES	CITHARINIDAE	<i>Distichodus rostratus</i>	RE		
CHARACIFORMES	CITHARINIDAE	<i>Ichthyborus besse besse</i>	RE		
CHARACIFORMES	CITHARINIDAE	<i>Nannocharax niloticus</i>	RE		
CLUPEIFORMES	CLUPEIDAE	<i>Alosa alosa</i>	RE		
CLUPEIFORMES	CLUPEIDAE	<i>Alosa fallax</i>	RE		
CYPRINIFORMES	COBITIDAE	<i>Cobitis maroccana</i>	VU	B2ab (iii); D2	Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus anema</i>	RE		
CYPRINIFORMES	CYPRINIDAE	<i>Barbus antinorii</i>	DD		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus bynni bynni</i>	LC		
CYPRINIFORMES	CYPRINIDAE	<i>Barbus callensis</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus deserti</i>	NT	B2b (i,ii,iii)	Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus figuiguensis</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus fritschii</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus harterti</i>	VU	A2ace	Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus issenensis</i>	VU	B1ab (ii,iii); D2	Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus ksibi</i>	VU	B1ab (ii,iii); D2	Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus labiosa</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus lepinyei</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus leptopogon</i>	DD		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus magniatlantis</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus massaensis</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus moulouyensis</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus nasus</i>	NT		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus neglectus</i>	RE		
CYPRINIFORMES	CYPRINIDAE	<i>Barbus pallaryi</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus paytonii</i>	VU	B2ab (iii)	Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus perince</i>	VU	B2ab (ii,iii)	
CYPRINIFORMES	CYPRINIDAE	<i>Barbus pobeguini</i>	DD		
CYPRINIFORMES	CYPRINIDAE	<i>Barbus reinii</i>	VU	B2ab (iii)	Yes

Order	Family	Scientific name	IUCN Red List Category (Northern Africa)	IUCN Red List Criteria	Endemic to the region?
CYPRINIFORMES	CYPRINIDAE	<i>Barbus setivimensis</i>	LC		Yes
CYPRINIFORMES	CYPRINIDAE	<i>Barbus stigmatopygus</i>	DD		
CYPRINIFORMES	CYPRINIDAE	<i>Barbus yeiensis</i>	DD		
CYPRINIFORMES	CYPRINIDAE	<i>Chelaethiops bibie</i>	EN	B2ab (i,ii,iii)	
CYPRINIFORMES	CYPRINIDAE	<i>Labeo coubie</i>	EN	B2ab (iii)	
CYPRINIFORMES	CYPRINIDAE	<i>Labeo niloticus</i>	LC		
CYPRINIFORMES	CYPRINIDAE	<i>Leptocypris niloticus</i>	EN	B1ab (i,ii,iii) + 2ab (i,ii,iii)	
CYPRINIFORMES	CYPRINIDAE	<i>Pseudophoxinus callensis</i>	LC		
CYPRINIFORMES	CYPRINIDAE	<i>Pseudophoxinus punicus</i>	EN	B1ab (iii) + 2ab (iii)	Yes
CYPRINIFORMES	CYPRINIDAE	<i>Raiamas senegalensis</i>	EN	B2ab (iii)	
CYPRINIFORMES	CYPRINIDAE	<i>Varicorhinus maroccanus</i>	DD		Yes
CYPRINODONTIFORMES	CYPRINODONTIDAE	<i>Aphanius apodus</i>	DD		Yes
CYPRINODONTIFORMES	CYPRINODONTIDAE	<i>Aphanius desioi</i>	DD		Yes
CYPRINODONTIFORMES	CYPRINODONTIDAE	<i>Aphanius dispar dispar</i>	LC		
CYPRINODONTIFORMES	CYPRINODONTIDAE	<i>Aphanius fasciatus</i>	LC		Yes
CYPRINODONTIFORMES	CYPRINODONTIDAE	<i>Aphanius saourensis</i>	CR	B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v)	Yes
CYPRINODONTIFORMES	POECILIIDAE	<i>Aplocheilichthys pfaffi</i>	DD		
CYPRINODONTIFORMES	POECILIIDAE	<i>Micropanchax loati</i>	RE		
LEPIDOSIRENIFORMES	PROTOPTERIDAE	<i>Protopterus aethiopicus aethiopicus</i>	DD		
OSTEOGLOSSIFORMES	ARAPAIMIDAE	<i>Heterotis niloticus</i>	RE		
OSTEOGLOSSIFORMES	GYMNARCHIDAE	<i>Gymnarchus niloticus</i>	DD		
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Hyperopisus bebe bebe</i>	RE		
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Marcusenius cyprinoides</i>	VU	B2ab (ii,iii)	
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Mormyrus caschive</i>	VU	B2ab (ii,iii)	
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Mormyrus hasselquistii</i>	RE		
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Mormyrus kannume</i>	VU	B2ab (ii,iii)	
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Mormyrus niloticus</i>	RE		
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Petrocephalus bane bane</i>	VU	B1ab (i,ii,iii) + 2ab (i,ii,iii)	
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Petrocephalus bovei bovei</i>	RE		
OSTEOGLOSSIFORMES	MORMYRIDAE	<i>Pollimyrus isidori isidori</i>	VU	B1ab (ii,iii) + 2ab (ii,iii)	
PERCIFORMES	ANABANTIDAE	<i>Ctenopoma kingsleyae</i>	DD		
PERCIFORMES	BLENNIIDAE	<i>Salaria fluviatilis</i>	LC		Yes
PERCIFORMES	CICHLIDAE	<i>Haplochromis bloyeti</i>	VU	B2ab (iii)	
PERCIFORMES	CICHLIDAE	<i>Haplochromis desfontainii</i>	EN	B2ab (i,ii,iii,iv,v)	Yes
PERCIFORMES	CICHLIDAE	<i>Haplochromis wingatii</i>	DD		
PERCIFORMES	CICHLIDAE	<i>Hemichromis bimaculatus</i>	EN	B2ab (ii,iii)	
PERCIFORMES	CICHLIDAE	<i>Hemichromis fasciatus</i>	DD		
PERCIFORMES	CICHLIDAE	<i>Hemichromis letourneuxi</i>	DD		
PERCIFORMES	CICHLIDAE	<i>Oreochromis aureus</i>	LC		
PERCIFORMES	CICHLIDAE	<i>Oreochromis ismailiaensis</i>	DD		Yes
PERCIFORMES	CICHLIDAE	<i>Pseudocrenilabrus multicolor multicolor</i>	DD		
PERCIFORMES	CICHLIDAE	<i>Sarotherodon galilaeus galilaeus</i>	LC		

Order	Family	Scientific name	IUCN Red List Category (Northern Africa)	IUCN Red List Criteria	Endemic to the region?
PERCIFORMES	CICHLIDAE	<i>Sarotherodon melanotheron heudelotii</i>	DD		
PERCIFORMES	CICHLIDAE	<i>Sarotherodon melanotheron melanotheron</i>	DD		
PERCIFORMES	CICHLIDAE	<i>Tilapia guineensis</i>	DD		
PERCIFORMES	CICHLIDAE	<i>Tilapia ismailiaensis</i>	DD		
PERCIFORMES	CICHLIDAE	<i>Tilapia rendalli</i>	DD		
PERCIFORMES	CICHLIDAE	<i>Tilapia zillii</i>	LC		
PERCIFORMES	LATIDAE	<i>Lates niloticus</i>	DD		
PERCIFORMES	MONODACTYLIDAE	<i>Monodactylus argenteus</i>	DD		
POLYPTERIFORMES	POLYPTERIDAE	<i>Polypterus bichir bichir</i>	RE		
POLYPTERIFORMES	POLYPTERIDAE	<i>Polypterus senegalus senegalus</i>	DD		
SALMONIFORMES	SALMONIDAE	<i>Salmo akairos</i>	VU	D2	Yes
SALMONIFORMES	SALMONIDAE	<i>Salmo macrostigma</i>	DD		Yes
SALMONIFORMES	SALMONIDAE	<i>Salmo pallaryi</i>	EX		Yes
SILURIFORMES	ARIIDAE	<i>Arius latiscutatus</i>	DD		
SILURIFORMES	BAGRIDAE	<i>Amarginops rueppelli</i>	DD		
SILURIFORMES	BAGRIDAE	<i>Auchenoglanis biscutatus</i>	VU	B2ab (ii,iii)	
SILURIFORMES	BAGRIDAE	<i>Auchenoglanis occidentalis</i>	VU	B2ab (ii,iii)	
SILURIFORMES	BAGRIDAE	<i>Bagrus bajad</i>	LC		
SILURIFORMES	BAGRIDAE	<i>Bagrus docmak</i>	LC		
SILURIFORMES	BAGRIDAE	<i>Chrysichthys auratus auratus</i>	LC		
SILURIFORMES	BAGRIDAE	<i>Chrysichthys nigrodigitatus</i>	DD		
SILURIFORMES	BAGRIDAE	<i>Clarotes laticeps</i>	RE		
SILURIFORMES	CLARIIDAE	<i>Clarias anguillaris</i>	DD		
SILURIFORMES	CLARIIDAE	<i>Clarias gariepinus</i>	LC		
SILURIFORMES	CLARIIDAE	<i>Heterobranchus bidorsalis</i>	VU	B2ab (iii)	
SILURIFORMES	CLARIIDAE	<i>Heterobranchus longifilis</i>	VU	B2ab (iii)	
SILURIFORMES	MALAPTERURIDAE	<i>Malapterurus electricus</i>	VU	B2ab (iii)	
SILURIFORMES	MOCHOKIDAE	<i>Chiloglanis niloticus</i>	DD		
SILURIFORMES	MOCHOKIDAE	<i>Mochokus niloticus</i>	VU	B2ab (iii)	
SILURIFORMES	MOCHOKIDAE	<i>Synodontis batensoda</i>	RE		
SILURIFORMES	MOCHOKIDAE	<i>Synodontis caudovittatus</i>	DD		
SILURIFORMES	MOCHOKIDAE	<i>Synodontis clarias</i>	VU	B2ab (iii)	
SILURIFORMES	MOCHOKIDAE	<i>Synodontis filamentosus</i>	DD		
SILURIFORMES	MOCHOKIDAE	<i>Synodontis frontosus</i>	DD		
SILURIFORMES	MOCHOKIDAE	<i>Synodontis membranaceus</i>	RE		
SILURIFORMES	MOCHOKIDAE	<i>Synodontis nigrita</i>	DD		
SILURIFORMES	MOCHOKIDAE	<i>Synodontis schall</i>	LC		
SILURIFORMES	MOCHOKIDAE	<i>Synodontis serratus</i>	VU	B2ab (iii)	
SILURIFORMES	MOCHOKIDAE	<i>Synodontis sores</i>	DD		
SILURIFORMES	SCHILBEIDAE	<i>Parailia pellucida</i>	DD		
SILURIFORMES	SCHILBEIDAE	<i>Schilbe mystus</i>	LC		
SILURIFORMES	SCHILBEIDAE	<i>Schilbe uranoscopus</i>	VU	B2b (ii,iii)	
SILURIFORMES	SCHILBEIDAE	<i>Siluranodon auritus</i>	RE		
TETRAODONTIFORMES	TETRAODONTIDAE	<i>Tetraodon lineatus</i>	DD		

Appendix 2. Red List status of northern African freshwater molluscs

Order	Family	Scientific name	IUCN Red List Category (North Africa)*	IUCN Red List Criteria	Endemic to the region?
MESOGASTROPODA	AMPULLARIIDAE	<i>Lanistes carinatus</i>	LC		
MESOGASTROPODA	AMPULLARIIDAE	<i>Lanistes varicus</i>	VU	D2	
MESOGASTROPODA	AMPULLARIIDAE	<i>Pila ovata</i>	LC		
BASOMMATOPHORA	ANCYLIDAE	<i>Ancylus fluviatilis</i>	LC		
BASOMMATOPHORA	ANCYLIDAE	<i>Ancylus strictus</i>	VU	B2ab(i,ii,iii,iv)	
BASOMMATOPHORA	ANCYLIDAE	<i>Ferrissia clessiniana</i>	DD		
BASOMMATOPHORA	ANCYLIDAE	<i>Ferrissia iselli</i>	DD		
BASOMMATOPHORA	ANCYLIDAE	<i>Ferrissia lhotelleriei</i>	DD		Yes
BASOMMATOPHORA	ANCYLIDAE	<i>Ferrissia pallaryi</i>	DD		Yes
BASOMMATOPHORA	ANCYLIDAE	<i>Ferrissia platyrhynchus</i>	DD		Yes
BASOMMATOPHORA	ANCYLIDAE	<i>Ferrissia</i> sp. indet.	DD		Yes
MESOGASTROPODA	BITHYNIIDAE	<i>Bithynia connollyi</i>	DD		
MESOGASTROPODA	BITHYNIIDAE	<i>Bithynia leachi</i>	EX		
MESOGASTROPODA	BITHYNIIDAE	<i>Bithynia tentaculata</i>	RE		
MESOGASTROPODA	BITHYNIIDAE	<i>Gabbiella senaariensis</i>	LC		
VENEROIDA	CORBICULIDAE	<i>Corbicula fluminalis</i>	LC		
UNIONOIDA	ETHERIIDAE	<i>Ethieria elliptica</i>	CR	B2ab(iii)	
MESOGASTROPODA	HYDROBIIDAE	<i>Attebania bernasconii</i>	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Belgrandia</i> (?) sp. nov. <i>wiwanensis</i> (nomen nudum)	VU	D2	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Belgrandiella</i> (?) <i>nana</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Belgrandiella</i> (?) sp. nov. <i>ramdani</i> (nomen nudum)	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Belgrandiella</i> (?) <i>seminium</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Bythinella</i> (?) <i>limnopsis</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Bythinella</i> (?) <i>mauritanica</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Bythinella</i> (?) <i>microcochlia</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Bythinella</i> (?) <i>punica</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Bythinella</i> (?) <i>sordida</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Bythinella</i> (?) sp. nov. <i>tiznitensis</i> (nomen nudum)	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Giustia bodoni</i>	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Giustia costata</i>	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Giustia gofasi</i>	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Giustia janai</i>	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Giustia mellalensis</i>	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Giustia meskiensis</i> (nomen nudum)	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Giustia midarensis</i>	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Giustia saidai</i>	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Heideella</i> (?) sp. nov. <i>boulali</i> (nomen nudum)	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Heideella</i> (?) <i>dolichia</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Heideella</i> (?) sp. nov. <i>kerdouensis</i> (nomen nudum)	CR	B1ab(iii)+2ab(iii)	Yes

Order	Family	Scientific name	IUCN Red List Category (North Africa)*	IUCN Red List Criteria	Endemic to the region?
MESOGASTROPODA	HYDROBIIDAE	<i>Heideella</i> (?) sp. nov. <i>knidirii</i>	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Heideella</i> (?) sp. nov. <i>salahi</i> (<i>nomen nudum</i>)	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Heideella</i> (?) sp. nov. <i>valai</i> (<i>nomen nudum</i>)	CR	B1ab(iii)+2a	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Heideella andraea</i>	VU	D2	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Heideella andreae</i>	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Heideella</i> sp. nov. <i>makhfamanensis</i> (<i>nomen nudum</i>)	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Horatia</i> sp. nov. <i>aghbalensis</i> (<i>nomen nudum</i>)	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Horatia</i> sp. nov. <i>haasei</i> (<i>nomen nudum</i>)	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia</i> (?) <i>elachista</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia</i> (?) <i>gracilis</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia</i> (<i>Peringia</i>) <i>recta</i>	LC		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia brondeli</i>	NT		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia djerbaensis</i>	VU		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia joossei</i>	NT		
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia maroccana</i>	EN	B2ab(i,ii,iii,iv)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia minoricensis</i>	EN	B2ab(iii)	
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia musaensis</i>	LC		
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia sordida</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Hydrobia ventrosa</i>	LC		
MESOGASTROPODA	HYDROBIIDAE	<i>Iglica soussensis</i>	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Marocopsis agadirensis</i>	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Mercuria</i> (?) <i>letourneuxiana</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Mercuria</i> (?) <i>perforata</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Mercuria</i> cf. <i>balearica</i>	EN	B2ab(iii)	
MESOGASTROPODA	HYDROBIIDAE	<i>Mercuria</i> cf. <i>zopissa</i>	CR	B1ab(iii)+2ab(iii)	
MESOGASTROPODA	HYDROBIIDAE	<i>Mercuria</i> sp. nov. <i>mirlbefsensis</i> (<i>nomen nudum</i>)	EN	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Mercuria punica</i>	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Mercuria similis</i>	LC		
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> cf. <i>spirata</i>	EN	B2ab(iii)	
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>barratei</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>constantinae</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>desertorum</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>doumeti</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>globulina</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>latasteana</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>luteola</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>oudrefica</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>ragia</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola</i> (?) <i>singularis</i>	EX		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola conovula</i>	VU	B2ab(iii)	
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola dupotetiana</i>	NT		
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola leprevieri</i>	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudamnicola meluzzii</i>	VU		Yes

Order	Family	Scientific name	IUCN Red List Category (North Africa)*	IUCN Red List Criteria	Endemic to the region?
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudammicola pallaryi</i>	CR	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Pseudoislamia</i> sp. nov. <i>yacoubii</i> (nomen nudum)	NT		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Semisalsa</i> (?) <i>arenaria</i>	DD		Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Semisalsa aponensis</i>	CR	B2ab(iii)	Yes
MESOGASTROPODA	HYDROBIIDAE	<i>Semisalsa aponensis</i>	LC		
MESOGASTROPODA	HYDROBIIDAE	<i>Semisalsa stagnorum</i>	LC		
UNIONOIDA	IRIDINIDAE	<i>Aspatharia chaiziana</i>	DD		
UNIONOIDA	IRIDINIDAE	<i>Chambardia letourneuxi</i>	EX		Yes
UNIONOIDA	IRIDINIDAE	<i>Chambardia rubens</i>	LC		
UNIONOIDA	IRIDINIDAE	<i>Mutela dubia</i>	LC		
UNIONOIDA	IRIDINIDAE	<i>Mutela rostrata</i>	LC		
BASOMMATOPHORA	LYMNAEIDAE	<i>Lymnaea</i> (?) <i>Stagnicola maroccana</i>	EN	B2ab(i,ii,iii,iv)	Yes
BASOMMATOPHORA	LYMNAEIDAE	<i>Lymnaea (Galba) truncatula</i>	LC		
BASOMMATOPHORA	LYMNAEIDAE	<i>Lymnaea (Lymnaea) stagnalis</i>	EN	B2ab(i,ii,iii,iv)	
BASOMMATOPHORA	LYMNAEIDAE	<i>Lymnaea (Pseudosuccinea) columella</i>	NA		
BASOMMATOPHORA	LYMNAEIDAE	<i>Lymnaea (Radix) natalensis</i>	LC		
BASOMMATOPHORA	LYMNAEIDAE	<i>Lymnaea (Radix) peregra</i>	LC		
BASOMMATOPHORA	LYMNAEIDAE	<i>Lymnaea (Stagnicola) palustris</i>	EN	B2ab(i,ii,iii,iv)	
BASOMMATOPHORA	LYMNAEIDAE	<i>Lymnaea auricularia</i>	EX		
UNIONOIDA	MARGARITIFERIDAE	<i>Margaritifera marocana</i>	CR	A2c; C1	Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis arbalensis</i>	DD		Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis brevicula</i>	CR	B2ab(iii)	Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis cariosa</i>	DD		
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis chlorotica</i>	CR	B1ab(i,ii,iii,iv)+2a b(i,ii,iii,iv)	Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis letourneuxi</i>	EN	B2ab(i,ii,iii,iv)	Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis magnifica</i>	EN	B2ab(iii)	Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis mourebeyensis</i>	EN	B2ab(iii)	Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis praemorsa</i>	LC		
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis saharica</i>	CR	B1ab(iii)+2ab(iii)	Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis scalaris</i>	EN	A2c	Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis subgraëllsiana</i>	VU	D2	Yes
MESOGASTROPODA	MELANOPSIDAE	<i>Melanopsis turgida</i>	DD		Yes
ARCHAEGASTROPODA	NERITIDAE	<i>Theodoxus maresi</i>	DD		Yes
ARCHAEGASTROPODA	NERITIDAE	<i>Theodoxus marteli</i>	VU	B2ab(i,ii,iii,iv)	Yes
ARCHAEGASTROPODA	NERITIDAE	<i>Theodoxus meridionalis</i>	EN	B1ab(i,ii,iii,iv)+2a b(i,ii,iii,iv)	
ARCHAEGASTROPODA	NERITIDAE	<i>Theodoxus niloticus</i>	LC		
ARCHAEGASTROPODA	NERITIDAE	<i>Theodoxus numidicus</i>	VU	B1ab(i,ii,iii,iv)+2a b(i,ii,iii,iv)	Yes
BASOMMATOPHORA	PHYSIDAE	<i>Physa acuta</i>	LC		
VENEROIDA	PISIDIIDAE	<i>Eupera ferruginea</i>	DD		
VENEROIDA	PISIDIIDAE	<i>Pisidium amnicum</i>	RE		
VENEROIDA	PISIDIIDAE	<i>Pisidium casertanum</i>	LC		
VENEROIDA	PISIDIIDAE	<i>Pisidium milium</i>	CR	B1ab(iii)+2ab(iii)	
VENEROIDA	PISIDIIDAE	<i>Pisidium nitidum</i>	CR	B2ab(iii)	
VENEROIDA	PISIDIIDAE	<i>Pisidium personatum</i>	VU	B2ab(iii)	

Order	Family	Scientific name	IUCN Red List Category (North Africa)*	IUCN Red List Criteria	Endemic to the region?
VENEROIDA	PISIDIIDAE	<i>Pisidium pirothi</i>	NT		
VENEROIDA	PISIDIIDAE	<i>Pisidium subtruncatum</i>	EN	B2ab(iii)	
VENEROIDA	PISIDIIDAE	<i>Pisidium tenuilineatum</i>	CR	B1ab(iii)+2ab(iii)	
VENEROIDA	PISIDIIDAE	<i>Sphaerium hartmanni</i>	LC		
VENEROIDA	PISIDIIDAE	<i>Sphaerium maroccanum</i>	DD		Yes
BASOMMATOPHORA	PLANORBIDAE	<i>Africanogyrus coretus</i>	LC		
BASOMMATOPHORA	PLANORBIDAE	<i>Anisus spirorbis</i>	EN	B2ab(i,ii,iii,iv)	
BASOMMATOPHORA	PLANORBIDAE	<i>Armiger crista</i>	EN	B2ab(i,ii,iii,iv)	
BASOMMATOPHORA	PLANORBIDAE	<i>Biomphalaria alexandrina</i>	LC		
BASOMMATOPHORA	PLANORBIDAE	<i>Biomphalaria glabrata</i>	NA		
BASOMMATOPHORA	PLANORBIDAE	<i>Biomphalaria pfeifferi</i>	LC		
BASOMMATOPHORA	PLANORBIDAE	<i>Bulinus forskalii</i>	LC		
BASOMMATOPHORA	PLANORBIDAE	<i>Bulinus truncatus</i>	LC		
BASOMMATOPHORA	PLANORBIDAE	<i>Gyraulus costulatus</i>	DD		
BASOMMATOPHORA	PLANORBIDAE	<i>Gyraulus ehrenbergi</i>	LC		
BASOMMATOPHORA	PLANORBIDAE	<i>Gyraulus laevis</i>	VU	B2ab(i,ii,iii,iv)	
BASOMMATOPHORA	PLANORBIDAE	<i>Helisoma duryi</i>	NA		
BASOMMATOPHORA	PLANORBIDAE	<i>Hippeutis complanatus</i>	EN	B2ab(i,ii,iii,iv)	
BASOMMATOPHORA	PLANORBIDAE	<i>Planorbarius metidjensis</i>	LC		
BASOMMATOPHORA	PLANORBIDAE	<i>Planorbis planorbis</i>	LC		
BASOMMATOPHORA	PLANORBIDAE	<i>Segmentorbis angustus</i>	VU	D2	
MESOGASTROPODA	PLEUROCERIDAE	<i>Cleopatra bulimoides</i>	LC		
MESOGASTROPODA	THIARIDAE	<i>Melanooides tuberculata</i>	LC		
UNIONOIDA	UNIONIDAE	<i>Anodonta lucasi</i>	CR	B1ab(i,ii,iii,iv)+2ab(i,ii,iii,iv)	Yes
UNIONOIDA	UNIONIDAE	<i>Anodonta pallaryi</i>	CR	B2ab(i,ii,iii,iv)	Yes
UNIONOIDA	UNIONIDAE	<i>Coelatura aegyptiaca</i>	LC		
UNIONOIDA	UNIONIDAE	<i>Nitia teretiuscula</i>	LC		
UNIONOIDA	UNIONIDAE	<i>Potomida littoralis</i>	EN	A2c; B2ab(i,ii,iii,iv)	Yes
UNIONOIDA	UNIONIDAE	<i>Unio durieui</i>	EN	A2c; B2ab(i,ii,iii,iv,v)	Yes
UNIONOIDA	UNIONIDAE	<i>Unio foucauldianus</i>	CR	A2c; B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)	Yes
MESOGASTROPODA	VALVATIDAE	<i>Valvata nilotica</i>	DD		
MESOGASTROPODA	VIVIPARIDAE	<i>Bellamya unicolor</i>	LC		

Appendix 3. Red List status of northern African Odonata

Order	Family	Scientific name	IUCN Red List Category (Northern Africa)	IUCN Red List Criteria	Endemic to the region?
Odonata	CALOPTERYGIDAE	<i>Calopteryx exul</i>	EN	B2ab(ii,iii,iv,v)	Yes
Odonata	CALOPTERYGIDAE	<i>Calopteryx haemorrhoidalis</i>	LC		
Odonata	CALOPTERYGIDAE	<i>Calopteryx virgo</i>	CR	B1ab(i,ii,iii,iv)+2ab(i,ii,iii,iv); C2a(i); D	
ODONATA	LESTIDAE	<i>Lestes barbarus</i>	LC		
ODONATA	LESTIDAE	<i>Lestes dryas</i>	VU	B1ab(iii)+2ab(iii)	
ODONATA	LESTIDAE	<i>Lestes numidicus</i>	DD		Yes
ODONATA	LESTIDAE	<i>Lestes virens</i>	LC		
ODONATA	LESTIDAE	<i>Lestes viridis</i>	LC		
ODONATA	LESTIDAE	<i>Sympecma fusca</i>	LC		
ODONATA	COENAGRIONIDAE	<i>Agriocnemis exilis</i>	RE		
ODONATA	COENAGRIONIDAE	<i>Agriocnemis sania</i>	RE		
ODONATA	COENAGRIONIDAE	<i>Ceriagrion glabrum</i>	RE		
Odonata	COENAGRIONIDAE	<i>Ceriagrion tenellum</i>	LC		
ODONATA	COENAGRIONIDAE	<i>Coenagrion caeruleum</i>	LC		
ODONATA	COENAGRIONIDAE	<i>Coenagrion mercuriale</i>	EN	B2ab(i,ii,iii,iv,v); C2a(i)	
ODONATA	COENAGRIONIDAE	<i>Coenagrion puella</i>	LC		
ODONATA	COENAGRIONIDAE	<i>Coenagrion scitulum</i>	NT		
ODONATA	COENAGRIONIDAE	<i>Enallagma cyathigerum</i>	DD		
ODONATA	COENAGRIONIDAE	<i>Enallagma deserti</i>	LC		Yes
ODONATA	COENAGRIONIDAE	<i>Erythromma lindenii</i>	LC		
ODONATA	COENAGRIONIDAE	<i>Erythromma viridulum</i>	LC		
ODONATA	COENAGRIONIDAE	<i>Ischnura evansi</i>	DD		
Odonata	COENAGRIONIDAE	<i>Ischnura fontaineae</i>	LC		
ODONATA	COENAGRIONIDAE	<i>Ischnura graellsii</i>	LC		
ODONATA	COENAGRIONIDAE	<i>Ischnura punilio</i>	LC		
ODONATA	COENAGRIONIDAE	<i>Ischnura saharensis</i>	LC		Yes
ODONATA	COENAGRIONIDAE	<i>Ischnura senegalensis</i>	DD		
ODONATA	COENAGRIONIDAE	<i>Pseudagrion hamoni</i>	VU	D2	
ODONATA	COENAGRIONIDAE	<i>Pseudagrion niloticum</i>	EN	B2ab(i,ii,iii,iv,v)	
ODONATA	COENAGRIONIDAE	<i>Pseudagrion nubicum</i>	EN	B2ab(i,ii,iii,iv,v)	
ODONATA	COENAGRIONIDAE	<i>Pseudagrion sublacteum</i>	CR	B2ab(iii)	
ODONATA	COENAGRIONIDAE	<i>Pseudagrion torridum</i>	LC		
Odonata	COENAGRIONIDAE	<i>Pyrrhosoma nymphula</i>	NT		
ODONATA	PLATYCNEMIDIDAE	<i>Mesocnemis robusta</i>	CR	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)	
ODONATA	PLATYCNEMIDIDAE	<i>Platycnemis subdilatata</i>	LC		Yes
ODONATA	AESHNIDAE	<i>Aeshna affinis</i>	VU	B2ab(ii,v)	
ODONATA	AESHNIDAE	<i>Aeshna cyanea</i>	EN	B2ab(i,iii)	
ODONATA	AESHNIDAE	<i>Aeshna isocles</i>	VU	B2ab(i,ii,iii)	
ODONATA	AESHNIDAE	<i>Aeshna mixta</i>	LC		
ODONATA	AESHNIDAE	<i>Anax ephippiger</i>	LC		
ODONATA	AESHNIDAE	<i>Anax imperator</i>	LC		

Order	Family	Scientific name	IUCN Red List Category (Northern Africa)	IUCN Red List Criteria	Endemic to the region?
ODONATA	AESHNIDAE	<i>Anax parthenope</i>	LC		
Odonata	AESHNIDAE	<i>Boyeria irene</i>	NT		
ODONATA	GOMPHIDAE	<i>Gomphus lucasii</i>	VU	A3c; C1	Yes
ODONATA	GOMPHIDAE	<i>Gomphus simillimus</i>	NT		
ODONATA	GOMPHIDAE	<i>Lindenia tetraphylla</i>	CR	B1ab(i,ii,iii,iv)+2ab(i,ii,iii,iv); C2a(i); D	
ODONATA	GOMPHIDAE	<i>Onychogomphus costae</i>	NT		
ODONATA	GOMPHIDAE	<i>Onychogomphus forcipatus</i>	LC		
ODONATA	GOMPHIDAE	<i>Onychogomphus uncatus</i>	LC		
ODONATA	GOMPHIDAE	<i>Paragomphus genei</i>	LC		
ODONATA	GOMPHIDAE	<i>Paragomphus pumilio</i>	LC		
ODONATA	CORDULEGASTRIDAE	<i>Cordulegaster boltonii</i>	NT		
Odonata	CORDULEGASTRIDAE	<i>Cordulegaster princeps</i>	NT		Yes
ODONATA	CORDULIIDAE	<i>Cordulia aenea</i>	RE		
ODONATA	CORDULIIDAE	<i>Oxygastra curtisii</i>	CR	B2ab(iii,iv); C2a(i)	
ODONATA	MACROMIIDAE	<i>Phyllomacromia picta</i>	RE		
ODONATA	LIBELLULIDAE	<i>Acisoma panorpoides</i>	EN	A2c; B2ab(iii)	
ODONATA	LIBELLULIDAE	<i>Brachythemis leucosticta</i>	LC		
ODONATA	LIBELLULIDAE	<i>Crocothemis erythraea</i>	LC		
ODONATA	LIBELLULIDAE	<i>Diplacodes lefebvrii</i>	LC		
ODONATA	LIBELLULIDAE	<i>Libellula quadrimaculata</i>	VU	D2	
ODONATA	LIBELLULIDAE	<i>Nesiothemis farinosa</i>	EN	B2ab(i,ii,iii,iv)	
Odonata	LIBELLULIDAE	<i>Orthetrum brunneum</i>	LC		
ODONATA	LIBELLULIDAE	<i>Orthetrum cancellatum</i>	LC		
ODONATA	LIBELLULIDAE	<i>Orthetrum chrysostigma</i>	LC		
ODONATA	LIBELLULIDAE	<i>Orthetrum coerulescens</i>	LC		
ODONATA	LIBELLULIDAE	<i>Orthetrum nitidinerve</i>	LC		
ODONATA	LIBELLULIDAE	<i>Orthetrum ransonnetii</i>	DD		
ODONATA	LIBELLULIDAE	<i>Orthetrum sabina</i>	LC		
ODONATA	LIBELLULIDAE	<i>Orthetrum trinacria</i>	LC		
ODONATA	LIBELLULIDAE	<i>Pantala flavescens</i>	NA		
ODONATA	LIBELLULIDAE	<i>Rhyothemis semihyalina</i>	RE		
Odonata	LIBELLULIDAE	<i>Selysiothemis nigra</i>	LC		
ODONATA	LIBELLULIDAE	<i>Sympetrum fonscolombii</i>	LC		
ODONATA	LIBELLULIDAE	<i>Sympetrum meridionale</i>	LC		
ODONATA	LIBELLULIDAE	<i>Sympetrum sanguineum</i>	VU	C1	
ODONATA	LIBELLULIDAE	<i>Sympetrum sinaiticum</i>	LC		
ODONATA	LIBELLULIDAE	<i>Sympetrum striolatum</i>	LC		
ODONATA	LIBELLULIDAE	<i>Trithemis annulata</i>	LC		
ODONATA	LIBELLULIDAE	<i>Trithemis arteriosa</i>	LC		
ODONATA	LIBELLULIDAE	<i>Trithemis kirbyi</i>	LC		
ODONATA	LIBELLULIDAE	<i>Urothemis edwardsii</i>	CR	A2ac; B1ab(ii,iii,iv,v)+2ab(ii,iii,iv,v); C1+2a(ii); D	
ODONATA	LIBELLULIDAE	<i>Zygonyx torridus</i>	NT		

Appendix 4. Red List status of northern African freshwater crabs

Order	Family	Scientific name	IUCN Red List Category (North Africa)*	IUCN Red List Criteria	Endemic to the region?
DECAPODA	POTAMIDAE	<i>Potamon algeriense</i>	LC		Yes
DECAPODA	POTAMONAUTIDAE	<i>Potamonautes berardi</i>	LC		
DECAPODA	POTAMONAUTIDAE	<i>Potamonautes niloticus</i>	LC		

Appendix 5. Red List status of northern African aquatic plants

Order	Family	Scientific name	IUCN Red List Category (Northern Africa)	IUCN Red List Criteria	Endemic to the region?
PTERIDALES	ADIANTACEAE	<i>Adiantum capillus-veneris</i>	LC		
ALISMATALES	ALISMATAACEAE	<i>Alisma gramineum</i>	NT		
ALISMATALES	ALISMATAACEAE	<i>Alisma lanceolatum</i>	LC		
ALISMATALES	ALISMATAACEAE	<i>Alisma plantago-aquatica</i>	LC		
ALISMATALES	ALISMATAACEAE	<i>Baldellia ranunculoides</i>	NT		
ALISMATALES	ALISMATAACEAE	<i>Baldellia repens</i>	VU	B2ab(ii,iii); C2a(i)	
ALISMATALES	ALISMATAACEAE	<i>Caldesia reniformis</i>	DD		
ALISMATALES	ALISMATAACEAE	<i>Damasonium bourgaei</i>	NT	B2b(ii,iii)	
ALISMATALES	ALISMATAACEAE	<i>Damasonium polyspermum</i>	VU	B2b(iii,iv); D2	
CARYOPHYLLALES	AMARANTHACEAE	<i>Alternanthera nodiflora</i>	DD		
CARYOPHYLLALES	AMARANTHACEAE	<i>Alternanthera pungens</i>	NA		
CARYOPHYLLALES	AMARANTHACEAE	<i>Alternanthera sessilis</i>	LC		
BLECHNALES	BLECHNACEAE	<i>Woodwardia radicans</i>	VU	D2	
LAMIALES	BORAGINACEAE	<i>Coldenia procumbens</i>	VU	D2	
LAMIALES	BORAGINACEAE	<i>Myosotis atlantica</i>	NT		Yes
LAMIALES	BORAGINACEAE	<i>Myosotis debilis</i>	NT		
LAMIALES	BORAGINACEAE	<i>Myosotis decumbens</i>	LC		Yes
LAMIALES	BORAGINACEAE	<i>Myosotis laxa</i>	LC		
LAMIALES	BORAGINACEAE	<i>Myosotis welwitschii</i>	LC		
ALISMATALES	BUTOMACEAE	<i>Butomus umbellatus</i>	EN	B2ab(ii,iii)	
CALLITRICHALES	CALLITRICHACEAE	<i>Callitriche brutia</i>	LC		
CALLITRICHALES	CALLITRICHACEAE	<i>Callitriche cribrosa</i>	DD		
CALLITRICHALES	CALLITRICHACEAE	<i>Callitriche lusitanica</i>	DD		
CALLITRICHALES	CALLITRICHACEAE	<i>Callitriche mathezii</i>	EN	B1ab(ii,iii,iv,v)+2ab(ii,iii,iv,v)	Yes
CALLITRICHALES	CALLITRICHACEAE	<i>Callitriche obtusangula</i>	LC		
CALLITRICHALES	CALLITRICHACEAE	<i>Callitriche pulchra</i>	DD		
CALLITRICHALES	CALLITRICHACEAE	<i>Callitriche regis-jubae</i>	DD		
CALLITRICHALES	CALLITRICHACEAE	<i>Callitriche stagnalis</i>	LC		
CALLITRICHALES	CALLITRICHACEAE	<i>Callitriche truncata</i>	LC		
CAMPANULALES	CAMPANULACEAE	<i>Campanula alata</i>	VU	B2ab(ii)	
CAMPANULALES	CAMPANULACEAE	<i>Campanula dimorphantha</i>	DD		
CAMPANULALES	CAMPANULACEAE	<i>Campanula mairei</i>	VU	B1ab(iii)	Yes
CAMPANULALES	CAMPANULACEAE	<i>Solenopsis bicolor</i>	NT		Yes
CAMPANULALES	CAMPANULACEAE	<i>Solenopsis laurentia</i>	LC		
CAMPANULALES	CAMPANULACEAE	<i>Sphenoclea zeylanica</i>	DD		
CARYOPHYLLALES	CARYOPHYLLACEAE	<i>Cerastium perfoliatum</i>	LC		
CARYOPHYLLALES	CARYOPHYLLACEAE	<i>Spergularia doumerguei</i>	VU	B1ab(iii)	Yes
CARYOPHYLLALES	CARYOPHYLLACEAE	<i>Spergularia embergeri</i>	VU	B1ab(iii)	Yes
CARYOPHYLLALES	CARYOPHYLLACEAE	<i>Spergularia marina</i>	LC		
CARYOPHYLLALES	CARYOPHYLLACEAE	<i>Spergularia tangerina</i>	LC		
CARYOPHYLLALES	CARYOPHYLLACEAE	<i>Stellaria alsine</i>	LC		
NYMPHAEALES	CERATOPHYLLACEAE	<i>Ceratophyllum demersum</i>	LC		

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NYMPHAEALES	CERATOPHYLLACEAE	<i>Ceratophyllum muricatum</i>	LC		
CHARALES	CHARACEAE	<i>Chara vulgaris</i>	LC		
ASTERALES	COMPOSITAE	<i>Ambrosia maritima</i>	LC		
ASTERALES	COMPOSITAE	<i>Bellis caerulescens</i>	LC		Yes
ASTERALES	COMPOSITAE	<i>Bellis prostrata</i>	NT		
ASTERALES	COMPOSITAE	<i>Blainvillea acmella</i>	DD		
ASTERALES	COMPOSITAE	<i>Ceruana pratensis</i>	LC		
ASTERALES	COMPOSITAE	<i>Cirsium chrysanthum</i>	NT		Yes
ASTERALES	COMPOSITAE	<i>Cirsium ducellieri</i>	VU	B1ab(iii)	Yes
ASTERALES	COMPOSITAE	<i>Conyza aegyptiaca</i>	DD		
ASTERALES	COMPOSITAE	<i>Doellia bovei</i>	DD		
ASTERALES	COMPOSITAE	<i>Ethulia conyzoides</i>	DD		
ASTERALES	COMPOSITAE	<i>Flaveria bidentis</i>	DD		
ASTERALES	COMPOSITAE	<i>Gnaphalium uliginosum</i>	LC		
ASTERALES	COMPOSITAE	<i>Grangea maderaspatana</i>	DD		
ASTERALES	COMPOSITAE	<i>Homognaphalium crispatum</i>	DD		Yes
ASTERALES	COMPOSITAE	<i>Homognaphalium pulvinatum</i>	DD		
ASTERALES	COMPOSITAE	<i>Hypochaeris angustifolia</i>	LC		Yes
ASTERALES	COMPOSITAE	<i>Lactuca virosa</i>	LC		
ASTERALES	COMPOSITAE	<i>Pluchea dioscoridis</i>	LC		
ASTERALES	COMPOSITAE	<i>Pluchea ovalis</i>	NT		
ASTERALES	COMPOSITAE	<i>Pseudoconyza viscosa</i>	DD		
ASTERALES	COMPOSITAE	<i>Pseudognaphalium luteoalbum</i>	LC		
ASTERALES	COMPOSITAE	<i>Pulicaria arabica</i>	LC		
ASTERALES	COMPOSITAE	<i>Pulicaria filaginoides</i>	CR	B1ab(iii)+2ab(iii)	Yes
ASTERALES	COMPOSITAE	<i>Pulicaria inuloides</i>	LC		
ASTERALES	COMPOSITAE	<i>Pulicaria laciniata</i>	LC		Yes
ASTERALES	COMPOSITAE	<i>Pulicaria vulgaris</i>	LC		
ASTERALES	COMPOSITAE	<i>Scorzoneroides atlantica</i>	LC		Yes
ASTERALES	COMPOSITAE	<i>Senecio aegyptius</i>	DD		
ASTERALES	COMPOSITAE	<i>Senecio giganteus</i>	NT		Yes
ASTERALES	COMPOSITAE	<i>Sonchus macrocarpus</i>	DD		Yes
ASTERALES	COMPOSITAE	<i>Sonchus maritimus</i>	LC		
ASTERALES	COMPOSITAE	<i>Sonchus mauritanicus</i>	NT		Yes
ASTERALES	COMPOSITAE	<i>Sphaeranthus suaveolens</i>	DD		
SOLANALES	CONVOLVULACEAE	<i>Convolvulus durandoi</i>	CR	B2ab(i,ii,iii,iv,v)	Yes
SOLANALES	CONVOLVULACEAE	<i>Cressa cretica</i>	LC		
SOLANALES	CONVOLVULACEAE	<i>Ipomoea carnea</i>	DD		
SOLANALES	CONVOLVULACEAE	<i>Ipomoea sagittata</i>	EN	B2ab(ii,iii,iv)	
ROSALES	CRASSULACEAE	<i>Crassula alata</i>	LC		
ROSALES	CRASSULACEAE	<i>Crassula tillaea</i>	LC		
ROSALES	CRASSULACEAE	<i>Crassula vaillantii</i>	NT		
ROSALES	CRASSULACEAE	<i>Sedum bracteatum</i>	DD		Yes
CAPPALES	CRUCIFERAE	<i>Cardamine pratensis</i>	VU	D2	Yes
CAPPALES	CRUCIFERAE	<i>Coronopus squamatus</i>	LC		
CAPPALES	CRUCIFERAE	<i>Lepidium violaceum</i>	VU	B2ab(iii)	Yes
CAPPALES	CRUCIFERAE	<i>Nasturtium officinale</i>	DD		
CAPPALES	CRUCIFERAE	<i>Rorippa amphibia</i>	EN	B2ab(iii)	
CAPPALES	CRUCIFERAE	<i>Rorippa hayanica</i>	VU	B1ab(iii)+2ab(iii)	Yes

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CAPPARALES	CRUCIFERAE	<i>Rorippa indica</i>	LC		
CAPPARALES	CRUCIFERAE	<i>Sisymbrella aspera</i>	LC		
CYPERALES	CYPERACEAE	<i>Blysmus compressus</i>	VU	D2	
CYPERALES	CYPERACEAE	<i>Bolboschoenus maritimus</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex acuta</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex acutiformis</i>	VU	B2ab(ii); D2	
CYPERALES	CYPERACEAE	<i>Carex demissa</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex distans</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex divisa</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex divulsa</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex echinata</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex elata</i>	EN	B1ab(ii,iii,iv)+2ab(ii,iii,iv)	
CYPERALES	CYPERACEAE	<i>Carex extensa</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex fissirostris</i>	EN	B1ab(iii,v)	Yes
CYPERALES	CYPERACEAE	<i>Carex flava</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex hirta</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex hispida</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex hordeistichos</i>	NT		
CYPERALES	CYPERACEAE	<i>Carex illegitima</i>	EN	B1ab(iii)	
CYPERALES	CYPERACEAE	<i>Carex laevigata</i>	EN	B1ab(iii)	
CYPERALES	CYPERACEAE	<i>Carex lepidocarpa</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex mairii</i>	NT		
CYPERALES	CYPERACEAE	<i>Carex maritima</i>	VU	D2	
CYPERALES	CYPERACEAE	<i>Carex muricata</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex nigra</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex otrubae</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex ovalis</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex pachystylis</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex paniculata</i>	VU	B2ab(iii)	
CYPERALES	CYPERACEAE	<i>Carex pendula</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex pseudocyperus</i>	VU	B2ab(ii,iii); D2	
CYPERALES	CYPERACEAE	<i>Carex punctata</i>	LC		
CYPERALES	CYPERACEAE	<i>Carex riparia</i>	VU	B2ab(iii); D2	
CYPERALES	CYPERACEAE	<i>Cladium mariscus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus alopecuroides</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus articulatus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus bulbosus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus capitatus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus compressus</i>	DD		
CYPERALES	CYPERACEAE	<i>Cyperus difformis</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus digitatus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus esculentus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus fuscus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus imbricatus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus laevigatus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus longus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus maculatus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus michelianus</i>	NT		

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CYPERALES	CYPERACEAE	<i>Cyperus microbolbos</i>	VU	D2	
CYPERALES	CYPERACEAE	<i>Cyperus papyrus</i>	VU	D2	
CYPERALES	CYPERACEAE	<i>Cyperus rotundus</i>	LC		
CYPERALES	CYPERACEAE	<i>Cyperus schimperianus</i>	LC		
CYPERALES	CYPERACEAE	<i>Eleocharis acicularis</i>	VU	B1b(iii)	
CYPERALES	CYPERACEAE	<i>Eleocharis caduca</i>	DD		
CYPERALES	CYPERACEAE	<i>Eleocharis geniculata</i>	NA		
CYPERALES	CYPERACEAE	<i>Eleocharis multicaulis</i>	NT	B2b(iii)	
CYPERALES	CYPERACEAE	<i>Eleocharis palustris</i>	LC		
CYPERALES	CYPERACEAE	<i>Eleocharis parvula</i>	NA		
CYPERALES	CYPERACEAE	<i>Eleocharis quinqueflora</i>	LC		
CYPERALES	CYPERACEAE	<i>Eleocharis uniglumis</i>	NT	D2	
CYPERALES	CYPERACEAE	<i>Fimbristylis bisumbellata</i>	LC		
CYPERALES	CYPERACEAE	<i>Fimbristylis cioniana</i>	CR	B2ab(iii)	
CYPERALES	CYPERACEAE	<i>Fimbristylis sieberiana</i>	NT		
CYPERALES	CYPERACEAE	<i>Fimbristylis squarrosa</i>	NT		
CYPERALES	CYPERACEAE	<i>Fuirena ciliaris</i>	LC		
CYPERALES	CYPERACEAE	<i>Fuirena pubescens</i>	NT		
CYPERALES	CYPERACEAE	<i>Isolepis cernua</i>	LC		
CYPERALES	CYPERACEAE	<i>Isolepis pseudosetacea</i>	LC		
CYPERALES	CYPERACEAE	<i>Isolepis setacea</i>	LC		
CYPERALES	CYPERACEAE	<i>Kreczetoviczia caespitosa</i>	NA	D	
CYPERALES	CYPERACEAE	<i>Mariscus hamulosus</i>	VU	B2ab(ii,iii,iv)c(iv)	
CYPERALES	CYPERACEAE	<i>Pycreus flavescens</i>	LC		
CYPERALES	CYPERACEAE	<i>Pycreus flavidus</i>	NT		
CYPERALES	CYPERACEAE	<i>Pycreus mundtii</i>	LC		
CYPERALES	CYPERACEAE	<i>Pycreus polystachyos</i>	LC		
CYPERALES	CYPERACEAE	<i>Rhynchospora modesti-lucennoi</i>	EN	B2ab(ii,iii,iv,v); C2a(i)	
CYPERALES	CYPERACEAE	<i>Schoenoplectus corymbosus</i>	LC		
CYPERALES	CYPERACEAE	<i>Schoenoplectus lacustris</i>	LC		
CYPERALES	CYPERACEAE	<i>Schoenoplectus litoralis</i>	LC		
CYPERALES	CYPERACEAE	<i>Schoenoplectus mucronatus</i>	CR	B1ab(iii)+2ab(iii)	
CYPERALES	CYPERACEAE	<i>Schoenoplectus praelongatus</i>	LC		
CYPERALES	CYPERACEAE	<i>Schoenoplectus subulatus</i>	LC		
CYPERALES	CYPERACEAE	<i>Schoenoplectus supinus</i>	NT		
CYPERALES	CYPERACEAE	<i>Schoenoplectus triquetter</i>	CR	B1ab(iv)+2ab(iv); C2a(ii); D	
CYPERALES	CYPERACEAE	<i>Schoenus nigricans</i>	LC		
CYPERALES	CYPERACEAE	<i>Scirpoides holoschenus</i>	LC		
THEALES	ELATINACEAE	<i>Elatine alsinastrum</i>	CR	B2ab(iii)	
THEALES	ELATINACEAE	<i>Elatine brochonii</i>	VU	B2ab(i,ii,iii,iv,v)	
THEALES	ELATINACEAE	<i>Elatine macropoda</i>	NT		
EUPHORBIALES	EUPHORBIACEAE	<i>Euphorbia cuneifolia</i>	LC		
EUPHORBIALES	EUPHORBIACEAE	<i>Euphorbia nereidum</i>	VU	B2ab(iii)	Yes
EUPHORBIALES	EUPHORBIACEAE	<i>Euphorbia paniculata</i>	LC		
GENTIANALES	GENTIANACEAE	<i>Centaurium candelabrum</i>	LC		Yes
GENTIANALES	GENTIANACEAE	<i>Centaurium pulchellum</i>	LC		
GENTIANALES	GENTIANACEAE	<i>Centaurium spicatum</i>	LC		

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GENTIANALES	GENTIANACEAE	<i>Cicendia filiformis</i>	LC		
GENTIANALES	GENTIANACEAE	<i>Exaculum pusillum</i>	NT		
CYPERALES	GRAMINEAE	<i>Aeluropus lagopoides</i>	LC		
CYPERALES	GRAMINEAE	<i>Aeluropus littoralis</i>	LC		
CYPERALES	GRAMINEAE	<i>Agrostis reuteri</i>	LC		
CYPERALES	GRAMINEAE	<i>Agrostis stolonifera</i>	LC		
CYPERALES	GRAMINEAE	<i>Agrostis tenerrima</i>	VU	B2ab(iii)	
CYPERALES	GRAMINEAE	<i>Alopecurus aequalis</i>	VU	D2	
CYPERALES	GRAMINEAE	<i>Alopecurus arundinaceus</i>	LC		
CYPERALES	GRAMINEAE	<i>Alopecurus bulbosus</i>	NT		
CYPERALES	GRAMINEAE	<i>Antinoria agrostidea</i>	LC		
CYPERALES	GRAMINEAE	<i>Arundo donax</i>	LC		
CYPERALES	GRAMINEAE	<i>Brachiaria deflexa</i>	DD		
CYPERALES	GRAMINEAE	<i>Brachiaria eruciformis</i>	LC		
CYPERALES	GRAMINEAE	<i>Brachiaria mutica</i>	LC		
CYPERALES	GRAMINEAE	<i>Catabrosa aquatica</i>	VU	B2ab(iii); D2	
CYPERALES	GRAMINEAE	<i>Crypsis aculeata</i>	LC		
CYPERALES	GRAMINEAE	<i>Crypsis acuminata</i>	LC		
CYPERALES	GRAMINEAE	<i>Crypsis alopecuroides</i>	LC		
CYPERALES	GRAMINEAE	<i>Crypsis schoenoides</i>	LC		
CYPERALES	GRAMINEAE	<i>Crypsis vaginiflora</i>	NT		
CYPERALES	GRAMINEAE	<i>Echinochloa colona</i>	LC		
CYPERALES	GRAMINEAE	<i>Echinochloa pyramidalis</i>	LC		
CYPERALES	GRAMINEAE	<i>Glyceria declinata</i>	VU	D2	
CYPERALES	GRAMINEAE	<i>Glyceria fluitans</i>	EN	B2ab(iii)	
CYPERALES	GRAMINEAE	<i>Glyceria notata</i>	LC		
CYPERALES	GRAMINEAE	<i>Glyceria spicata</i>	LC		
CYPERALES	GRAMINEAE	<i>Hemarthria altissima</i>	NT		
CYPERALES	GRAMINEAE	<i>Imperata cylindrica</i>	LC		
CYPERALES	GRAMINEAE	<i>Leersia hexandra</i>	LC		
CYPERALES	GRAMINEAE	<i>Leersia oryzoides</i>	LC		
CYPERALES	GRAMINEAE	<i>Leptochloa fusca</i>	LC		
CYPERALES	GRAMINEAE	<i>Leptochloa ginae</i>	EN	B1ab(iii)	Yes
CYPERALES	GRAMINEAE	<i>Leptochloa panicea</i>	LC		
CYPERALES	GRAMINEAE	<i>Microproprsis tuberosa</i>	CR	B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	
CYPERALES	GRAMINEAE	<i>Molinia caerulea</i>	VU	B1ab(iii)+2ab(iii)	
CYPERALES	GRAMINEAE	<i>Panicum coloratum</i>	LC		
CYPERALES	GRAMINEAE	<i>Panicum hygrocharis</i>	DD		
CYPERALES	GRAMINEAE	<i>Panicum repens</i>	LC		
CYPERALES	GRAMINEAE	<i>Paspalidium geminatum</i>	LC		
CYPERALES	GRAMINEAE	<i>Paspalidium obtusifolium</i>	LC		
CYPERALES	GRAMINEAE	<i>Phalaris aquatica</i>	LC		
CYPERALES	GRAMINEAE	<i>Phalaris arundinacea</i>	LC		
CYPERALES	GRAMINEAE	<i>Phalaris brachystachys</i>	LC		
CYPERALES	GRAMINEAE	<i>Phalaris caesia</i>	EN	B2ab(ii,iii,v)	
CYPERALES	GRAMINEAE	<i>Phalaris coerulescens</i>	LC		
CYPERALES	GRAMINEAE	<i>Phalaris elongata</i>	LC		
CYPERALES	GRAMINEAE	<i>Phalaris paradoxa</i>	LC		

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CYPERALES	GRAMINEAE	<i>Phalaris truncata</i>	LC		
CYPERALES	GRAMINEAE	<i>Phragmites australis</i>	LC		
CYPERALES	GRAMINEAE	<i>Phragmites mauritianus</i>	LC		
CYPERALES	GRAMINEAE	<i>Poa dimorphanta</i>	LC		
CYPERALES	GRAMINEAE	<i>Polypogon maritimus</i>	LC		
CYPERALES	GRAMINEAE	<i>Polypogon monspeliensis</i>	LC		
CYPERALES	GRAMINEAE	<i>Polypogon viridis</i>	LC		
CYPERALES	GRAMINEAE	<i>Puccinellia convoluta</i>	VU	B1ab(iv)+2ab(iv)	
CYPERALES	GRAMINEAE	<i>Puccinellia festuciformis</i>	VU	B2ab(iii); D2	
CYPERALES	GRAMINEAE	<i>Saccharum spontaneum</i>	LC		
CYPERALES	GRAMINEAE	<i>Sorghum halepense</i>	LC		
CYPERALES	GRAMINEAE	<i>Spartina maritima</i>	EN	B2ab(iii)	
CYPERALES	GRAMINEAE	<i>Sphenopus divaricatus</i>	LC		
THEALES	GUTTIFERAE	<i>Hypericum afrum</i>	NT		Yes
HALORAGALES	HALORAGACEAE	<i>Laurembergia tetrandra</i>	RE		
HALORAGALES	HALORAGACEAE	<i>Myriophyllum alterniflorum</i>	LC		
HALORAGALES	HALORAGACEAE	<i>Myriophyllum spicatum</i>	LC		
HALORAGALES	HALORAGACEAE	<i>Myriophyllum verticillatum</i>	LC		
LILIALES	HYACINTHACEAE	<i>Cathissa broteroi</i>	LC		
HYDROCHARITALES	HYDROCHARITACEAE	<i>Hydrocharis morsus-ranae</i>	EN	B2ab(i,ii); D2	
HYDROCHARITALES	HYDROCHARITACEAE	<i>Najas graminea</i>	DD		
HYDROCHARITALES	HYDROCHARITACEAE	<i>Najas horrida</i>	VU	A2be+4be	
HYDROCHARITALES	HYDROCHARITACEAE	<i>Najas marina</i>	LC		
HYDROCHARITALES	HYDROCHARITACEAE	<i>Najas minor</i>	LC		
HYDROCHARITALES	HYDROCHARITACEAE	<i>Najas pectinata</i>	VU	D2	
HYDROCHARITALES	HYDROCHARITACEAE	<i>Ottelia alismoides</i>	LC		
HYDROCHARITALES	HYDROCHARITACEAE	<i>Vallisneria spiralis</i>	CR	B2ab(iii)	
CARYOPHYLLALES	ILLECEBRACEAE	<i>Illecebrum verticillatum</i>	LC		
LILIALES	IRIDACEAE	<i>Iris pseudacorus</i>	LC		
LILIALES	IRIDACEAE	<i>Romulea antiatlantica</i>	CR	B2ab(iii)	Yes
ISOETALES	ISOETACEAE	<i>Isoetes histrix</i>	LC		
ISOETALES	ISOETACEAE	<i>Isoetes setacea</i>	CR	B2ab(iii)	
ISOETALES	ISOETACEAE	<i>Isoetes velata</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus acutiflorus</i>	NT		
JUNCALES	JUNCACEAE	<i>Juncus acutus</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus anceps</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus articulatus</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus bufonius</i>	EN	B1ab(ii,iii,iv,v)	Yes
JUNCALES	JUNCACEAE	<i>Juncus bulbosus</i>	NT		
JUNCALES	JUNCACEAE	<i>Juncus capitatus</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus conglomeratus</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus effusus</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus foliosus</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus fontanesii</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus gerardi</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus heterophyllus</i>	NT		
JUNCALES	JUNCACEAE	<i>Juncus inflexus</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus littoralis</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus maritimus</i>	LC		

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JUNCALES	JUNCACEAE	<i>Juncus maroccanus</i>	CR	B1ab(iii)+2ab(iii)	Yes
JUNCALES	JUNCACEAE	<i>Juncus punctorius</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus pygmaeus</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus sorrentini</i>	EN	B1ab(ii,iv)+2ab(ii,iv)	
JUNCALES	JUNCACEAE	<i>Juncus sphaerocarpus</i>	NT	B1ab(iv)+2ab(iv)	
JUNCALES	JUNCACEAE	<i>Juncus squarrosus</i>	NA		
JUNCALES	JUNCACEAE	<i>Juncus striatus</i>	NT		
JUNCALES	JUNCACEAE	<i>Juncus subnodulosus</i>	VU	B1ab(iii)+2ab(iii)	
JUNCALES	JUNCACEAE	<i>Juncus subulatus</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus tenageia</i>	LC		
JUNCALES	JUNCACEAE	<i>Juncus tingitanus</i>	CR	B2ab(ii,iii,v)	
JUNCALES	JUNCACEAE	<i>Juncus valvatus</i>	NT		
NAJADALES	JUNCAGINACEAE	<i>Triglochin bulbosa</i>	NT		
NAJADALES	JUNCAGINACEAE	<i>Triglochin maritima</i>	NA		
NAJADALES	JUNCAGINACEAE	<i>Triglochin palustris</i>	NA		
LAMIALES	LABIATAE	<i>Lycopus europaeus</i>	LC		
LAMIALES	LABIATAE	<i>Mentha aquatica</i>	LC		
LAMIALES	LABIATAE	<i>Mentha cervina</i>	CR	B2ab(iii)	
LAMIALES	LABIATAE	<i>Mentha gattefossei</i>	NT		Yes
LAMIALES	LABIATAE	<i>Mentha longifolia</i>	LC		
LAMIALES	LABIATAE	<i>Mentha pulegium</i>	LC		
LAMIALES	LABIATAE	<i>Mentha spicata</i>	LC		
LAMIALES	LABIATAE	<i>Mentha suaveolens</i>	LC		
LAMIALES	LABIATAE	<i>Teucrium scordium</i>	LC		
FABALES	LEGUMINOSAE	<i>Acacia nilotica</i>	NA		
FABALES	LEGUMINOSAE	<i>Cullen americanum</i>	NT		
FABALES	LEGUMINOSAE	<i>Cullen plicatum</i>	LC		
FABALES	LEGUMINOSAE	<i>Dichrostachys cinerea</i>	DD		
FABALES	LEGUMINOSAE	<i>Genista ancistrocarpa</i>	EN	B1ab(ii,iii,iv,v)+2ab(ii,iii,iv,v)	
FABALES	LEGUMINOSAE	<i>Lotus benoistii</i>	CR	B2ab(ii,iii,iv,v)	Yes
FABALES	LEGUMINOSAE	<i>Vicia fulgens</i>	CR	B2ab(ii,iii,iv,v)	Yes
ARALES	LEMNACEAE	<i>Lemna aequinoctialis</i>	LC		
ARALES	LEMNACEAE	<i>Lemna gibba</i>	LC		
ARALES	LEMNACEAE	<i>Lemna minor</i>	LC		
ARALES	LEMNACEAE	<i>Lemna trisulca</i>	VU	B1ab(iii)+2ab(iii)	
ARALES	LEMNACEAE	<i>Spirodela polyrhiza</i>	NA		
ARALES	LEMNACEAE	<i>Spirodela punctata</i>	LC		
ARALES	LEMNACEAE	<i>Wolffia arrhiza</i>	VU	D2	
ARALES	LEMNACEAE	<i>Wolffiella buyalina</i>	LC		
ARALES	LENTIBULARIACEAE	<i>Pinguicula fontiqueriana</i>	VU	B1ab(iii)+2ab(iii)	Yes
ARALES	LENTIBULARIACEAE	<i>Pinguicula lusitanica</i>	EN	B2ab(iv)	
ARALES	LENTIBULARIACEAE	<i>Utricularia australis</i>	NT		
ARALES	LENTIBULARIACEAE	<i>Utricularia gibba</i>	NT		
ARALES	LENTIBULARIACEAE	<i>Utricularia inflexa</i>	VU	D2	
ARALES	LENTIBULARIACEAE	<i>Utricularia minor</i>	CR	B2ab(iii)	
ARALES	LENTIBULARIACEAE	<i>Utricularia vulgaris</i>	LC		
MYRTALES	LYTHRACEAE	<i>Ammannia auriculata</i>	LC		
MYRTALES	LYTHRACEAE	<i>Ammannia baccifera</i>	LC		

Order	Family	Scientific name	IUCN Red List Category (Northern Africa)	IUCN Red List Criteria	Endemic to the region?
MYRTALES	LYTHRACEAE	<i>Ammannia senegalensis</i>	LC		
MYRTALES	LYTHRACEAE	<i>Lythrum acutangulum</i>	LC		
MYRTALES	LYTHRACEAE	<i>Lythrum baeticum</i>	VU	B2ab(iii)c(ii,iii,iv)	
MYRTALES	LYTHRACEAE	<i>Lythrum borysthenicum</i>	LC		
MYRTALES	LYTHRACEAE	<i>Lythrum hyssopifolia</i>	LC		
MYRTALES	LYTHRACEAE	<i>Lythrum junceum</i>	LC		
MYRTALES	LYTHRACEAE	<i>Lythrum portula</i>	LC		
MYRTALES	LYTHRACEAE	<i>Lythrum salicaria</i>	LC		
MYRTALES	LYTHRACEAE	<i>Lythrum thymifolia</i>	LC		
MYRTALES	LYTHRACEAE	<i>Lythrum tribracteatum</i>	LC		
MARSILEALES	MARSILEACEAE	<i>Marsilea aegyptiaca</i>	LC		Yes
MARSILEALES	MARSILEACEAE	<i>Marsilea capensis</i>	NA		
MARSILEALES	MARSILEACEAE	<i>Marsilea crenulata</i>	DD		
MARSILEALES	MARSILEACEAE	<i>Marsilea minuta</i>	CR	B2ab(ii,iii,iv,v)	
MARSILEALES	MARSILEACEAE	<i>Marsilea strigosa</i>	EN	B2ab(ii,iii,iv,v)	
MARSILEALES	MARSILEACEAE	<i>Pilularia minuta</i>	CR	B2ab(i,ii,iii,iv,v)	
SOLANALES	MENYANTHACEAE	<i>Menyanthes trifoliata</i>	EN	B2ab(iii)	
SOLANALES	MENYANTHACEAE	<i>Nymphoides peltata</i>	CR	D	
CARYOPHYLLALES	MOLLUGINACEAE	<i>Corrigiola litoralis</i>	LC		
CARYOPHYLLALES	MOLLUGINACEAE	<i>Glinus lotoides</i>	LC		
CARYOPHYLLALES	MOLLUGINACEAE	<i>Glinus runkewitzii</i>	DD		Yes
NYMPHAEALES	NYMPHAEACEAE	<i>Nuphar lutea</i>	NA	B1ab(i)+2ab(i)	
NYMPHAEALES	NYMPHAEACEAE	<i>Nymphaea alba</i>	VU	B1ab(iii)+2ab(iii,iv)	
NYMPHAEALES	NYMPHAEACEAE	<i>Nymphaea caerulea</i>	CR	B2b(i,ii,iii)c(ii,iv)	
NYMPHAEALES	NYMPHAEACEAE	<i>Nymphaea lotus</i>	CR	B1b(i,ii,iv)+2b(i,ii,iv) c(ii,iv)	
MYRTALES	ONAGRACEAE	<i>Epilobium angustifolium</i>	VU	D2	
MYRTALES	ONAGRACEAE	<i>Epilobium atlanticum</i>	VU	D2	
MYRTALES	ONAGRACEAE	<i>Epilobium hirsutum</i>	LC		
MYRTALES	ONAGRACEAE	<i>Epilobium mirei</i>	VU	D2	Yes
MYRTALES	ONAGRACEAE	<i>Epilobium numidicum</i>	CR	B2ab(iii)	Yes
MYRTALES	ONAGRACEAE	<i>Epilobium obscurum</i>	NT		
MYRTALES	ONAGRACEAE	<i>Epilobium parviflorum</i>	LC		
MYRTALES	ONAGRACEAE	<i>Epilobium psilotum</i>	NT		Yes
MYRTALES	ONAGRACEAE	<i>Epilobium tetragonum</i>	LC		
MYRTALES	ONAGRACEAE	<i>Ludwigia palustris</i>	NT		
MYRTALES	ONAGRACEAE	<i>Ludwigia stolonifera</i>	LC		
ORCHIDALES	ORCHIDACEAE	<i>Anacamptis laxiflora</i>	DD	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)	
ORCHIDALES	ORCHIDACEAE	<i>Anacamptis palustris</i>	DD		
ORCHIDALES	ORCHIDACEAE	<i>Dactylorhiza elata</i>	NT		
ORCHIDALES	ORCHIDACEAE	<i>Dactylorhiza maurusia</i>	EN	B1ab(iii)	Yes
ORCHIDALES	ORCHIDACEAE	<i>Serapias stenopetala</i>	CR	C2a(i)b	Yes
OSMUNDALES	OSMUNDACEAE	<i>Osmunda regalis</i>	LC		
ROSALES	PARNASSIACEAE	<i>Parnassia palustris</i>	LC		
PLANTAGINALES	PLANTAGINACEAE	<i>Littorella uniflora</i>	VU	D2	
PLANTAGINALES	PLANTAGINACEAE	<i>Plantago lacustris</i>	VU	B2ab(ii,iii)	Yes
PLUMBAGINALES	PLUMBAGINACEAE	<i>Limonium battandieri</i>	DD		Yes
PLUMBAGINALES	PLUMBAGINACEAE	<i>Limonium cymuliferum</i>	NT		Yes

Order	Family	Scientific name	IUCN Red List Category (Northern Africa)	IUCN Red List Criteria	Endemic to the region?
PLUMBAGINALES	PLUMBAGINACEAE	<i>Limonium duriaei</i>	VU	B2ab(iii)	Yes
PLUMBAGINALES	PLUMBAGINACEAE	<i>Limonium duriusculum</i>	DD		
PLUMBAGINALES	PLUMBAGINACEAE	<i>Limonium mouretii</i>	NT	B1ab(iii)	Yes
PLUMBAGINALES	PLUMBAGINACEAE	<i>Limonium ornatum</i>	VU	B1ab(iii)	Yes
PODOSTEMALES	PODOSTEMACEAE	<i>Tristicha trifaria</i>	DD		
POLYGONALES	POLYGONACEAE	<i>Persicaria bistorta</i>	VU	B1ab(iii,v)	
POLYGONALES	POLYGONACEAE	<i>Persicaria hydropiper</i>	LC		
POLYGONALES	POLYGONACEAE	<i>Persicaria lanigera</i>	VU	D2	
POLYGONALES	POLYGONACEAE	<i>Persicaria lapathifolia</i>	LC		
POLYGONALES	POLYGONACEAE	<i>Persicaria limbata</i>	NT		
POLYGONALES	POLYGONACEAE	<i>Persicaria obtusifolia</i>	DD		Yes
POLYGONALES	POLYGONACEAE	<i>Persicaria salicifolia</i>	LC		
POLYGONALES	POLYGONACEAE	<i>Persicaria senegalensis</i>	LC		
POLYGONALES	POLYGONACEAE	<i>Polygonum amphibium</i>	VU	B1ab(iii)+2ab(ii,iii)	
POLYGONALES	POLYGONACEAE	<i>Rumex aegyptiacus</i>	DD		Yes
POLYGONALES	POLYGONACEAE	<i>Rumex algeriensis</i>	CR	B2ab(ii,iii); D	Yes
POLYGONALES	POLYGONACEAE	<i>Rumex conglomeratus</i>	LC		
POLYGONALES	POLYGONACEAE	<i>Rumex crispus</i>	LC		
POLYGONALES	POLYGONACEAE	<i>Rumex dentatus</i>	NT		
POLYGONALES	POLYGONACEAE	<i>Rumex ginii</i>	NT		Yes
POLYGONALES	POLYGONACEAE	<i>Rumex palustris</i>	VU	B2ab(iii); D2	
POLYGONALES	POLYGONACEAE	<i>Rumex pulcher</i>	LC		
POLYGONALES	POLYGONACEAE	<i>Rumex tunetanus</i>	CR	B1ab(ii,iii)+2ab(ii,iii)	Yes
CARYOPHYLLALES	PORTULACACEAE	<i>Montia fontana</i>	LC		
CARYOPHYLLALES	PORTULACACEAE	<i>Portulaca oleracea</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Groenlandia densa</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton coloratus</i>	NA	B1ab(iii)+2ab(iii)	
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton crispus</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton hoggarensis</i>	DD		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton lucens</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton natans</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton nodosus</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton panormitanus</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton pectinatus</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton perfoliatus</i>	NT		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton polygonifolius</i>	NT		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton pusillus</i>	NT		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton schweinfurthii</i>	NT		
NAJADALES	POTAMOGETONACEAE	<i>Potamogeton trichoides</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Ruppia cirrhosa</i>	LC		
NAJADALES	POTAMOGETONACEAE	<i>Ruppia maritima</i>	LC		
PRIMULALES	PRIMULACEAE	<i>Anagallis crassifolia</i>	NT		
PRIMULALES	PRIMULACEAE	<i>Anagallis tenella</i>	LC		
PRIMULALES	PRIMULACEAE	<i>Lysimachia cousiniana</i>	NT		Yes
PRIMULALES	PRIMULACEAE	<i>Lysimachia vulgaris</i>	CR	B1ab(ii)+2ab(ii)	
PRIMULALES	PRIMULACEAE	<i>Primula boveana</i>	DD		Yes
PRIMULALES	PRIMULACEAE	<i>Samolus valerandi</i>	LC		

Order	Family	Scientific name	IUCN Red List Category (Northern Africa)	IUCN Red List Criteria	Endemic to the region?
PTERIDALES	PTERIDACEAE	<i>Pteris incompleta</i>	VU	C2a(i)	
PTERIDALES	PTERIDACEAE	<i>Thelypteris interrupta</i>	EN	B2ab(ii,iii,iv,v)	
PTERIDALES	PTERIDACEAE	<i>Thelypteris palustris</i>	VU	B2ab(iii)	
RANUNCULALES	RANUNCULACEAE	<i>Aquilegia vulgaris</i>	LC		Yes
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus aquatilis</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus aurasiacus</i>	LC		Yes
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus dyris</i>	LC		Yes
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus ficaria</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus flammula</i>	VU	D2	
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus granatensis</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus bederaceus</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus lateriflorus</i>	VU	D2	
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus ophioglossifolius</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus peltatus</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus penicillatus</i>	VU	D2	
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus repens</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus rionii</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus sardous</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus sceleratus</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus trichophyllus</i>	LC		
RANUNCULALES	RANUNCULACEAE	<i>Ranunculus tripartitus</i>	VU	B1ab(iii)+2ab(iii); D2	
CAPPARALES	RESEDACEAE	<i>Reseda battandieri</i>	VU	B1ab(iii); D2	Yes
RHAMNALES	RHAMNACEAE	<i>Frangula alnus</i>	VU	B1ab(i)+2ab(i)	
ROSALES	ROSACEAE	<i>Potentilla maura</i>	NT		Yes
ROSALES	ROSACEAE	<i>Potentilla supina</i>	LC		
RUBIALES	RUBIACEAE	<i>Galium debile</i>	LC		
RUBIALES	RUBIACEAE	<i>Galium elongatum</i>	LC		
RUBIALES	RUBIACEAE	<i>Galium uliginosum</i>	DD		
RUBIALES	RUBIACEAE	<i>Oldenlandia capensis</i>	CR	B1ab(ii,iii)+2ab(ii,iii)	
SALICALES	SALICACEAE	<i>Salix atrocinerea</i>	LC		
SALICALES	SALICACEAE	<i>Salix mucronata</i>	DD		
SALICALES	SALICACEAE	<i>Salix pedicellata</i>	LC		
SALVINALES	SALVINIACEAE	<i>Salvinia natans</i>	DD		
ROSALES	SAXIFRAGACEAE	<i>Chrysosplenium dubium</i>	VU	D2	
SCROPHULARIALES	SCROPHULARIACEAE	<i>Bacopa monnieri</i>	EN	B1ab(iii)+2ab(iii)	
SCROPHULARIALES	SCROPHULARIACEAE	<i>Gratiola linifolia</i>	EN	B1ab(iii)+2ab(iii)	
SCROPHULARIALES	SCROPHULARIACEAE	<i>Gratiola officinalis</i>	VU	D2	
SCROPHULARIALES	SCROPHULARIACEAE	<i>Jamesbrittenia dissecta</i>	NT		
SCROPHULARIALES	SCROPHULARIACEAE	<i>Limosella aquatica</i>	NT		
SCROPHULARIALES	SCROPHULARIACEAE	<i>Linaria fallax</i>	NT		Yes
SCROPHULARIALES	SCROPHULARIACEAE	<i>Peplidium maritimum</i>	DD		
SCROPHULARIALES	SCROPHULARIACEAE	<i>Scrophularia auriculata</i>	LC		
SCROPHULARIALES	SCROPHULARIACEAE	<i>Scrophularia eriocalyx</i>	EN	B1ab(ii,iii,iv,v)	Yes
SCROPHULARIALES	SCROPHULARIACEAE	<i>Scrophularia tenuipes</i>	NT		Yes
SCROPHULARIALES	SCROPHULARIACEAE	<i>Veronica anagallis-aquatica</i>	LC		
SCROPHULARIALES	SCROPHULARIACEAE	<i>Veronica anagalloides</i>	LC		
SCROPHULARIALES	SCROPHULARIACEAE	<i>Veronica catenata</i>	LC		

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SCROPHULARIALES	SCROPHULARIACEAE	<i>Veronica kaiseri</i>	DD		Yes
SCROPHULARIALES	SCROPHULARIACEAE	<i>Veronica rubrifolia</i>	DD		
SCROPHULARIALES	SCROPHULARIACEAE	<i>Veronica scardica</i>	DD		
SELAGINELLALES	SELLAGINELLACEAE	<i>Selaginella balansae</i>	LC		Yes
SELAGINELLALES	SELLAGINELLACEAE	<i>Selaginella denticulata</i>	LC		
MYRTALES	TRAPACEAE	<i>Trapa natans</i>	EN	B1ab(iii)+2ab(iii)	
TYPHALES	TYPHACEAE	<i>Sparganium erectum</i>	NT		
TYPHALES	TYPHACEAE	<i>Sparganium natans</i>	DD		
TYPHALES	TYPHACEAE	<i>Typha angustifolia</i>	LC		
TYPHALES	TYPHACEAE	<i>Typha domingensis</i>	DD		
TYPHALES	TYPHACEAE	<i>Typha elephantina</i>	LC		
TYPHALES	TYPHACEAE	<i>Typha latifolia</i>	LC		
APIALES	UMBELLIFERAE	<i>Apium crassipes</i>	NT		
APIALES	UMBELLIFERAE	<i>Apium graveolens</i>	LC		
APIALES	UMBELLIFERAE	<i>Apium inundatum</i>	VU	B2ab(i)	
APIALES	UMBELLIFERAE	<i>Apium nodiflorum</i>	LC		
APIALES	UMBELLIFERAE	<i>Apium repens</i>	VU	B2ab(ii,iii)	
APIALES	UMBELLIFERAE	<i>Berula erecta</i>	LC		
APIALES	UMBELLIFERAE	<i>Carum asinorum</i>	EN	B2ab(iii)	Yes
APIALES	UMBELLIFERAE	<i>Carum foetidum</i>	NT		
APIALES	UMBELLIFERAE	<i>Carum jahandiezii</i>	NT		Yes
APIALES	UMBELLIFERAE	<i>Carum lacuum</i>	VU	B2ab(iii)	Yes
APIALES	UMBELLIFERAE	<i>Chaerophyllum atlanticum</i>	NT		Yes
APIALES	UMBELLIFERAE	<i>Eryngium atlanticum</i>	NT		Yes
APIALES	UMBELLIFERAE	<i>Eryngium corniculatum</i>	VU	D2	
APIALES	UMBELLIFERAE	<i>Eryngium maroccanum</i>	NT		Yes
APIALES	UMBELLIFERAE	<i>Eryngium pusillum</i>	LC		
APIALES	UMBELLIFERAE	<i>Eryngium variifolium</i>	VU	B1ab(iii)	Yes
APIALES	UMBELLIFERAE	<i>Hohenackeria polyodon</i>	NT		
APIALES	UMBELLIFERAE	<i>Hydrocotyle vulgaris</i>	LC		
APIALES	UMBELLIFERAE	<i>Oenanthe crocata</i>	LC		
APIALES	UMBELLIFERAE	<i>Oenanthe fistulosa</i>	LC		
APIALES	UMBELLIFERAE	<i>Oenanthe globulosa</i>	LC		
APIALES	UMBELLIFERAE	<i>Oenanthe lachenalii</i>	LC		
APIALES	UMBELLIFERAE	<i>Oenanthe peucedanifolia</i>	LC		
APIALES	UMBELLIFERAE	<i>Oenanthe pimpinelloides</i>	VU	B1a+2ab(ii)	
APIALES	UMBELLIFERAE	<i>Oenanthe silaifolia</i>	LC		
APIALES	UMBELLIFERAE	<i>Peucedanum munbyi</i>	NT		Yes
ROSALES	VAHLIACEAE	<i>Vahlia dichotoma</i>	DD		
ROSALES	VAHLIACEAE	<i>Vahlia digyna</i>	DD		
LAMIALES	VERBENACEAE	<i>Clerodendrum acerbianum</i>	LC		
LAMIALES	VERBENACEAE	<i>Phyla nodiflora</i>	LC		
LAMIALES	VERBENACEAE	<i>Verbena officinalis</i>	LC		
LAMIALES	VERBENACEAE	<i>Verbena supina</i>	LC		
VIOLALES	VIOLACEAE	<i>Viola maroccana</i>	LC		Yes
NAJADALES	ZANNICHELLIACEAE	<i>Athenia orientalis</i>	VU	B2ab(iii)	
NAJADALES	ZANNICHELLIACEAE	<i>Zannichellia obtusifolia</i>	DD		
NAJADALES	ZANNICHELLIACEAE	<i>Zannichellia palustris</i>	LC		
NAJADALES	ZANNICHELLIACEAE	<i>Zannichellia peltata</i>	LC		

Appendix 6. CD

Please find the Cd on the inside cover of the back of the book, including the species summaries, distribution maps and spatial data.

IUCN Red List of Threatened Species™ – Regional Assessments

Freshwater Africa

The Status and Distribution of Freshwater Biodiversity in Eastern Africa. Compiled by William R.T. Darwall, Kevin G. Smith, Thomas Lowe, Jean-Christophe Vié, 2005.

The Status and Distribution of Freshwater Biodiversity in Southern Africa. Compiled by William R.T. Darwall, Kevin G. Smith, Denis Tweddle and Paul Skelton, 2009.

The Status and Distribution of Freshwater Biodiversity in Western Africa. Compiled by Smith, K.G., Diop, M.D., Niane, M. and Darwall, W.R.T., 2009.

Mediterranean

The Status and Distribution of Freshwater Fish Endemic to the Mediterranean Basin. Compiled by Kevin G. Smith and William R.T. Darwall, 2006.

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