TOUR DU VALAT

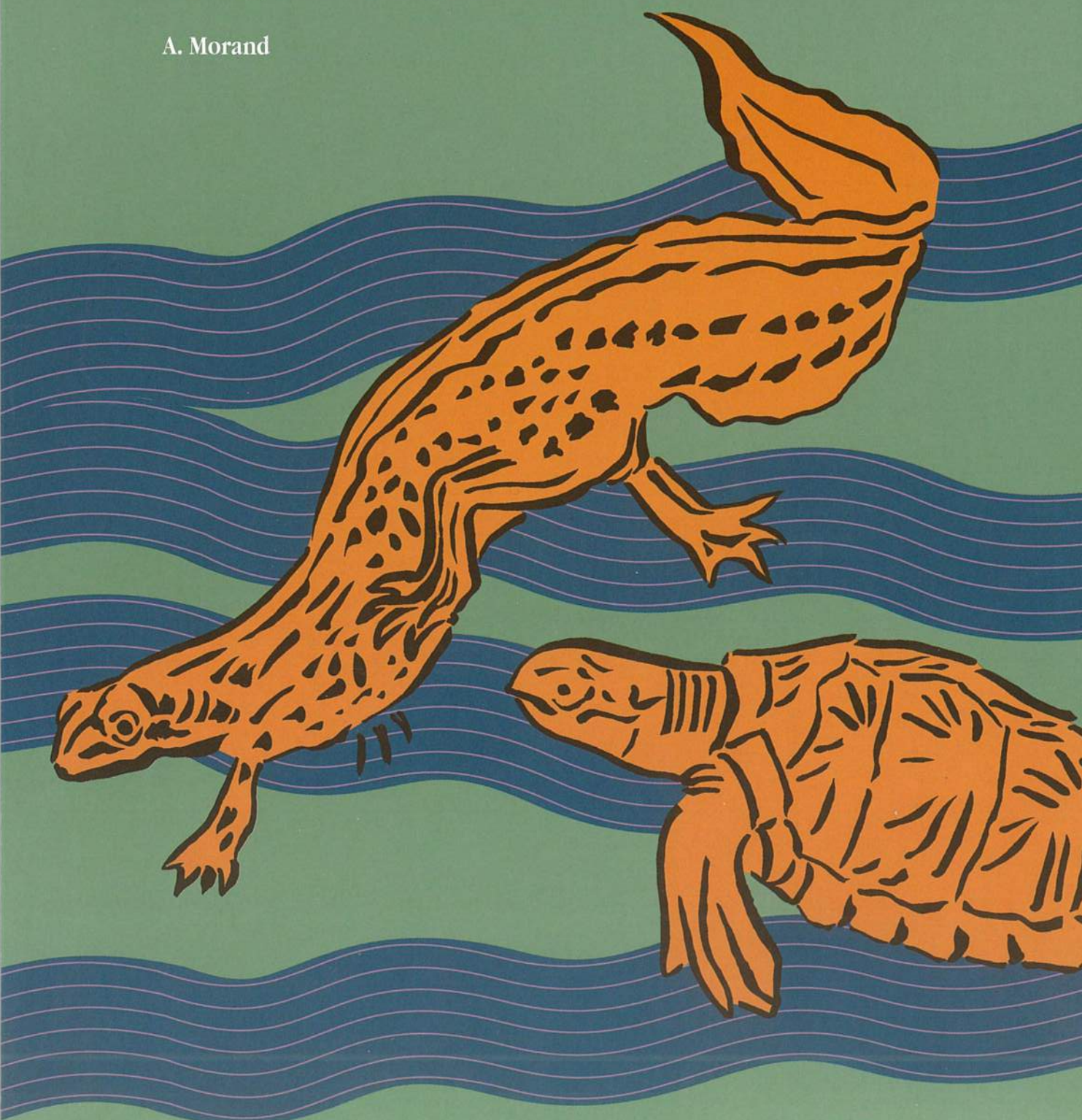
MedWet

Conservation of Mediterranean Wetlands

Amphibians & reptiles

Ecology and management

A. Morand



MedWet

The MedWet initiative

The Mediterranean basin is rich in wetlands of great ecological, social and economic value. Yet these important natural assets have been considerably degraded or destroyed, mainly during the 20th century. MedWet is a concerted long-term collaborative action, launched in Grado, Italy in 1991, to stop and reverse this loss and to ensure the wise use of wetlands throughout the Mediterranean.

The MedWet initiative is guided by the Mediterranean Wetlands Committee (MedCom), under the umbrella of the Ramsar Convention on Wetlands, which brings together 25 governments from the region, the European Commission, the Barcelona and Bern Conventions and international NGOs. It seeks partners and funds for implementing the Mediterranean Wetland Strategy, which includes conservation actions in wetlands of major importance in the region (especially Ramsar sites) and the promotion of national wetland policies, which take account of wetland values during the planning process. MedWet also provides a forum for regional exchange of experience at a technical level and publishes a range of wetland management tools with financial support from the European Union.

The concept of MedWet and its importance for promoting wise use of Mediterranean wetlands has been unanimously endorsed by the Contracting Parties to the Ramsar Convention on Wetlands.

The MedWet publication series

Wetlands are complex ecosystems, which increasingly require to be managed in order to maintain their wide range of functions and values. The central aim of the MedWet publication series is to improve the understanding of Mediterranean wetlands and the policy issues that surround them, and to make sound scientific and technical information available to those involved in their management.

A. Morand
Amphibians and reptiles, ecology and management
Conservation of mediterranean wetlands - number 11
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Titles of the collection:

1. Characteristics of Mediterranean Wetlands
2. Functions and Values of Mediterranean Wetlands
3. Aquaculture in Lagoon and Marine Environments
4. Management of nest sites for Colonial Waterbirds
5. Wetlands and Water resources
6. Aquatic emergent Vegetation, Ecology and Management
7. Conservation of Freshwater Fish
8. Vegetation of temporary Marshes, Ecology and Management
9. Salinas and Nature Conservation
10. Wetlands and Hydrology
11. Amphibians and Reptiles, Ecology and Management

Conservation of Mediterranean Wetlands
MedWet

Amphibians and reptiles

Ecology and management

A. Morand

Number 11

Series editors : J. Skinner and A. J. Crivelli

T. Nazirídis

Preface

Lost species can never be replaced, but much can be done to save earthís diversity for future generations and better use resources to benefit many more people in the decades ahead.
This is GEFís message to solving the problem of the loss of biological diversity that threaten our livelihood, no matter where we live.
In the Mediterranean, where biological diversity is exceptionally high, and threats to this natural heritage are equally challenging, GEF endeavours to undertaking concrete activities and actions for the conservation and sustainable management of biological diversity. This is the objective of GEF through, among others, the MedWetCoast project, which is dedicated for the conservation of Mediterranean wetlands and coastal ecosystems in five Mediterranean countries and the Palestinian Authority.
It is in such a context that the conservation of amphibians and reptiles becomes an integral part to the conservation of the ecosystem and leads to better understand the ecological benefits contributed by these species within larger ecosystem processes.
The importance of amphibians and reptiles in efforts for conservation of biological diversity stems from the fact that the level of endemism* of reptiles and amphibians in the Mediterranean is among the highest. Between the various taxonomic groups, 50 species of amphibians and 179 species of reptiles are recognised in the Mediterranean, of which 27 species of amphibians and 111 reptiles are endemic.
The contribution of this MedWet Publication is a very important one as it highlights the links between the status of these species, the ecosystem in which they dwell and the biophysical and socio-economic factors that threaten their survival.
Whatís more important in this publication is the way it provides a sound scientific understanding of the functions, problems and management measures for the conservation of amphibians and reptiles, making such information accessible and transferable to the key actors involved in biodiversity conservation.

Emma Torres
Deputy Executive Coordinator
GEF/UNDP

Emys orbicularis **in the Kerkini marshes, northern Greece.**

Contents

Background

Even the youngest of us can recognise a frog, a snake or a turtle, irrespective of whether we have seen one close up or only in pictures. However, it is not so easy to define these animals scientifically and it is even harder to establish a conservation strategy adapted to these fragile and often neglected species.

The first chapter is aimed at those wishing to get to know these animals better, to grasp a few of their many mythological representations, their origins and the complexity of their classification. Despite being dependant on water for a large part or their life cycle, most amphibians and some reptiles also need forests and wetlands where they feed, and tree stumps, stones and forest litter under which they can shelter.

The second chapter presents different species of amphibians and reptiles of Mediterranean wetlands as well as their habitats.

The third chapter, which expands on knowledge about the biology and population dynamics, as well as community* ecology, considers the important idea of adaptation by species to their environment. Despite the possibility for physiological, demographic and behavioural plasticity, these species are constrained by certain biological traits that oblige them to occupy particular habitats. It is therefore pointless to expect that they could reproduce and that a population would thrive for long in a habitat that does not meet the species' ecological or biological requirements.

The fourth chapter aims to specify the natural and anthropogenic* causes for the disappearance of amphibians and reptiles. Important national and international programmes support a comparative approach in both field and experimental studies. This modelling has produced numerous results for all the environments on this planet that are inhabited by these animals. Their disappearance is a reality and it is now urgent to intervene in order to establish long term protective actions and management plans that consider their environmental needs and complex life cycle.

At present few important and sufficiently independent experiments exist in the field of the conservation of these two groups.

* *Refer to glossary, page 101*

The intention of this work, in particular during the first chapters, is to present a rapid but clear and precise overview of our present knowledge on amphibians and reptiles.

The last chapter and the five technical cards, at the end of the work should be useful tools for anyone needing to manage amphibians and reptiles, irrespective of the institutional framework in which they are working. The aim is to present experiments that are rich in learning and to establish a few general guidelines that can be used when these animals are being sampled, when an amphibian pond is being built, when the user is preparing technical fact sheets and / or short monographs.

This work in no way constitutes a collection of ready made solutions that will provide the reader with sufficient material to replace an expert; it will not replace an expert opinion adapted to the region under consideration. Nevertheless, based on a variety of information and both general and specific advice this work aims to promote multiple facetted projects in which pedagogy and dialogue work together and actions are based on both knowledge and experience from the field.

F. Andreone

The Fire salamander, subspecie *gigliolii* from Calabria, Italy.

D. Heuclin/Bios

Introduction

Despite the venom of amphibians and reptiles making up part of the therapeutic arsenal used by medicine and despite their physiology and biology having greatly contributed to the development of science, these animals are still all too often considered with disdain, or even fear and repugnance. Rarely has any animal been attributed so many virtues and evil spells.

Since the Bronze Age, sculptured objects witness cults, such as the Celts, that worshipped snakes. In antiquity snakes were venerated. In Greek mythology they are the symbol of supreme power, of knowledge, wisdom and longevity. Athena is never separated from an ammodyte viper, which is hidden behind her shield. Greeks and Romans kept captive snakes in their temples consecrated to Asclepius, the god of medicine for the Greeks, who became Esculape for the Romans. The caduceus of our doctors and chemists bears his symbol. In Christianity and in the bible the snake is the incarnation of evil. This symbolism is the source of snake phobia.

Oriental philosophy and African myths give amphibians a somewhat more positive image. They are the symbol of fecundity, resurrection

The Green toad, *Bufo viridis*.

and immortality. Nevertheless, Judaeo-Christian tradition is gradually imposing its evil conception of these animals in the collective subconscious of western civilisation[1]. Popular belief has made the toad the most diabolical creature of the animal kingdom. "It suckles cows". "It makes wine go off". "It has the evil eye, it charms people and their animals". "Its secretions gives dogs rabies". "Its breath is venomous". This profusion of myths shows the fertility of human imagination, which unfortunately lead to the most horrendous atrocities being directed at all those who dared to be interested in such benign creatures. Fire leads to hell, and thus the salamander with his flamboyant coat is a sulphurous creature serving Satan. Incidentally, its name originates from the Arab-Persian word meaning "he who lives in fire". According to received wisdom, plants wither and fruits, rivers and well water are poisoned on contact with the salamander. The salamander can cross the flames of an inferno unscathed. In the Middle Ages the salamander was even sold as a fire extinguisher! Supreme glory, the salamander nevertheless adorned the coat of arms of François Ist, alluding to fire.

For centuries, amphibians and reptiles were blamed for a genuine avalanche of horrors. In medieval times the Christian Church in the West made frogs, toads and snakes symbols of sexual depravation and diabolical temptations.

As well as these symbolic roles, amphibians and reptiles are given folkloric roles in rural communities, where rational explanations to make nature more predictable and more hospitable are sought. Thus the frog has been made into a meteorologist, responsible for predicting the weather. Amphibians and snakes have also always been part of the pharmacopoeia, from Pliny the Ancient to the present, and in particular the well-known theriaca, made up of viper flesh and venom, and used against snakebites.

The symbolism of the snake hardly changes over time; it remains a genius of evil, holding an apple, which is symbolic of sin. With its fixed and "murderous" stare, the snake hypnotises and leads a person to death. During the Renaissance, with the revival of literature, the frog and toad found new cultural expression and are used to embody certain rather negative characteristics (fear, cowardice, foolishness, vanity and pride) and other more positive ones (shyness, charm, gentleness and true beauty). The Swedish naturalist Carl Von Linné (1707-1778) who gave us the classification system for animal and plant species that is still in use today, said about these "dirty and repugnant animals..." that "their Creator didn't go to the trouble to make much of them...". A large number of species of reptiles and amphibians exist in the wetlands of the Mediterranean basin. While we are only just beginning to understand the complexity of the relationships that exist between

1 - Wasserman (1990)

the ecological strategies of the herpetological populations and the constraints of aridity, several species are already close to extinction. At the beginning of this third millennium, environmental problems are more than ever in the news. During the coming years wetlands will be rehabilitated, which implies new challenges on how to preserve their biodiversity.

Magic ? Witchcraft? Folk remedies and medicine of the future

Theriacas (from Greek "thêr": ferocious beast), viper alcohols and toad and frog-based remedies can be found since the earliest times and among all cultures. These therapies are still very much in use by the Ecuadorian jungle Indians, who use the secretions from a small bicolour tree frog as a healing agent which is applied, mixed with saliva, on the wound. The injured person feels queasy and vomits, and is very weak for several hours. In Europe the winegrowers of Southwest France protect their harvest by spraying the ripe bunches of grapes with toxic secretions from toads that are first salted. The thieves who then suffer from diarrhoea and vomiting for several days do not return and curse the farmer/wizard who thus punished them.

From folk empiricism to experimental trials, since the second half of the XIX Century, man has been increasingly interested in the potential applications of the most virulent venoms and poisons. Several institutes are specialised in treating venomous bites and in the development of serum*. More than a hundred species of venomous frogs from Latin America are studied by researchers in the hope of finding drugs to stimulate the heart or brain or relaxing/relieving drugs against pain and muscular contractions. In 1977 in forests threatened by destruction one of the pioneers of batrachian-medicine found the small tree frog *(Epidobates tricolor)* which produces an analgesic that is 200 times more powerful than morphine. The batrachian-toxin of another species *(Phyllobates terribilis)* is 100 times stronger than strychnine and as yet no serum exists against it[2]. Despite the venom of several amphibians being more potent than that of many snakes, the fact they do not have inoculation apparatus makes them, generally of little danger for man. All the amphibians' toxic substances are secreted by cutaneous glands, in particular the granular glands that are located in concentrated clusters arranged symmetrically in relation to the dorsal median line, or in the parotoid glands behind the eyes for the toads of our regions. Simple sweating at the surface of the skin excretes these substances.

These few friendly or frightening examples are witness to the multiplicity of uses for the poisons and venoms. The uses as a means of killing or healing constitute further reasons for conserving these wonderful species.

2 - Daly & Witkop (1971)

T. Stoeckle/Bios

Origin, taxonomy, genetics and endemism

The variety of amphibians and reptiles is surprising. The differences between these two groups of animals are more obvious than their similarities, but according to scientific tradition dating back almost 2 centuries, they are studied together in a field known as herpetology (from the Greek herpô which means to crawl). The 4,500 species of amphibians that exist today live alongside approximately 7,000 species of reptiles, thus surpassing the number of bird and mammal species combined. Relatively, there are few amphibian and reptile species in the wetlands of the Mediterranean regions. The island fauna and the endemic* species are particularly vulnerable to the destruction of their habitat.

A fossilized frog found in the geological Nature Reserve of Luberon, southern France.

Leaving the water

350 to 400 million years ago the climate was tropical and alternated between dry and rainy seasons. Fish that lived in marshlands, which would dry out periodically, would die asphyxiated. It is therefore not surprising that these lagoon and lake environments were places of ecological transition, and were favourable to innovative speciation* whereby the first vertebrates conquered the terrestrial environment.

Amphibians can be divided into three major groups: the Gymnophiones, or Apoda, rare, vermiform animals, which lack limbs and are only found in hot regions; the Caudata which include those newts and salamanders which keep their tails after the larval stage; the Anura, whose tail regresses during metamorphosis.

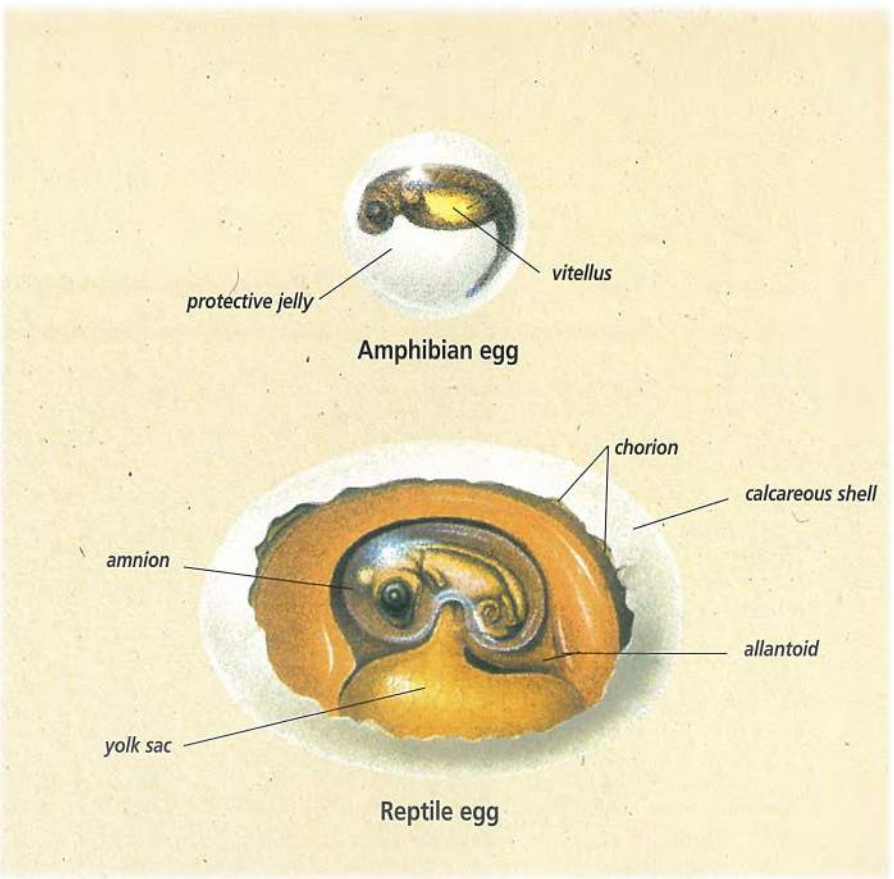
Undoubtedly fish remain the uncontested masters of the aquatic environment and their peak was during the Devonian* period. So much so that this period is known as the "age of the fish". Amphibians started to conquer the terrestrial environment about 380 million years ago. The passage from an aquatic lifestyle to a terrestrial one was not without its difficulties. Undoubtedly, the terrestrial environment presented adaptation problems of a dimension until then never before encountered by these pioneers.

The word "amphibian" literally means "double life", and refers directly to the fact that most of these animals have to live both in the water and on land at different periods of their life cycle. During the aquatic stage of their life they breathe oxygen from the water using gills just like fish. At the time of metamorphosis* most species acquire a functional lung which enables them to breathe in the open air.

F. Andreone

The Stream frog
Rana graeca.

Furthermore, these primitive amphibians evolved very rapidly and fairly successfully freed themselves from the aquatic environment by developing naked skin made up of a single layer of permeable keratinised* cells which is kept humid by the activity of numerous cutaneous glands. Dehydration remains a considerable risk, and these animals cope with it in different ways, as we will see below. Reptiles, on the other hand, have further overcome the problems of conserving water by means of their horny skin, that is made up of several layers of flattened and dead epidermis cells, and which prevents the evaporation of body water.



Despite being more evolved than fish or amphibians, no reptile, bird or mammal has managed to achieve embryonic development that does not take place in the liquid environment of their ancestors. An important evolutionary stage was the innovation by reptiles of a closed cavity filled with liquid that enables the development of the egg, and that we call the amniotic cavity*. Another originality of this amniotic egg, the allantoid*, appeared at the same time as the amnion, and the two formations make up a pair. It permits respiratory exchanges via the eggshell. The amniotic egg of reptiles presents two further advantages for conquering land: the very resistant protective shell and the abundance of nutritive materials that make up a necessary reserve for the embryo to develop.

Establishment of present day populations

The understanding of the herpetological populations of the Mediterranean area is complex. Most of the families of amphibians and reptiles that populate the Mediterranean basin today appeared during the tertiary* era.

The constitution of the present day fauna results from several factors: exchange between continental masses, adaptive radiation and climatic changes, survivors following the "cretaceous crisis".
For approximately two million years our environment has undergone a series of glaciations that are separated by warmer interglacial periods, such as the present one. The ensemble of these phenomena has lead to the continual remodelling of the amphibian and reptile communities* of the Mediterranean basin. During the last great glaciation of Würm, which ended about 10,000 years ago, icecaps and inter-continental glacial areas covered most of the European continent.

Thus, most of Europe was uninhabitable for amphibians and reptiles as it was covered with arctic tundra and steppe. The postglacial climatic warming allowed medium latitudes to be recolonised by amphibians and reptiles from southern refuges. Three vast regions served as refuges[3]: southwest Europe (Iberian peninsular); Italy and southeast Europe (the steppes the length of the Black Sea and the Caspian Sea). The Alps and the Pyrenees were obstacles to recolonisation. More recently man has introduced species during his travels. This is the case for the genus *Alytes* in the Moroccan Rif, which

F. Andreone

The Tyrrhenian painted frog.

3 - Zwiderwick (1980)

A. Morand

The Midwife toad, *Alytes obstetricans*.

is genetically similar to the Midwife toad *(Alytes obstetricans)*[4] and to the Painted frog *(Discoglossus pictus)* in Catalonia.

Many gaps still exist in our knowledge about the origins of this small fauna of the Mediterranean area, which is one of the most "disturbed" regions of the globe from a geological point of view. The rarity of paleontological data and doubts about the taxonomic position of this fauna means that many of the hypotheses proposed can still be debated.

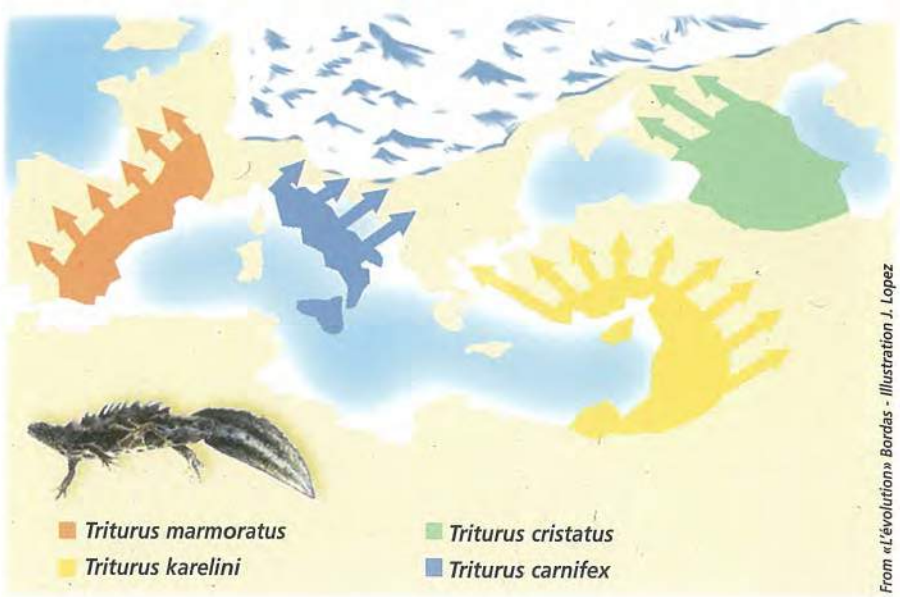
4 - Arntzen (1984)

Taxonomy and genetics

The colonisation of new ecological spaces, together with biotic interactions favouring differentiation of populations has led to an increased diversification of taxons*. Taxonomy, a booming science, has been enriched by genetic techniques whose contribution can no longer be ignored by scientists or managers.

Taxonomy is an as yet incomplete discipline; it does not always guarantee the name of a species. Surprisingly, in Europe even today we still discover species that are new to science. Thus, the Pyrenean frog *(Rana pyrenaica)* was discovered in 1990 in the Spanish Pyrenees[5]. This species belongs to the group of brown frogs, and is endemic* to this region where it lives in small cold and well oxygenated mountain streams. It is very often found with the Pyrenean brook salamander *(Euproctus asper)*. The determination of its taxonomic identity compared to that of the Common frog *(Rana temporaria)*, also present in this area, is fundamental given that they occupy different habitats and have developed a different biological strategy. A new species of Parsley frog was also found in the South of Spain[6].

The fact that species, which are descendants of a common ancestor, often share the same habitat means that hybridization is possible. In Europe five species of large newts exist, whose origins and speciation* probably date back to the time of the Quaternary glaciations. These



Theoretical geographic speciation model: the example of the *Cristatus* group. Speciation and the independent evolution of isolated populations has been favoured by the alteration of glacial and inter-glacial phases, a large number of mountain chains and a very pronounced fragmentation of the continental masses.

5 - Serra-Cobo et al. (1998)
6 - Sanchez-Herraiz et al. (2000)

glaciations lead to the isolation of populations of a primitive species and its subsequent evolution into distinct species. The Crested newt *(Triturus cristatus)* and the Marbled newt *(T. marmoratus)* can hybrid together when there is a high degree of syntopy*. However, this hybridization leads to descendants with lower viability.

The Green frogs complex – an identification problem

Green frogs are amphibious animals that, unlike many other species of amphibians, live exclusively in aquatic environments both during their reproduction period and during other periods of activity. They are common and frequent and their abundant tadpoles play an active role in filtering stagnant waters. They belong to a group where the taxonomic levels are hard to identify. This group is an excellent model for the study of hybridogenetic mechanisms[7] in amphibians. Hybridogenesis can be defined as being a reproductive system in which the hybrids persist by mating with one of the parent species. In the Rhone valley, the specific complex of green frogs present an intermediate hybrid form between two parent species with well defined genetic identities, the Marsh frog *(Rana ridibunda)* and the small Pool frog *(Rana lessonae)*. To the South of the valley the Marsh frog reproduces with Iberian water frog *(Rana perezi)* to produce the hybrid *R. grafi*.

This very large group of populations exhibits differences in morphology, physiology (hibernation strategy and tolerance of variations in the level of oxygen) and behaviour (quality and strength of sound emissions). This creates a problem as to

A. Morand

Rana lessonae.

the ecological and evolutionary significance of hybridogenesis[8-9]. Understanding the relationships between the genomic composition of populations and their habitats has become a priority scientific objective.

The characterisation of individuals using only morphological and behavioural criteria has in fact been shown to be insufficient. Enzymatic studies are necessary in order to specify the correspondence between the distribution of genotypes and the ecological typology of different sites.

These techniques help to explain both the phenomenon of speciation and allow the history of the population of green frogs in the Mediterranean basin and in Europe to be understood. The techniques will also confirm suspicion about the presence of other species of green frogs *(Rana epeirotica, Rana shqiperica)* in France that probably escaped from shipments imported for gastronomic purposes.

7 - Graf & Polls- Pelaz (1989)
8 - Pagano et al. (1999)
9 - Schmeller (1999)

Endemism

Contrary to birds, which exhibit weak endemism within the Mediterranean biome, endemism in amphibians and reptiles is extremely high, but nevertheless less remarkable than that of freshwater fish in the north Mediterranean region[10].

During evolution, the species that are present today progressively occupied more or less vast regions that make up what we call their distribution area. Certain species like the common toad *(Bufo bufo)* have a very large distribution area over all of Europe while other species such as the European blind cave salamander *(Proteus anguinus)* are limited to a few sites on the Adriatic coast.
This disparity in distribution and the variations in abundance of populations between regions are caused by geological, climatic and historical phenomena as well as the adaptive characteristics of the species. Thus, species with a high thermal tolerance can develop in markedly different climates.

F. Andreone

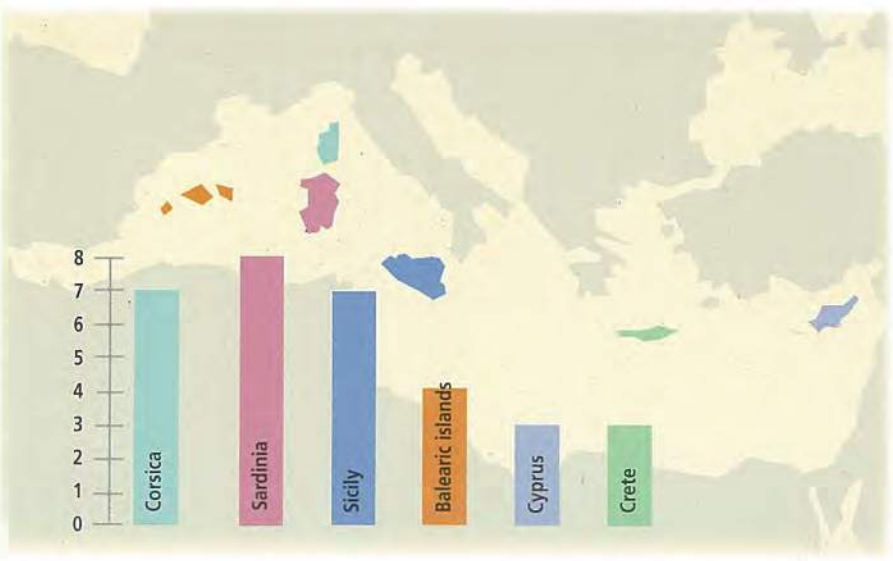
The Corsican mountain newt, ***Euproctus montanus*** from Corsica Island.

10 - Maitland & Crivelli (1996)

Amphibians and reptiles of the Mediterranean islands

Different species of reptiles and amphibians were isolated on the Mediterranean Islands during the last great glaciation when inlandsis* covered all the north and northwest of Europe as well as the mountains. Several populations have continued to evolve under the constraints of their environment and many have acquired specificities that differentiate them today from their ancestral species. However, the essential element which strikes the observer of an island environment straightaway, and which is a well-known fact since Darwin, is the shortage of animal species. A limited capacity to disperse and to cross maritime barriers is one of the reasons explaining the small number of taxons. The lack of favourable biotopes*, in particular of fresh water and competition* and/or predation by indigenous species can also explain the failure of certain colonisations. Ultimately, the current fauna comes mainly from previous connections between the islands and the European and African continent as well as from introductions by man.

The systematic herpetological survey of islands has made considerable progress with the recent discovery of two endemic amphibians – *Alytes muletensis* – on Majorca[11] – not previously identified and the Corsican painted frog *(Discoglossus montalentii)*. On the islands of the western Mediterranean basin, the levels of endemicity of batrachians are high because of the age of the fauna there and because of their low capacity for displacement. They reach 63% in Sardinia, 29% in Corsica, 25% in the Balearic Islands and 0% in all the other islands[12]. Whether it be new species, sub-species or small isolated populations, this range of genetic variation that is a source of evolution and biological innovation, is very often threatened. Any disruption to the habitat of these species leads to irreversible consequences.



Amphibian's species richness in the large Mediterranean islands: the Balearic islands, Corsica, Sardinia, Sicily, Crete and Cyprus.

11 - Alcover & Mayol (1980)
12 - Delaugerre & Cheylan (1992)

A. Morand

Diversity of habitats and of species

The majority of species divide their existence between both aquatic and terrestrial environments. The simultaneous presence of several environments is necessary for their life cycle. The habitat of a species includes its reproductive sites, where the eggs and/or the larvae develop, the sites of juvenile growth, the environment where the adult spends its active life as well as the sites for over-summering and hibernation. The passage from one environment to another occurs by means of migration.

Amphibians and reptiles are distributed in a great variety of wetlands, which differ in geological substrate and surface area, bathymetry, hydrological characteristics (source of water, length of the hydroperiod*, seasonality...), physicochemical conditions (pH, conductivity...), etc...

In Europe and around the Mediterranean the majority of amphibian species have to return to a fresh water environment in order to reproduce and to deposit their eggs or larvae. The developmental cycle thus includes an aquatic phase of variable duration.

The typical habitat of the Corsican mountain newt.

Although reptiles are freed from the aquatic environment, at least for the laying of their eggs, certain species still remain linked to water. Although the Crocodilia group lives in close relation with wetlands, only species belonging to the groups of Squamata (snakes and lizards) and Testudinata (turtles) respectively are of interest in the area studied. In the Mediterranean biome few species of lizards must have access to wet environments, whereas in the peat bogs of Northern Europe the Viviparous lizard *(Lacerta vivipara)* is common, and can dive into the water to take refuge. This lizard has a broad geographic distribution. It is found from Scotland to Sakhalin Island and from the north of Spain to the polar circle.

The water snakes

A super-predator of frogs, newts and their larvae as well as fish, aquatic snakes are a common feature of wetlands. Three species are particularly associated with the water. With a yellowish necklace, underlined at the back by a black band, the Grass snake *(Natrix natrix)* is an elegant swimmer which advances by undulating the body and holding its head above the water. It is the aquatic snake with the greatest geographical distribution: found in almost all of Europe and North Africa. The Viperine snake *(Natrix maura)*, is still called "aspic d'eau" in France, because of its resemblance to the Adder *(Vipera berus)*, which has similar colouring and attitude to the Viperine snake. The Viperine snake is found near to water and feeds exclusively on aquatic animals. The resemblance between this inoffensive Viperine snake and true vipers has led to doubts about whether vipers were found by water or not. It has been established that certain species of vipers, including Adder, do go to water in order to hunt fish. Nevertheless they remain relatively rare inhabitants and are occasional visitors to the wetlands. The Dice snake *(Natrix tesselata)* closely resembles the Viperine snake, but is even more aquatic. It replaces the Viperine snake to the east, from Italy to Asia Minor, and as far north as the Czech Republic.

Natrix maura

A. Fatras/Bios

A diversity of aquatic habitats and populations

Amphibians, turtles and snakes are present in most Mediterranean wetlands. One finds them in marshes, lakes and rivers on the continent and on small islands that they have colonised by means of past connections or through introduction by man.

For the past century the most significant environmental problems in the Mediterranean basin have been related to water resources[13]. The recent history of amphibians and reptiles has been marked by extremes of climate and human actions. Their distribution reveals the natural dynamics of the environment and of civilisations. The Mediterranean wetlands consequently constitute either isolated "sites" or are sometimes part of a much larger regional area which can contain a high number of environments and of communities*.

Torrents, rivers, springs and streams

The diversity of water courses and of microhabitats* created by the river dynamics means that the environment can be occupied by different species. For example, salamander larvae can be found in the most upstream zones of streams, where they continue to be super-predators in these fish-free habitats. Salamander larvae can also be found in great numbers in tiny pools fed by springs, especially in particularly arid areas. Under such conditions, they become cannibals. In Corsica the Corsican mountain newt *(Euproctus montanus)* and the Tyrrhenian painted frog *(Discoglossus sardus)* live in the largest and deepest sections of running water in streams and torrents. Finally, the Marsh frog and the Stream frog *(Rana graeca)* only occupy the banks of the main bed of large rivers. Their tadpoles, which are elongate and have a powerful tail, are hence adapted to life in running water. Irrespective of the environment these communities in running water always have low species richness*.

13 - Pearce (1996)

Fresh water lakes and permanent lakes

In Spain and in the French Pyreneans, it is these Midwife toads that are found in small lakes at altitudes greater than 2000 m.

There are considerable variations in the mesologic (size, depth...) and trophic characteristics of these water bodies. Generally lakes and ponds have an unvaried reptile and amphibian fauna. However, these environments can shelter significant populations of one or two species. One of the limiting factors is the presence of structured fish communities that influence the survival of the amphibian larvae. Certain species are however not affected by this presence, in particular the green frog and the common toad. The vegetation of the banks provides shelter and feeding zones for other species. The mountain lakes in Greece, Albania and Morocco have very few species. At these latitudes, green frogs, a zoological group with a poorly defined taxonomic status, are amongst the rare species that are found at more than 2000 m altitude.

Dayas, chotts and sebkhets

The Poiret newt *(Pleurodeles poireti)* has great reproductive flexibility and is often the first amphibian in Numidie (extreme northeast of Algeria) to reproduce, between September and February, once water returns to its biotopes. Early drying out of its reproduction sites leads to the death of the larvae and means reproduction has failed.

In the wetlands of North Africa, there are vast depressions or lagoons that fill with rainwater from surface water runoff and from the water table. Their surface area is often differentiated into several parts including marshy zones that are permanently or temporarily flooded. In Morocco, the aquatic fauna in such environments is made up of molluscs, annelids, crustaceans and insects. Included in the vertebrates, one can find up to nine species of Anura amphibians, the Viperine snake and the Spanish terrapin *(Mauremys leprosa)*. The Anura are distributed according to the hydroperiod and the water salinity. Few species reproduce successfully in the brackish waters, except for the Green toad *(Bufo viridis)* whose tadpoles seem to

D. Delfino/Bios

The chott El Dierid, Tunisia.

The white dragon or "human-fish" of underground waters: the European blind cave salamander

It is by mere chance that the European blind cave salamander or *Proteus* was first discovered in a flood of underground water in 1685 in what is now Slovenia. The peasants mistook this animal, with its unusual morphology and a chimera side, for a dragon. This is probably how it earned its name (from Latin: "anguis": snake and the Greek god: Proetus, shepherd of sea monsters). This species is unique. Its nearest relatives, with the exception of five other species of the genus *Necturus*, which live in the rivers of North America, live in large rivers and underground lakes in the karstic areas of the Dinaric Alps that border the Adriatic Sea. Its distribution area includes more than 250 locations, and extends from the Trieste region in Italy to the southeast to the regions of Dubrovnik and Trebinje, and includes Yugoslavia, Slovenia, Croatia, Bosnia-Herzegovina and Montenegro.

The *Proteus* is a spindly animal, shaped like an eel and between twenty and thirty centimetres in length. It has an elongated, triangular head that ends in a flattened or square muzzle. Its short and under developed limbs have three fingers at the front and two at the back. These limbs are unsuitable for walking. The *Proteus*, which never metamorphoses, maintains characteristics of the Caudata larvae that are typically aquatic throughout its life, such as its skin, which is a whitish-pink and almost human. It possesses Leydig cells, which should increase the integumentary permeability; the organs of a lateral line like a fish; its eyes are without eyelids and cease to develop during growth. It has three pairs of external gills, which are spread like a bouquet of red feathers around the neck and the bronchial slits. The *Proteus* compensates for its blindness with a very developed sense of smell. It can detect the odour of its favourite prey, which are small endemic cavernicolous invertebrates (chironomid, crustacea larvae), and small dead animals in the detritus[14].

Eggs are fixed one-by-one to the lower side of stones and rocks. Because of the low temperatures (10°C) in these deep caves, it takes them approximately three months to hatch. The female guards her eggs until they hatch, which she defends by pushing away any intruders. Any disturbance to the water captured by the cilium along her lateral line informs the *Proteus* about her environment. When the eggs hatch the larvae measure 2 cm and look like miniature versions of their parents. Growth is very slow, and sexual maturity is only attained between 14 and 16 years of age, while optimal fecundity is only between 20 and 30 years old. With a disconcerting resemblance to man, the oldest *Proteus* can exceed 60 years of age.

This amphibian has become very rare. It has been the victim of a lucrative traffic to satisfy the curiosity of certain scientists, aquariophiles and unscrupulous tourists, and the species is under the threat of extinction. Furthermore, the use of fertilizers, pesticides and insecticides, hydrocarbons and oils, and effluents from industry can cause veritable underground catastrophes. The pollution of water tables and of the limestone network by infiltrating surface waters constitutes a very serious threat, not only to the populations of *Proteus* but also, to all others species of the underground world[15].

14 - Uiblein et al. (1992)
15 - Sket (1997)

tolerate slightly saline water (= 4 g/l). The discoglosse peint can withstand salinities up to 8g/l NaCl[16].
In the northern half of Morocco, the Sharp-ribbed salamander *(Pleurodeles waltl)* can also be found by lifting stones and tree stumps close to temporary or permanent dayas, or in certain slow flowing wadis.
When water only remains for a few weeks, salt concentrations are very high, and no species has been able to adapt to such hostile conditions. The sebkhets of west Algeria do not even have any aquatic vegetation[17].

The Poiret's newt: what future?

Two species of Caudata of the Salamandridae family exist in Algeria:
- a rare and enigmatic species, *Salamandra algira* (Bedriaga, 1883) which is confined to mountain forests.
- the Poiret's newt *(Pleurodeles poireti* Gervais, 1835) which is endemic in the northeast of Algeria and northern Tunisia.
This newt bears the name of the abbot Poiret, a botanist who visited the surroundings of Calle (El Kala) in 1785 and who, in 1789, published "A journey in Barbary: amphibian animals of Algeria".
For a long time it was believed that two or three species of newts coexisted in Algeria (Poiret's newt, Hagenmüller newt and *Triturus nebulosus*). This confusion is doubtless due to the great morphological plasticity of the species, probably in relation to developmental heterochrony*.
Despite often being a species that is selected for work in molecular biology, its ecology is paradoxically poorly understood. Under laboratory conditions, the adults can lead a predominantly aquatic life. In the wild the Poiret newt prefers pools and temporary ditches to lakes and ponds, probably because of predation by fish on its larvae. In the aquatic environment its larvae and adults feed on crustaceans (artemia*, daphnia), insects and amphibian larvae. Being a polyphagous predator, the newt is a key species in the environment it occupies. Once larval development is completed, the juveniles leave the aquatic environment before over-summering in crevices or under stones.
The species is fairly common in Numidie and found on both the plain and in the mountains. It does not however benefit from any protected status despite its vulnerability related to its endemicity. The biotopes it inhabits are threatened with degradation or disappearance. Unfortunately they are not subject to any protective measures in Algeria. The consequences of recent developments (road building) are more indirect, as this leads to the fragmentation of both habitats and populations, which renders the species even more fragile. In certain sites, this situation is even more worrying because of the introduction of exotic fish *(Cyprinus carpio, Gambusia affinis)* that also propagate in temporary environments. In order to ensure the future of the Poiret's newt, understanding about its ecology must be improved and vigorous conservation measures for its habitat are necessary.

Dr Boujema Samraoui,
University of Annaba, Algeria.

16 - *Knoepffler (1962)*
17 - *Grillas & Roché (1997)*

Puddles and temporary marshes

In the "marismas*" or temporary marshes of the Guadalquivir delta, which is flooded from October to July, amphibian reproduction is not random. During the reproductive season, around ten species, including seven Anura and three Caudata, share the fresh, brackish and salt-water environments[18].

The seasonal aridity of the Mediterranean climate favours the development of ephemeral puddles and seasonal marshes. These shallow environments, without fish, can either be isolated, or prolific, with many within a few hectares. Their size varies from a few square metres to several thousand hectares. Their fauna and flora are typical of the Mediterranean basin, and are often endemic and very vulnerable.

In Israel and Morocco, the survival of the Spadefoot toads *(Pelobates syriacus, Pelobates varaldii)* is dependant on winter rains that keep the ponds where they reproduce filled with water for more than four consecutive months.

There is no doubt that the advantages of a temporary endorheic environment are very high for amphibians and reptiles. These environments can harbour many or only one or two species. Their location, morphology and the water quality condition these variations in richness. Today these environments no longer depend solely on rainfall as they are managed and receive irrigation and/or drainage water.

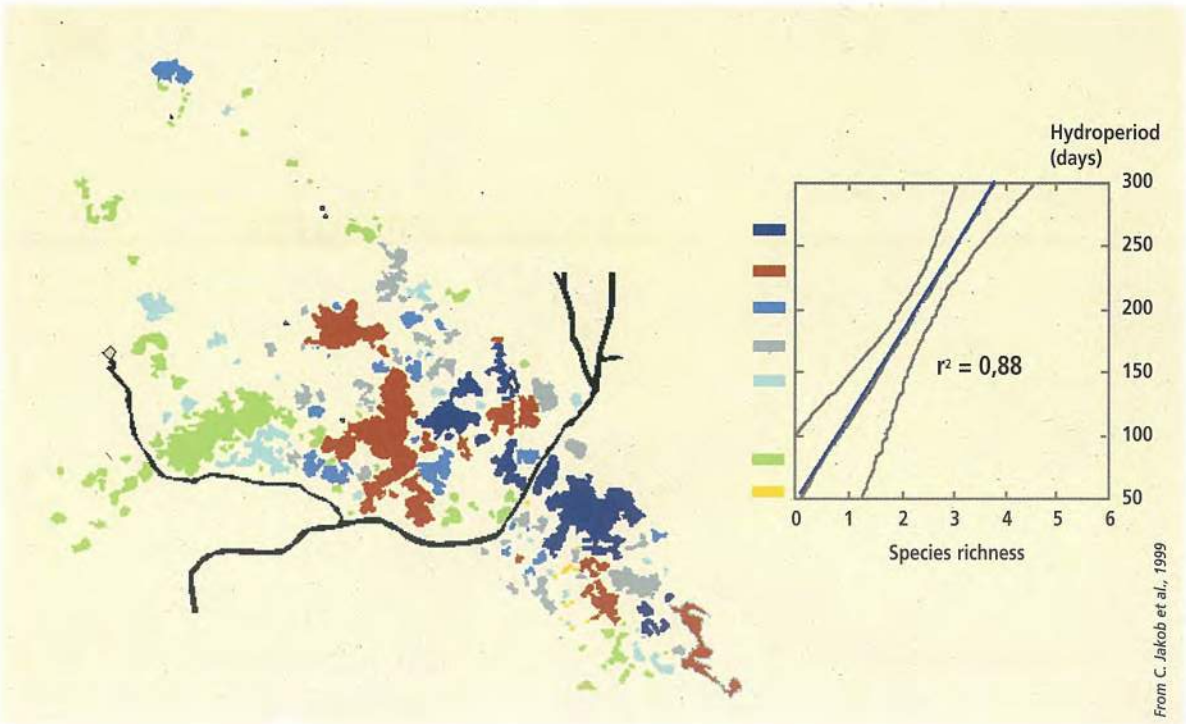
1. *Bufo calamita*
2. *Pelodytes punctatus*
3. *Triturus marmoratus*
4. *Emys orbicularis*
5. *Triturus vulgaris*
6. *Hyla meridionalis*
7. *Natrix natrix*
8. *Rana perezi*
9. *Ardea cinerea*
10. *Pelobates cultripes*

18 - Diaz-Paniagua (1992)

Hydroperiod and amphibian communities

The Roque-Haute reserve in the Hérault region in France has a Mediterranean climate, characterized by hot dry summers and a rainy season in the autumn and winter. More than 200 temporary ponds (between 10 and 2,500 m^2) are distributed across this plateau, which is only 3 kilometres from the sea. These ponds result from basalt mining that has been carried out at least since the Middle Ages and until recent times. Seven amphibians species have been counted, and some of these species' distributions are confined to the south of France and to the Iberian Peninsula. These are: Marbled newt, Palmate newt *(T. helveticus)*, Natterjack *(Bufo calamita)*, Western spadefoot toad *(Pelobates cultripes)*, Parsley frog *(Pelodytes punctatus)*, Stripeless tree-frog *(Hyla meridionalis)*, and Iberian water frog. There is a close relationship between the hydroperiod and the number of species that reproduce in each of the ponds[19]. The Palmate newt, Marbled newt and Stripeless tree-frog are among the most abundant species and are best represented in the various types of ponds. The Western spadefoot toad only occupies ponds that are filled with water for a long time, whereas the Parsley frog can also reproduce in ponds with a short hydroperiod. Thus, similarly to other Mediterranean systems, the hydroperiod is one of the major factors structuring this community of amphibians.

More than two hundred temporary pools, to which hydroperiod is correlated (as number of days), and the number of species of amphibians.



19 - *Jakob et al. (1999)*

Artificial wetlands

Watering holes and ponds in karstic and desert areas are favourable places for aquatic communities to develop. However, excrement and trampling by cattle in this stagnant water quickly turns such an environment inhospitable for larval survival. Washing places, wells and cisterns, etc... are other works of man that can be of herpetological interest[20].

Gravel quarries that are still being exploited generally are of little interest for fauna; most of the time they even have a negative impact on both the environment and on the herpetofauna[21]. However, once they have been abandoned, they can become very attractive for several species. The bottom of the gravel pit is covered with a fine film of silt, and it is possible, if the banks slope gently, for them to be colonised by semi-aquatic vegetation. This provides a multiplicity of microhabitats that are favourable to amphibians and reptiles. Furthermore, the frequent fluctuations in the water level prevents the establishment of structured fish communities. Thus, certain gravel pits that have been abandoned for about ten years in the plains of the major bed* of the Haut-Rhone River are sites of high interest for amphibians[22].

One generally, and rightly, associates human activities with a reduction in biological diversity. In the case of amphibians and probably of some reptiles, it is probable that man has locally assisted the extension of certain species by the creation of secondary biotopes.

J.M. Prévot/Bios

The habitat of Midwife toad *(Alytes obstetricans)* in southern France.

20 - Pinston (1990)
21 - Welsh & Ollivier (1998)
22 - Morand & Joly (1995)

Alluvial valleys: regime of disturbance and biodiversity

Nowhere is the diversity of amphibian and reptile species as high as in the alluvial valleys of large rivers[23-24]. Such richness is due to the functional diversity of the terrestrial and aquatic environments of these valleys. River dynamics, the natural disturbance regime, is responsible for a mosaic of wetlands, which in turn, are at the origin of a high biodiversity. Each of these aquatic or semi-aquatic ecosystems is representative of various degrees of influence by the active river channels, and undergoes various modes of abiotic and biotic disturbance. At any given time, the valley consists of sites at various stages of ecological succession*, from gravel banks that are altered with each flood to old eutrophic* oxbow lakes which have permanently been abandoned by the running waters of the river.

A coexistence of species results, each with very diverse ecological requirements. These assemblages or populations of species are primarily conditioned by the size of the sites; their heterogeneity; the distance from the minor bed*; the alternation of being filled with water and dried out and relationships with predators and aquatic competitors present. Unfortunately, alluvial valley landscapes have been greatly modified over several centuries by all sorts of development such as dams, draining, fish farms and hydroelectric works. In common with many other species, amphibians and reptiles pay the price of these modifications to the functioning of the hydrosystems*.

Nevertheless, the current state of our knowledge enables us to believe that real convergence of interest between the hydraulic management of alluvial valleys and persistent rich and diversified communities of amphibians and reptiles can exist. Aquatic sites that are peripheral to the main channel of large rivers effectively play an important role in absorbing floods. It is probably not too late to undertake restoration projects to create favourable conditions for viable populations of amphibian or reptiles in accord with the management of the whole watershed*.

23 - Joly & Morand (1997)
24 - Real et al. (1993)

From refuge to growing site: the terrestrial environment

The terrestrial environment surrounding the water body has multiple functions that need to be preserved (feeding zone, site for laying eggs, site for hibernation or over-summering).

Another important condition for the environment of amphibians, and of reptiles that are linked to wetlands, is the presence of adequate shelters where they can be isolated from heat during the day, in particular during dry spells. Many species occupy aquatic environments during the night in order to hunt, but must shelter during the day in the crevices of dead tree stumps, or in cracks in the ground. Some species have to find suitable ground they can dig into and where they can isolate themselves several centimetres from the surface. The distribution of the Western spadefoot toad is thus related to the juxtaposition of sandy environments and places for reproduction in fresh or slightly brackish water. In order to grow, juvenile European tree frogs need to consume large numbers of invertebrates that they find in wet fields. The aquatic habitat where the larvae develop cannot be very far from terrestrial habitats that are favourable to the other stages of their lifecycle.

During the winter, several species of amphibians, but also many reptiles, migrate towards dry places that still have a high humidity. Salamanders, toads and water snakes are sometimes found together at the entrance of mines and other underground environments. More usually, individuals of several different species take refuge under stones. Ultimately, both amphibians and reptiles must alternate between an aquatic life stage and a terrestrial one. The challenge for scientists and conservationists is the identification of which of the aquatic and terrestrial factors are important for the management of their populations and environments.

T. Naziridis

Diversity of adaptations

Almost all animal species on this planet, apart from mammals and birds, are "cold blooded" animals, or ectotherms. Nevertheless, amphibians and reptiles are by no means more primitive than birds or mammals. Their behaviour, biodemographic strategies and physiology are just as complex, and just as well adapted to the extremely variable environments that they inhabit.

Caspian terrapin, *Mauremys caspica*, sunbathing in a Greek wetland.

Except for warm-blooded animals, most living creatures are apparently perfectly functional with a variable body temperature. Ectotherms (also known as cold-blooded animals) are characterised by the fact that they need external energy in order to keep warm. This adaptation presents many advantages. The animal does not have to maintain its temperature at the cost of wasting energy when the environment cools down, or by losing water by evaporation when heat becomes excessive.

Certain Mediterranean wetlands are characterized by a serious lack of water at certain times of the year and by very high variations in temperature. These temperature variations are not only seasonal but also differ according to the hour of day. For amphibians and reptiles, ectothermy does not mean passive acceptance of hydrological and/or thermal constraints imposed by a given environment. The animal is free to move and thus to choose its thermal environment according to its needs: when the priority is economy, at times of rest, a cool environment is chosen; when the priority is performance, at times of activity such as when it is searching for food, a warm environment is chosen.

1. *Natrix maura*
2. *Bufo calamita*
3. *Discoglossus galganoi*
4. *Pelobates cultripes*
5. *Hyla arborea*

J. Lopez

Adaptations for fighting against heat and dryness

Reptiles, like amphibians, which do not live permanently in wetlands sometimes have to fight against the heat and dryness of the air.

• They lead a twilight and nightlife: generally poikilothermic animals, which are more sensitive to hyperthermic stress, tend to hide from the sun's rays and lead a twilight or nocturnal.

• They drink water via the skin: contrary to reptiles with their horny impermeable skin, the thin skin of the amphibians means that mostly they cannot spend more than a day in the open air as they are quickly dehydrated. This characteristic is an advantage when water is abundant, as amphibians do not need to drink, because they absorb water through their permeable skin from all wet surfaces.

• They limit loss and recycling of water: amphibians compensate for their inefficient kidneys by the permeability of their bladder and by recycling water in their diluted urine[25]. The excretion of waste is also favourable for reptiles in arid environments, as this waste is transformed into the not very soluble uric acid which is eliminated in a precipitated solid form. This limits water loss.

These protective measures are useful in the short term, but are not enough on their own and only adapted behaviour or the other specific physiological mechanisms found in some rare species allow amphibians to occupy very arid zones[26].

• Some bury themselves for over-summering: the Western spadefoot toad is a typically Mediterranean species, which exhibits digging behaviour during the day, thus allowing it to avoid the highest temperatures. It is particularly well equipped to fight dryness. Its two hind legs have a kind of horny prolongation that it uses as a spade. Once water is in short supply or the temperature becomes too high, it digs a hole in the ground by moving backwards and hides there. It can bury itself up to 1 metre in depth. Its American cousins can generally withstand up to 8 or 9 months, resigning themselves to a state of lethargy similar to hibernation, which is called over-summering. This summer sleep ends with the first downpour. The amphibians appear from out of the ground and rush to the nearest pool.

25 - Warburg (1972)
26 - McClanahan et al. (1994)

Resisting the cold by avoiding or controlling freezing

For the species of continental Europe and those of the northern Mediterranean the winter season is a physiologically difficult period because it combines the general effects of a drop in temperature, scarcity of food, and sometimes the absence of water.

Amphibians and reptiles have a low capacity to disperse. They cannot withdraw from the cold and its consequences by migrating, as birds do, moving to areas with milder winter climates. Amphibians must therefore find effective shelters where they are. Most choose relatively warm over-wintering sites, underwater or deeply buried underground. This is generally also the case for reptiles. Amphibian species spend the winter underground, or in the mud at the bottom of permanent aquatic environments. This sometimes requires significant migrations. Even if the water freezes at the surface, the water at the bottom of the pond generally remains liquid at about 4°C.

A certain number of species control freezing, generally by being equipped with a substance that prevents the cells from freezing. Frogs, snakes, and turtles use glucose as an antifreeze, while some species of the *Hyla* genus use glycerol, the alcohol that we add to car radiators during the winter! For several years researchers at Carleton University in Ottawa have been studying a group of amphibians and reptiles that hibernate while letting themselves freeze[27]. The Wood frog *(Rana sylvatica)*, a vicarious species* of the Agile frog *(Rana dalmatina)* in Europe, lives in North America and over-winters under a layer of snow and leaves at an ambient temperature of -8°C.

A third strategy is super cooling, a variant of the above strategy, whereby the body fluids are maintained liquid at temperatures at which they should normally freeze.

All these strategies are accompanied by a reduction in metabolism of between 90 and 99 % compared to normal. This extends the time of use of body reserves by a factor of 10 to 100.

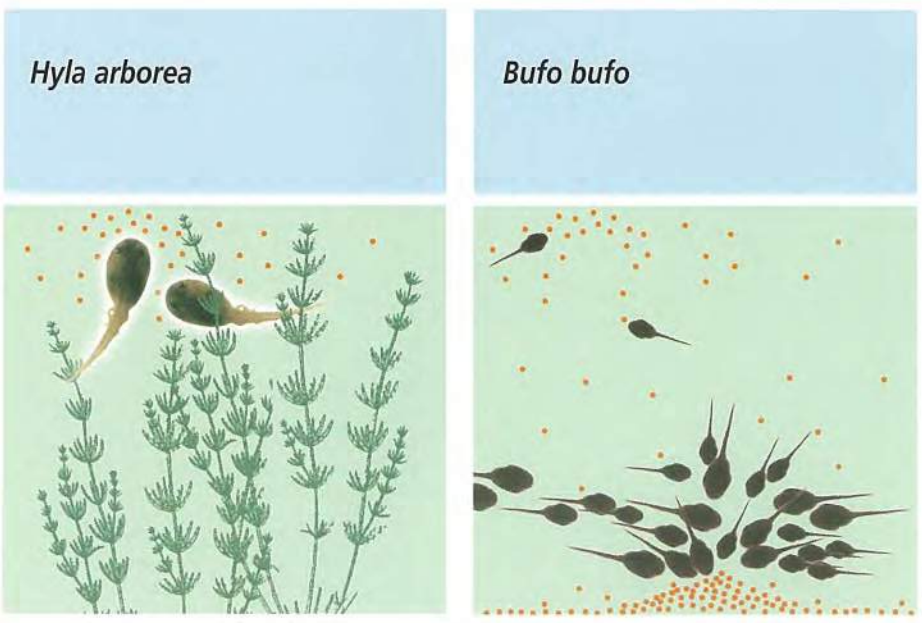
27 - *Storey & Storey (1991)*

Feeding: the beak and the tooth

Feeding is necessary for all living creatures, and whoever takes the trouble to study amphibians and reptiles in detail cannot help but admire their feeding techniques.

A change in diet

Contrary to the larvae of Caudata, which are exclusively predatory, tadpoles are usually considered as being benthic organisms equipped with a horny beak that they use to graze on aquatic plants. This image was however found to be more complex during the past two decades following stomach contents studies, the comparative analysis of oral and filtration apparatus and the distribution of tadpoles in the water column. Detritus, suspended organic particles and associated microbial fauna, periphyton*, living macrophytes and animal prey items make up as many different food categories as there are species and developmental stages of tadpoles. Thus, the tadpoles of the European tree frog and probably those of the Stripeless tree frog are adapted to filtering the water column or the surface water film[28]. The Natterjack and Yellow-bellied toad *(Bombina variegata)* frequently feed in small oligotrophic ponds; they are well adapted to taking suspended matter[29]. On the other hand, the tadpoles of the Common toad are generally benthic and are scrapers of deposited organic matter. There is great variation in diets and feeding modes that is related to the availability of resources and the heterogeneity of the environment, according to phenomena determined by competition and other biotic interactions. Some tadpoles are carnivorous. In Spain, in temporary



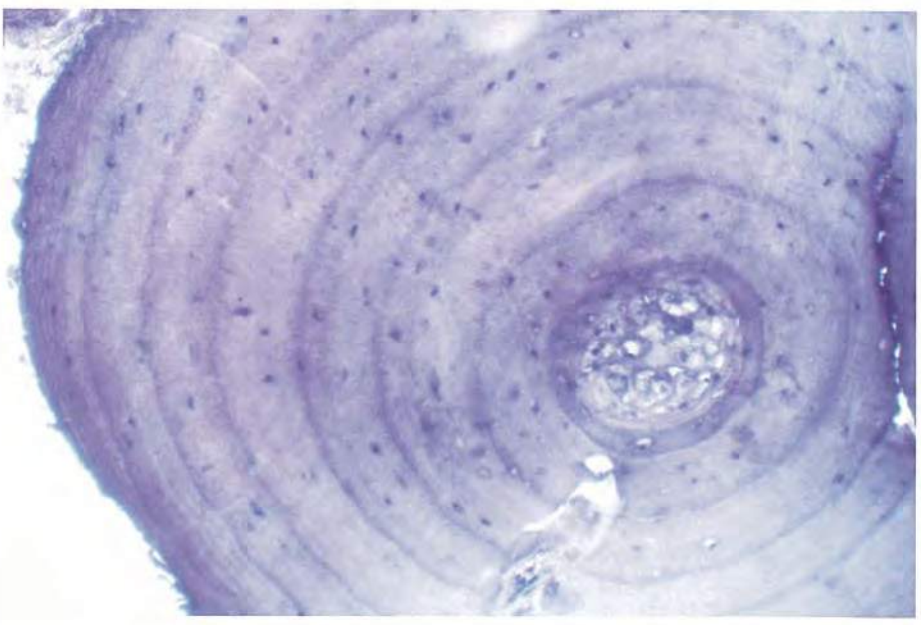
Certain tadpoles *(B. bufo)* have chemical repellents to dissuade fish from feeding on them. Moving in shoals is also a strategy to avoid predation. The Tree frog tadpoles take refuge in the vegetation; they are most vulnerable as they search for particles to feed on.

28 - Diaz- Paniagua (1985)
29 - Viertel (1987)

ponds with low productivity, the tadpoles of the Parsley frog and the Western spadefoot toad, species with early reproduction, feed on the eggs of the Natterjack[30], a species with late reproduction.

Actively hunt for prey or wait and watch for them to come

All the adult amphibians of the Mediterranean regions are carnivorous and usually only eat live prey. They do not react to motionless prey, as it is movement that stimulates the capture reflex. With their squat bodies, very short legs and not very webbed feet, the Natterjack is very mobile and actively hunts on sandy ground. Newts feed actively on land and in the water. They locate their prey (earth worms, chironomids, crustaceans...), seize them in their jaws made of small conical teeth, and to ingest them better, retract their eyes. The depression of the eyes, in amphibians, helps with the progression of the prey towards the oesophagus. Compared to the Natterjack or to newts, the Common toad waits peacefully hidden, until a slug or an insect is within range and it projects its prehensile tongue. Toads and frogs are often the prey of other active hunters, such as the Viperine snake or the Grass snake. Similarly to pike, the European pond terrapin lies in wait behind a curtain of vegetation until an aquatic insect, a tadpole or a small fish pass within reach of their beak. They can also go in search of prey, slowly moving through the aquatic vegetation.



C. Miaud

Cross section of a Grass frog's phalanx. The nine lines of arrested growth and the periphery tell us that this individual is 10 years old.

30 - Tejedo & Recques (1994)

Growth, age at maturity and life expectancy

Both longevity and age at maturity are poorly understood for amphibians and reptiles. This information, derived from skeletochronology* techniques, is however fundamental in order to consider the temporal dimension of strategies to conserve these species.

Much work exists on the demography of certain zoological groups such as fish, however little relates to amphibians and reptiles[31]. For the male, age at maturity is defined as the age at which he participates in reproductive behaviour for the first time, while for the female it is the age at which she deposits her first clutch. The energy expenditure and the risks incurred at the time of reproduction directly influence the longevity of the individual. Longevity and age at maturity are variable parameters from one species to the next and even within the same species between different populations. Altitude, temperature, isolation of the population and the number of predators influence the age structure[32].

Certain species live for a long time while others live for much less. Thus, the Green frogs are species with a short lifespan whereas the Yellow-bellied toad and the large newts (Marbled and Crested newt) are long-lived species (between ten and fifteen years). They reproduce at between two and four years of age[33,34]. It can be assumed that only species that reproduce under very unstable conditions exhibit a long life expectancy and a relatively early age at maturity in order to compensate for the risks of the environment. Thus, during the life of an individual, only one favourable year to reproduce may compensate for all the bad years. In the Mediterranean countries, where rainfall is not regular from one year to the next, and may even fail in certain years, these adaptive strategies mean climatic hazards can be compensated for.

31 - Castanet & Smirina (1990)
32 - Miaud et al. (1999)
33 - Caetano (1990)
34 - Plytycz & Bigaj (1993)

The different stages of reproduction

The evolutionary tendency of the amphibian group is for progressive migration from the aquatic environment to a terrestrial one. However, in the Mediterranean biome it is noted that, with some exceptions, amphibians must return to the fresh water environment to reproduce and deposit their eggs or larvae there. Turtles and aquatic snakes return to the water shortly after their terrestrial hatching.

Only a few amphibian species are partially liberated from the aquatic environment. Examples include the Midwife toads, whose males carry their eggs around their rear limbs; their tadpoles carry out part of their development within the egg, until they are released in a pond.

The exchange of reproductive cells is preceded by preparatory behaviour and/or an elegant bridal dance. These rites are specific to each species. For the Caudata, the ceremony is primarily made up of a series of stereotypical behaviour, while the Anura emit more or less sonorous vocalizations. Each male has a specific song and they often confront each other over the possession of the female. The aquatic environment means fecundation can be external, the mode used by all Anura and which follows a pseudo coupling (or amplexus). The eggs are simply sprayed by the male's semen when they are released from the female's cloaca*. The male Caudata deposits a spermatophore* in the water that the female absorbs with her cloacal lips and the help of her rear legs. In snakes and turtles mating also follows a complex ceremony. The male snake has two retracted hemipenis at the base of the tail, but only one of the two is introduced into the female. Turtles and snakes only have one reproductive mode, egg laying (oviparity*), the notable exceptions are the vipers that are ovoviviparous*, they release already formed young.

F. Andreone

Cave salamander, *(Hydromantes)*, living in caves in Italy and in the South of France lay about a dozen eggs. The female, who is very attentive, remains curled up around the eggs until they hatch.

Larval development strategies

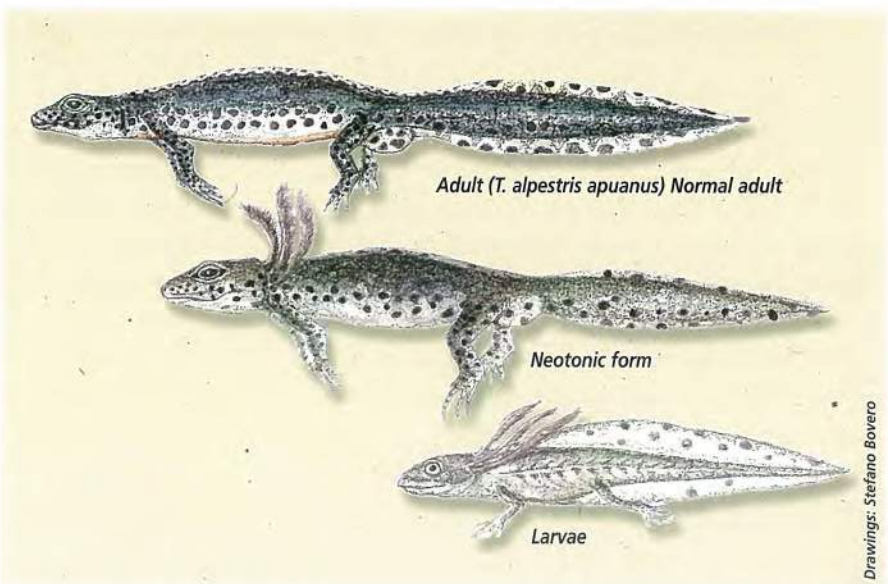
For amphibians the larval development strategy differs according to the species, the region and the season. Metamorphosis is the sign of passage from larval life to adult life. When development in the aquatic environment lasts for a long period, it favours a large size at metamorphosis but increases the risk of predation and also death due to drying out. On the other hand, a large size at metamorphosis increases juvenile survival and the capacity to disperse in arid environments.

In 1863, the famous Mexican salamander or axolotl, which is known to have been a delicacy for the Aztecs, was brought to France. It reproduced while still in the larval stage and to everyone's great surprise; some of the larvae changed morphology and left the water. They became the small Tiger salamander *(Ambystoma mexicanum)* that was already known In fact the axolotl and the Tiger salamander were two forms of the same species.

The processes of growth and development are closely related to temperature[35], to food resources and to competition. Some species such as the Natterjack find optimal development conditions in hot water (up to 35°C). The tadpoles of the European tree frog do not tolerate temperatures below 15°C. Both Green frogs and Tree frogs are thermophilous species, i.e. they like heat.

Competition is another factor which influences growth either due to limited resources (exploitation competition) or by growth inhibitors (competitive interference). These lead to either a reduction in size and/or an increase in the time required for development.

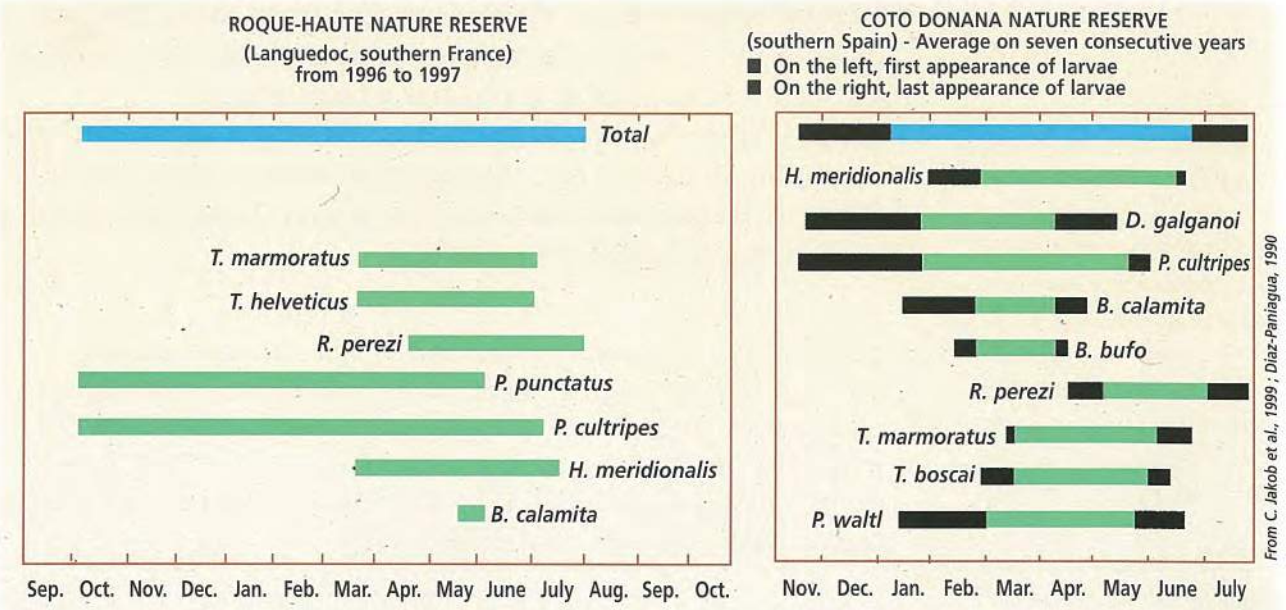
This delay in development can lead to an increase in mortality (drying out in shallow environments or predation in permanent water-bodies).



Neotony is optional for the Triturus genus and can be inhibited by injecting thyroid hormones.

35 - *Morand et al. (1997)*

A large body size reduces the risk of predation and increases competitive aptitude.



Based on the staggered maturation and deposit of eggs, clearly iteroparous species, which spread their reproductive effort across the whole season, can be distinguished from semelparous ones, which have a single, generally explosive reproduction, and which only reproduce once per season. Within species, temporary populations also exist.

Metamorphosis, an anatomical and physiological tidal wave

The birth of the green frog, the Common toad, and all other amphibians is an extraordinary process, within several weeks metamorphosis modifies the anatomy and physiology of the tadpole. During these major changes, certain organs are lost (the tadpole's tail, gills...), while others appear (legs, lungs...). Metamorphosis is thus a set of complex biochemical, physiological and morphological phenomena, all which are controlled by thyroid hormones.
The simple ablation of the thyroid gland, or the absence of one of the necessary components prevents the metamorphosis. If metamorphosis does not occur, the tadpoles become very large but cannot reproduce. However, the non-metamorphosed larvae of Caudata can reproduce, this is called neoteny.
Amphibians are classified in three groups according to their capacity to metamorphose. The Anura (toads, frogs...); the Caudata with optional neoteny (Alpine newt, Mountain newt, Axololt...) and the Caudata with obligatory neoteny (European blind cave salamander).

Dispersal for survival and colonisation of other environments

Often it is assumed that all amphibians and reptiles, within a single group, possess the same ability to disperse. This is not the case. Some species are sedentary while others are nomadic. Within a single species, the juveniles are generally the dispersive phase whereas the adults remain where they find a favourable reproductive site.

Species are associated with habitats that constitute either sites for growth, for reproduction, or for hibernation or over-summering. It is a specific characteristic of both amphibians and those reptiles that are linked to wetlands that they occupy both an aquatic environment and a terrestrial one; several species regularly carry out seasonal migrations between these two environments. However, observation during their terrestrial phase is difficult because both amphibians and reptiles are often nocturnal and lead a discrete life. Newts inhabit crevices, crevasses and rodents' burrows, all of which are difficult to access. We tend to assume that the adults of all species can easily disperse and colonise new habitats. This assumption is however seldom confirmed.

Isolation, dispersion and the functional relationships between these two parameters are fundamental for the ecology of these vertebrates and for their conservation. Dispersion during the reproductive season can be related to the drying out of a site or to the introduction of predators. Thus, European pond terrapins are able to move across land and traverse up to 500 metres in two days if their pond dries out[36]. Other species prefer to over-summer sheltered from the heat. The distances covered during intra-annual dispersion phenomena by batrachians are in general shorter than those observed between two successive reproduction seasons. These distances seldom exceed two kilometres and vary according to species considered and the possible habitats for dispersion[37].

36 - Naulleau (1992)
37 - Joly et al. (2001)

A. Hodalic/Saola

Disappearance and decline of populations

The differences between present and past rates of extinction are far from negligible. The present day wave of extinctions is unprecedented, and numerous species of both amphibians and reptiles are menaced with imminent extinction.

In many regions of the world, amphibians are threatened with extinction. Why? Pollution, climatic warming, rarefaction of stratospheric ozone, illness? None of these causes suffice to explain this decline, but added together, and to the destruction of habitat, the introduction of exotic predators and excessive consumption, it is more easy to understand this phenomenon that is also of concern for reptiles...

The European blind cave salamander.

The decline of amphibians: true or false problem?

During the seventies no sooner were some species discovered than they disappeared for reasons that remain unexplained. What is even stranger is the fact that they lived in areas around the world where there was no obvious reason to expect their disappearance. These facts are far from anecdotal and alerted scientists who decided to study the problem very seriously. Even more worrying was the fact that amphibians are probably indicators of global environmental degradation. The Declining Amphibian Population Task Force (DAPTF) of the Species Survival Commission (SSC) of the World Conservation Union (UICN) was created in 1991.

Controversy about the world decline of amphibians centres around two major questions. To what extent is this decline a real phenomena rather than natural fluctuations[38,39], and, are the causes changes at a global level or are they micro-changes at a local scale that are difficult to detect?

There are several hypotheses that try to explain the disappearance of amphibians in the world. However, most of them are impossible to test, either because they are too complex, or because they are based on insufficient data due to the lack of in-depth long-term research. Another difficulty is that each species reacts differently to rain, humidity and temperature. Most amphibian populations fluctuate spectacularly from one year to the next according to variations in these parameters. Only by recording these demographic variations over several years can the controversy between alarming scenarios of disappearance and natural fluctuations be avoided[40,41].

F. Andreone

Lanza's alpine salamander, *Salamandra lanzai* in the Piemont region in Italy.

38 - Wake (1991)
39 - Peachman et al. (1991)
40 - Reed & Blaustein (1995)
41 - Pounds et al. (1996)

Disappearance and decline of populations

F. Andreone

***Hyla sarda* found in Corsica and Sardinia.**

The influence of global changes (ozone layer, greenhouse effect) can be significant in the temperate and polar areas of the north. The negative effects of an increase in ultraviolet radiation on the eggs and embryos of certain species have been shown[42].

Climatic and microclimatic changes due to El Nino are strongly suspected to be responsible for the disappearance of amphibians in the wet forests of Australia and Central America[43]. Most scientists believe that these causes are real, but they are generally less important than other causes such as the disappearance and fragmentation of wetlands. The introduction of fish also constitutes a very serious threat for indigenous amphibians. There is no doubt about the impact of acid rains and of strongly polluting substances such as heavy metals, whereas the effects of weed-killers and insecticides are difficult to evaluate. Viruses such as microscopic fungi are another potential cause of concern that are also currently part of the well studied assumptions[44].

On the basis of these different hypotheses, this set of factors, acting in isolation or together, undoubtedly has effects on the population of amphibians. At present researchers agree that the cause of the disappearance of amphibians should not be attributed to a single factor, but to the synergistic effect of various factors.
Is the disappearance of amphibians a real problem or not? Long-term studies show that the situation has become critical in many places, and even if doubt still persists, it is essential that we recognise the problem, and believe in our capacity to solve it with action[45]. Species with the lowest fecundity and turnover rate are the most threatened. The disappearance of the amphibians must therefore be considered as a real problem[46] and an alarm signal, especially as this phenomenon is directly related to water resource management and wetland conservation strategies. Many reptiles show similar tendencies with a reduction in size of their populations and experts are now establishing the extent of the problem and the threats facing this group[47].

42 - Blaustein et al. (1996)
43 - Laurance (1996)
44 - Kiesecker et al. (2001)
45 - Wake (1998)
46 - Houlakan et al. (2000)
47 - Gibbons et al. (2000)

The causes are numerous and diverse, and in order to direct conservation activities, it is essential that they be very precisely identified.

The causes can be of natural origin and may include climate change, the dynamics of the environment and vegetation, species interactions or speciation phenomena... However, over recent centuries, the rates of extinction have been much higher and inconsistent with natural rates of extinction. These rates are due to human activities and the anthropisation* of the environment. In the Mediterranean today, there is hardly an environment that has not been subjected to the direct or indirect influence of man.

A pathogenic fungus destroys Spanish amphibians[48]

About ten years ago, the Midwife toad was found in at least 35 ponds of a sampled set. In 1999, it was found only in five ponds, i.e.: it had disappeared from approximately 86 % of all the sites it previously occupied, at which time its population had been one of most abundant in the park. In the five remaining ponds, this species' tadpole density had decreased. On the banks of the ponds a large number of barely metamorphosed juveniles were also found. Samples of these individuals were taken and their epidermis was analysed. Infection by tiny "chytridiaux" fungus was found. This is a new genus of *Batrachochytrium*, which until then only infected plants and invertebrates. This is the first proven case that really shows the decline of a European population, moreover a Mediterranean one, caused by a fungal infection! The symptoms of this infection are very similar to those observed in amphibians living at high altitudes in protected zones in the United States and in Australia.

Low fecundity probably explains the extent of decline of this particular species, as it seems that the Common toad, which is also found at this site, is less vulnerable due to its high fecundity and shorter duration of its larval stage in the aquatic environment. Furthermore, the origin of this fungal disease is still unknown. An initial hypothesis blamed exotic species for its introduction. Another hypothesis is that there may have been greater sensitivity to this fungus due to physicochemical changes in water quality.

48 - *Bosch et al. (2001)*

Degradation and disappearance of wetlands

The expansion of farmlands, urban and industrial development projects and fires lead to the disappearance and degradation of wetlands, with subsequent consequences on the water cycle and a reduction in populations of amphibians and reptiles.

There is no doubt that the most serious threat for the amphibian and reptile populations of the Mediterranean wetlands is the disappearance of favourable habitats. Agriculture[49] is one of the first culprits with the inconsiderate conversion of wet areas into cultivatable soil or intensive pastures by draining. These practices transform the landscape into monocultures (poplar trees, corn, eucalyptus...) or into over-grazed and degraded zones. The Mediterranean basin has not escaped this modern agricultural policy, which leaves monotonous and sometimes sterile, farmland landscapes, as exploitation has only been considered with the short term in mind. These new environments are very sensitive to fires and are the source of irreversible environmental degradation. Furthermore, they decrease atmospheric humidity, which is a significant factor for this species and for amphibians in general.

In Spain, the natural forests, where European golden-striped salamander *(Chioglossa lusitanica)* is found, have been displaced by monocultures of eucalyptus and pines.[50]

The hydrological regime of rivers has been greatly changed by dike construction, riverbank development and dams. In addition to the impact from agricultural runoff, these constructions lead to a reduction in the water table level under the floodplain. The evolution of plant successions is accelerated and very often the wetland is condemned to drying out and disappearing, to be replaced by shrubby moor. Since the demise of agricultural, the majority of wet marshes and meadows are left to pure and simple abandon, and a consequent homogenization of the environment.

49 - Oldham (1998)
50 - Vences (1993)

Habitat fragmentation

During the Rio Conference in 1992, habitat fragmentation was designated as being one of the major causes for the decline of biological diversity on a world scale.

The reduction in wetland surface area clearly leads to a decrease in animal and plant production. The number of species and population sizes fall. The survival of a population below a certain threshold, known as the viable minimal size, is often seriously compromised. If these populations are considered together within a larger area, for example the region, rather than separately, it can be seen that they become increasingly isolated from each other. A low capacity to disperse and significant sedentariness are common characteristics of amphibians and reptiles that make them vulnerable to such risks. Thus, at present, most species exist in small populations that are increasingly far from each other. This isolation prevents contact and genetic exchange between populations of a single species. Habitat fragmentation is considered one of the most significant problems leading to the disappearance of amphibians and reptiles[51].

F. Andreone

Male of *Triturus alpestris*.

51 - Lehniten et al. (1999)

Water and air pollution

The waters of the Rhone in France, the Nile in Egypt, the Po in Italy, the Ebre in Spain and those of other rivers are polluted with agricultural and industrial effluents. Coastlines are no better, threatened in particular by visible pollution episodes such as black tides, eutrophication* and blooms of green and red algae that menace the remaining beaches where turtles lay their eggs.

The disappearance of certain amphibian species in regions where land use has remained unchanged for a long time must be due to exogenous factors. The main cause of pollution comes from the discharge of organic residues. The second cause of pollution, which is even more serious, is the contamination of fresh water by toxic industrial discharges (for example, heavy metals). The acidification of water bodies by the deposition of atmospheric sulphuric acid dissolved in rainwater ("acid rain") from human sources is another probable factor leading to destruction.

All these pollution forms can increase amphibian larvae mortality. Detergents and insecticides have also been formally identified as causes for mortality.

The European pond terrapin and water snakes are located at the top of the food web, their tissues concentrate all the toxic pesticides that their prey contain, and they end up being poisoned themselves. The

A. Morand

Dead tadpoles following a spraying of insecticide.

Mediterranean turtles also suffer the consequences of pollution. In particular many Loggerheads are found with tar on their heads, in their oral cavities and in the intestine[52]. Several have been found dead and beached on the Italian coast. Heavy metals and pesticides are probably responsible for their intoxication.

Nightmare frogs and toads

"We observe more with our thoughts, than with our eyes" This quotation could apply perfectly to the monstrous amphibian with its eyes on the roof of its mouth which survived to adulthood in a garden in England. In France, abnormalities have been known to exist since the works of Jean Rostand, who devoted a fair proportion of his work to the study of ponds with monsters. What is the teratogenic agent at the origin of polydactyly in the Green frog of these ponds with monsters?

The increasingly frequent discovery of monstrous amphibians in the lakes of Minnesota in North America worries experts. In certain cases the concentrations of malformed individuals reaches 70%. Some frogs have additional legs; others have a cyclopean eye... More than one hundred malformations have been listed. Generally they are observed just after hatching, which suggests that an active agent is present during embryonic development. Three hypotheses seem probable: small parasitic worms, ultraviolet radiation from the sun which is poorly filtered by the ozone layer that has become too thin, a chemical agent (pesticide...).

52 - *Groombridge (1990)*

Consumption and over-exploitation

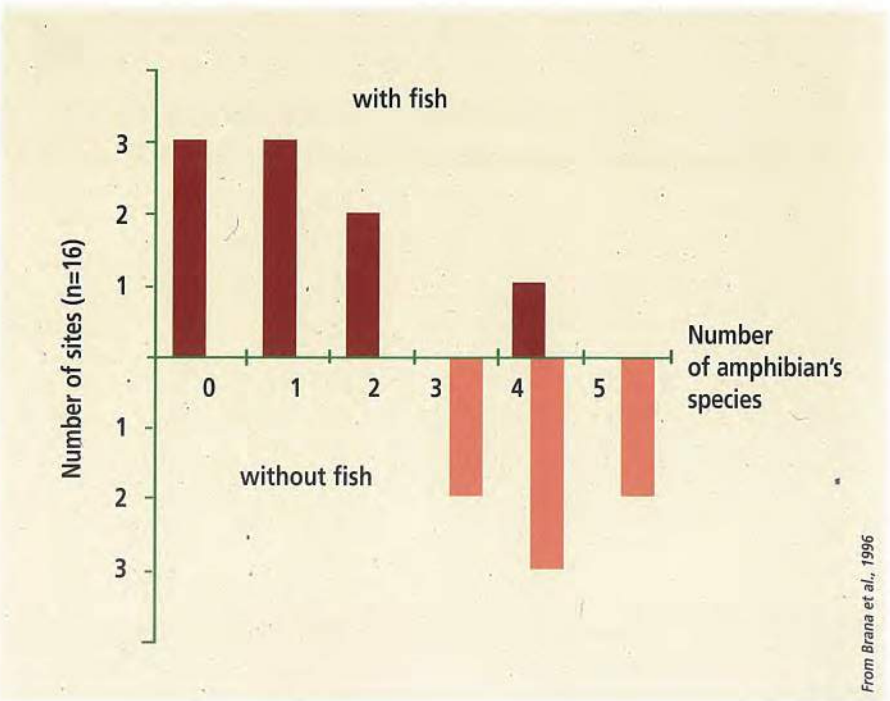
For a long time the frog escaped gastronomy because it was considered unsuitable for consumption, and even toxic or poisonous.

Unfortunately, culinary customs changed and frogs became a luxury food item for the Italians, Germans and French, the latter being even known as "frog eaters" or "froggies" by the British. Over consumption of some species at the beginning of 20th Century has accelerated their disappearance. Despite their agility, frogs are easily caught in traps. At night, with a torch or lamp, they can be caught by hand and do not try to escape. Techniques for catching frogs range from artisanal fishing with a small ball of red cloth at the end of a string as bait for the Green frogs, to keep net fishing for Grass frogs. All these techniques enable considerable quantities of frogs to be caught in a few hours. The most important restaurants compete in the variety of recipes using frogs' legs. Artisanal collection can no longer meet demand. In France, fishing pressure on frogs has become so high that since 1980, a law that limits catches to a family's consumption has regulated it. France imports approximately 4,000 tons of frogs' legs per year, i.e. about 100 million animals per year.

In the Marismas* of the Guadalquivir, soup made from the fresh water turtle from Almonte is considered a delicacy. For this reason poaching is intense. Mediterranean marine turtles also become trapped in lost fishing nets from many trawlers, and from poaching. The low price of turtle meat creates significant demand, in particular in Egypt and in Tunisia, where they end up on markets and then on local inhabitants' or tourists' plates depending on the country. It has become imperative to evaluate the consequences of these captures.

Intensive culture of frogs: a myth that became reality

The amphibians' life cycle makes the intensive culture of these animals difficult, in particular because of the propagation of disease and the difficulty in feeding juveniles, which require live mobile prey[53]. Several projects to market frogs have been conceived in the Mediterranean area. In Algeria, private investors initiated the culture and collection of Iberian water frogs for export. No data exist on the success or failure of these companies. In France, in Languedoc-Roussillon, a culture programme was launched in 1995 and included over 25 installations. More than 125,000 Grass frogs were marketed. The objective of such an operation, beyond its economic one, is to increase awareness about the protection of the Grass frogs within the framework of controlled exploitation. The programme is run in collaboration with farmers and concentrates on the three most significant phases of the life cycle: reproductive migration, larval development and migration during the first winter. The clutch is protected from various predators and the tadpoles reared in extensive ponds. It is only necessary to ensure the water is renewed regularly, to limit growth inhibitors, and to reduce the density of tadpoles in the rearing tanks. Thus a large number of juveniles can be produced, which are then released into the natural environment and, in the long term, should increase the number of adult individuals. A study[54] has shown that under essentially comparable extensive culture conditions, if the clutch is not protected, resulting populations will be lower, which has an effect on population dynamics and the age structure.



Amphibian species presence, richness and composition in lakes with or without fish.

Fish :
Salmo trutta, Salvelinus fontinalis, Oncorhynchus mykiss, Phoxinus phoxinus, Tinca tinca, Rutilus arcasii.
Amphibians :
Chioglossa lusitanica, Salamandra salamandra, Triturus alpestris, Triturus boscai, Triturus helveticus, Triturus marmoratus, Alytes obstetricans, Bufo bufo, Rana iberica, Rana perezi, Rana temporaria.

53 - Neveu & Régnier (1985)
54 - Augert & Joly (1993)

Introduction of exotic species

The introduction of exotic species is a global phenomenon, and has become a serious problem in aquatic ecosystems. Competition, niche displacement and predation are often explanations given for the decline of some indigenous populations.

Several studies suggest that the decline of indigenous amphibian species can be attributed to the introduction of the American bullfrog *(Rana catesbeiana)* or exotic fish. The North American frog became naturalised (capable of reproducing) in Italy in the thirties and then colonized the Iberian Peninsula[55, 56]. It was first recorded in France, in the 1980's in the Bordeaux region. It is also present in Belgium, Germany and the Netherlands following recent introductions (through pet shops or for culture as a food item). Because it is somewhat larger than any indigenous species and it is a predator, it is commonly assumed that this species has a negative impact on autochthonous* batrachologic fauna, in particular on aquatic species such as the Green frog. These assumptions are partly the conclusions from American studies and a certain number of European observations. They are however still speculative and for this reason it is important that further thorough studies should be carried out as the probable real threats, although not quantified, may increase in the near future.

Amphibian predation by allochthonous* fish is a more serious threat, especially given that their prey have no adaptations against these new predators. The pumpkinseed *(Lepomis gibbosus)* and probably the black bullhead *(Ictalurus melas)* are indigenous predators of tadpoles. It has been shown that the presence of carnivorous fish leads to the disappearance of amphibians in mountain lakes, for example where salmonid stocking has been carried out[57]. The newt larvae are devoured, while adults are limited to small peripheral ponds that dry out much more quickly.

Another consequence of the introduction of new species is the loss of genetic identity of indigenous species by hybridization (this is the case for Green frogs). The consequences at the adaptive level of such combinations of genetic material still remain to be evaluated (loss of resistance to certain environmental conditions in the local species...). Ultimately, ecological knowledge is still insufficient. More generally and more worrying, the introduction of exotic species may also lead to the introduction of previously unknown parasites.

55 - Andreone et al. (1987)
56 - Stumpel (1992)
57 - Brana et al. (1996)

F. Andreone

Conservation and management

Mediterranean wetlands are in urgent need of pragmatic conservation and management measures. Degradation and habitat fragmentation, water pollution, overexploitation and the introduction of exotic species are the principal causes of the rapid decline of reptiles and amphibians.

Both directly and indirectly, wetlands have changed considerably as a result of human activities - in particular in the Mediterranean basin where there hardly remains a watercourse, marsh or pond that can be considered not to be under threat.

The biology of conservation and ecology of restoration are new disciplines, and still in their early days. Nevertheless, research is currently very active in these fields. Each day new data are available for the managers of wild fauna and of the natural environment. However, in the case of amphibian and reptile populations, few studies exist on which to objectively base evaluations of environmental development, of reintroductions or of reinforcement of populations.

In practice, the managers of Mediterranean wetlands have an important role to play in the protection and management of herpetological fauna. The management of the aquatic environment is essentially an interdisciplinary field that requires traditional know-how at the same time as the competences of ecologists and engineers.

Salamandrina terdigitata.

Conservation of marine turtles.

Among the 8 species of marine turtles that are classified as threatened or in danger in the world, the Loggerhead *(Caretta caretta)* and the Green turtle *(Chelonia mydas)* are the only turtles that regularly, and in great numbers, nest on some of the beaches of the Eastern basin of the Mediterranean. Of a population of between 100,000 and 200,000 individuals in the world[58], on average 2,000 female Loggerhead reproduce in the Mediterranean each year, mainly between Greece, Turkey and Cyprus[59]. However, some observations have been made on the coasts of Libya, Syria, Israel, Lebanon, Egypt, Tunisia and Italy. The Green turtle is found in the Eastern Mediterranean; it nests on the coasts of southeast Turkey where there are around 300 to 350 individuals (data from 1988) whereas in Cyprus there are less than fifty.
The populations of these two species are presently threatened. The causes of mortality are diverse:

Natural causes and predation
Predators play a role throughout the turtle's life cycle. A study carried out on Turkish beaches showed that during the antenatal phase, to 235 nests (17,254 eggs), wild canines (foxes and dogs) and crabs *(Ocypoda cursor)* were the cause of 70-80% mortality[60]. Foxes *(Vulpes vulpes)* and Jackals *(Canis aureus)* are also responsible for the destruction of more than 75% of Green turtle nests[61]. Another natural cause of mortality is flooding by the sea. Because of the low proportion of eggs surviving to hatch, other factors causing mortality can have significant consequences on the demography of the population.

Anthropogenic causes
Almost all the known large reproducing populations are seriously threatened to a greater or lesser extent by international tourism and its consequences. These include the destruction of nests by parasols or traffic,

Beaches where sea turtles reproduction occurs within the Mediterranean region.

58 - Groombridge (1990)
59 - Margaritoulis (1998)
60 - Erk'akan (1993)
61 - Brown & Macdonald (1995)

M. Gunther/Bios

The Loggerhead, *Caretta caretta*.

noise, night lighting, the numerous tourist developments and subsequent pollution. Intensive commercial fishing of the green turtle has lead to the almost complete disappearance of Israeli and Turkish populations. The Loggerhead is also threatened by overexploitation. With regard to marine pollution, oil catastrophes and the subsequent oil slicks are of particular concern, as is the presence of plastic bags that further add to the causes of mortality. Under these circumstances, the prospects for long-term survival of these two marine turtles are not good in the Mediterranean.
During recent years, various protection measures have been undertaken or are planned, in particular in the Laganas bay in Greece, the south of Turkey and in Cyprus. Generally, they aim to protect by measures regulating tourist developments, coastal installations, navigation and fishing on the principal beaches where turtles lay their eggs and in their feeding zones (usually shallow water that is rich in underwater vegetation). In Greece, MEDASSET (Mediterranean Association to Save the Sea Turtles) and STPS (Sea Turtle Protection Society) are very active in saving threatened clutches.

A decrease in captures and a review of fishing gear is urgent. An alternative to turtles for alimentary and medicinal purposes also needs to be found (they are attributed with aphrodisiac qualities), particularly in Tunisia. These measures are all of high priority.

Natural mortality at hatching can be reduced by both limiting natural predation on the beaches by guarding and protecting nests from predators, and by carrying out artificial incubation. Moreover, such operations contribute to knowledge and public awareness. These measures should not however be a substitute to preventing the disappearance of spawning and feeding areas, or to reducing overexploitation, especially as these measures act on one of the least significant stages in terms of population maintenance. According to demographic monitoring models[62], Loggerhead adult and sub-adult females of 70 cm or more constitute the most significant fraction of the population. They return only once every four years to their spawning sites. Any reduction in this stock would be a serious and immediate threat to the population.

X. Eichaker/Bios

The Green turtle, *Chelonia mydas*.

62 - Laurent (1993)

Protected areas and protected status

Prevention is one of the best means available of avoiding the destruction of wetlands and of limiting all possible sources of habitat degradation (pollution, draining...), as well as limiting thoughtless and uncontrolled economic exploitation.

These effects are obviously of primary concern not only for amphibians and reptiles but also, for all the biological heritage of these rich and diversified environments.

Public authorities are increasingly concerned about the environment, and have thus created specialised administrative structures and laws. Since the Rio Summit, organised in 1992 by UNCED (United Nations Conference on the Environment and Development), politicians and environmentalists no longer talk about nature conservation without referring to the Convention on Biological Diversity that is ratified by more than 176 countries.

Most of the countries of the Mediterranean basin have a set of protected areas where legislation imposes constraints on certain human activities with the aim of conservation. These protected areas bring together a diverse range of zones of variable surface area and for which the protection characteristics differ according to the protected area's denomination and the country concerned. Another form of protection is the purchase of land by organisations responsible for removing them from the property market (these are called "Conservatoires" (Conservation areas) in France).

An example of a reserve for amphibians is the one on the Balearic Islands created for the Mallorcan midwife toad *(Alytes muletensis)*. This reserve is part of the Biosphere Reserve network of the Council for Europe that includes several hundred reserves of which approximately one tenth are in the Mediterranean area.

In order to maintain amphibian and reptile populations, a few important regulations exist, in particular:

- the Bern Convention on "The conservation of European wildlife and natural habitats" which includes several amphibian and reptile species. Based on the recommendations of a group of experts, made up of a delegate from each member country and representatives from certain NGO's **idem: (Non-Governmental Organisations) such as SEH

(Societas Europaea Herpetologica) or UICN (The World Conservation Union), new threatened species can be added;

- the Washington Convention concerning the regulation of international commerce of threatened species (CITES – The Convention on International Trade in Endangered Species of Wild Fauna and Flora), intervenes by prohibiting the importation of certain species, and fixing exportation quotas not to be exceeded;
- the Community or "Habitat-Fauna-Flora" Directive, adopted in 1992 and based on the fact that species' protection is not always necessary, but that of habitats is a priority. One can cite temporary Mediterranean ponds as being priority habitats among the "dormant water" habitats (CORINE biotopes code);
- related to the Community Directive, the Natura 2000 programme is an European network of Conservation areas. The Member States must set up management plans for each of these zones, and more importantly, must make them a reality as a site in the Natura 2000 network. Thus, the spawning beaches of the Loggerhead, one of the priority species of the Habitat Directive, are part of this network;
- the World Conservation Union's (UICN) red list of threatened animal species.

The diverse threats that menace the amphibian and reptile species of the Mediterranean wetlands have lead to their being included on the Annexes of these different regulations (see table at the end of the book).

F. Andreone

Males of *Pelobates fuscus* in the Piemont region, Italy.

However, conservation of biodiversity issues are not yet given sufficient priority and national plans generally only support large sites that represent a small fraction of all wetlands in a given country. The micro-zones that make up a significant proportion of the Mediterranean basin wetlands are not on geographical maps because of their small size but also because of their transitory and seasonal character. They are neglected by scientists and managers. The protection and management of them is a challenge for developers who are concerned with the spatial and temporal diversity of the Mediterranean landscape. Furthermore, only true thought and global planning applied to all the Mediterranean wetlands can ensure the long-term survival of the amphibians and reptiles found in these environments.

A group to study and take action for the Mediterranean

The Alghero Declaration (1995) on Coastal and Marine Biodiversity in the Mediterranean was organized at Alghero in Sardinia[63]. It calls upon the bordering countries, as well as other members of the European Union, to protect the sea from pollution, and to maintain and develop the flora and fauna of the Mediterranean coasts. This declaration emphasizes the importance of the uniqueness of each population and takes into account their biodemographic strategies and other life history characteristics, as well as their isolation and endemicity. It sets out a number of recommendations concerning the amphibian and reptile species and sub-species.

This declaration takes an emergency approach by carrying out actions to safeguard all isolated and threatened continental or island populations. It grants specific support to local NGO's of those countries with financial difficulties as regards protection and those that are far from the main research centres. A committee of experts proposes research programs applied to the real needs of conservation management of habitats and species.
In 1997 the group of herpetology experts reconvened in Alghero to stress the importance of the protection of those islands and coasts that are often isolated and thus forgotten. Sixteen islands in Croatia shelter 8 amphibian species, and the east coast has a spawning beach for the Loggerhead. In former Yugoslavia, several karstic islands are habitat zones for the European pond terrapin, the Caspian terrapin, the Leatherback turtle *(Dermochelys coriacea)*, the Green turtle, and the Italian crested newt *(Triturus carnifex)*. Finally, the beaches of Lebanon are spawning zones for the Green turtle and the Loggerhead.

The Alghero Declaration is a significant step in organising, coordinating and decentralising protection programmes for vulnerable and threatened species of the Mediterranean basin.

63 - *Anonymous (1995)*

Knowledge for better management

The protection of a species will only be successful if the genetic inheritance it represents is also managed.

This management can only be conceived based on sound knowledge of the species, its biology and its population's characteristics. For instance, one knows that although a species is present in a given location, it may be condemned in the long term if its numbers fall below a certain level. Populations must be monitored in order to evaluate their demographic tendencies over time. Monitoring programmes designed to detect changes in the size of the most threatened populations need to be set up. These methods are very instructive, not only for estimating the population size, but also for providing information about demographic parameters and habitat use. They are, however, expensive in both time and human resources; carrying them out requires adequate and suitable training.

Perspectives not really encouraging for the Green turtle and the Loggerhead : During the XXth permanent committee of the Bern Convention, a file was opened against Turkey, because of the lack of protected spawning sites. The Cypriot government was asked to immediately protect two species of turtle, threatened by tourist development (Akamas peninsular).

If maintenance or restoration work of favourable environments for the upkeep or development of amphibians and reptiles is to be planned, or reintroduction operations are to be prepared, careful and in-depth thought has to be given to the species and its habitats.

Their adaptive and/or evolutionary potential has to be taken into account at different spatial and temporal scales. Which of the species' ecological requirements are to be considered? What is the maximum capacity of the environment? What is the future for the population and the environment? Will the regime of natural disturbances be enough to maintain the mosaic of environments favourable for their life cycle, or will man have to regularly intervene? What will the cost of these operations be? The answers to all these questions lead to the setting up of a management plan, whose actions must then be followed by rigorous scientific monitoring.

Managing species and the environment: from knowledge to action

Present day research in the field of studying and protecting biodiversity focus on at least three hierarchical levels, namely: genetic diversity, species diversity and ecosystems diversity. The protection of a species necessarily involves the conservation of habitats and the maintenance or restoration of their ecological qualities.

Acting on the aquatic environment.

No "ready-to-use" guidelines exist as yet for managing aquatic and terrestrial environments in order to preserve amphibian populations, and even less so for reptile ones. The amphibians' whole life is organised around the water body where they deposit their eggs or larvae. Unfortunately, a standard water body that would meet the requirements of all amphibian species does not exist! Amphibians do not always return to a water body that was intended for them, following its creation or restoration. In addition to the chemical quality of the water, many other environmental factors play a considerable role. The surface area, depth, variations in the level of water, current, as well as the type of substrate and climate influence the composition of vegetation and animal associations. The interactions of all these factors are complex.

The more threatened a species is, the rarer it is, and the harder it is to carry out scientific research on the biology of the species. The research becomes expensive in both time and energy, and because of the lack of solid knowledge acquired, action plans and management measures are often disappointing.

F. Andreone

The Italian stream frog, *Rana italica*.

Protective improvements

The installation of fences or low, impassable walls along the roadside, which force animals to use tunnels ("frog passes") that pass under the road is a solution to reduce mortality. However, the efficiency of these devices has not been well tested to date, as it is easier to find financial backing to construct the devices than for programmes for the long-term monitoring of their effectiveness. The frequentation rates have seldom been quantified, it would seem some species get lost forever in these tunnels or fall prey to specialized predators at their entrance or exit. The construction of frog passes needs to take the biology of the species into account: for example, certain animals may be desiccated because of the absorbent nature of the concrete or earth on the ground of these "migration tunnels". It is therefore preferable to line them with dead leaves.

Another example of a measure taken to preserve connectivity* between environments is the dislocation of the reproduction site by creating a new site near the environment for the terrestrial life stage. In the case of road developments, if the old site is located at the other side of the construction works, it is destroyed at the same time. This solution has proven reliable in certain cases. Toads seem to be able to learn that a new site for reproduction is available in their environment. They even seem to be able to evaluate which is most favourable by behaviour that we still do not understand[66]. However, planning such compensatory measures when undertaking construction work should not exempt the developers from considering the different possibilities for road works and opting for the least destructive solutions.

A frog pass.

C. Ruoso/Bios

66 - *Schlupp & Podloucky (1994)*

The construction of artificial ponds in Israel to safeguard the amphibians

Israel was formerly known to have between 1,200 to 1,500 ponds of pluvial origin, which would form in the Spring and that were largely maintained by villagers and shepherds. Up until the 1950's, these temporary ponds played a significant role, as watering holes for animals, and even as a source of drinking water for villagers. The expansion of farmlands, water extraction and urbanisation has lead to their decline. Today only about one hundred of these ponds remain, of which a few dozen have been declared small natural reserves. However, these ponds suffer from pollution from both rainwater that feeds them and from the runoff from the agricultural plains and urbanisation.

Today six species of amphibians exist in Israel: two Caudata and four Anura.
A seventh species, that was formerly present in Israel, is today considered extinct. The Israel painted frog *(Discoglossus nigriventer)* was only known to inhabit the wetlands of the Hula lake in the Jordan valley, and it has not been observed since 1955.
All these species reproduce in temporary pools and small ponds. It is common belief in Israel that all these species, despite being protected by law, are at risk of extinction because of the degradation and deterioration of their habitats. Three species at the southern limit are close to extinction: the Fire salamander *(Salamandra salamandra infraimmaculata)* in the Galileo mountains and the Carmel area; the Banded newt *(Triturus vittatus vittatus)* in the Galileo mountains, the Carmel area, the Judaea hills and along the coastal plains, and the Spadefoot toad *(Pelobates syriacus)*, most threatened in Golan, Galileo and on the coastal plains. The three others species are *Rana levantina*, the Green toad *(Bufo viridis)* and *Hyla savignii*. Four of the six species are distributed in a 250 m^2 area (Mount Carmel close to Haïfa): these are the Green toad, the Green frog, the Tree frog and the salamander. The Spadefoot toad is only found around Mount Carmel and on the plains on red and marshy grounds. The short duration of the hydroperiod during the reproduction period is the principal factor limiting the survival of all these species.
In 1994, in order to save these habitats, the NNPPA initiated a five-year program to create 60 artificial ponds within the natural reserves in order to increase the number of ponds (currently there are approximately 120 ponds). Ten ponds have been created each year. So far approximately 15 ponds have been restored and about thirty have been dug in the natural reserves of Galileo, Carmel and in the Menasche and the Judaea hills. More recently, a special "hard" pond (in cement) has been built on Mount Carmel to collect and preserve rainwater for the reproduction for a relic population of salamanders.

Over the past three years the population of salamanders on Mount Carmel has been monitored. Only one pond remains where a viable population can be maintained - Berekhat Sekher, an irrigation pond, which is filled by the rain and measures 30 x 24 metres. In December 1998, the NNPPA created an intermediate sized pond (9.4 x 7.4 x 1.15 m) as an alternative refuge for the salamander, where its reproduction and larval development could be supported by maintaining the water for at least three to four months. The pond has a sloping ramp

at one end and is dammed with rocks at the other, thus allowing the unrestricted passage of the salamanders and other amphibians. The bed of the pond was covered with sediments from a nearby pond. After the first rains healthy Crustacean communities developed. Salamander larvae were then introduced from the neighbouring ponds.

These new habitats, associated with those of Berekhat, will enable the local salamander population to be safeguarded. Another similar program is planned for the Spade foot toad in another nearby reserve, Ashdot Yagur NR. Ultimately, the fact that these "hard" ponds are being created as sites for amphibian reproduction is a promising, although expensive, method. A rigorous scientific monitoring program is carried out regularly, meaning this programme can be altered if necessary[64].

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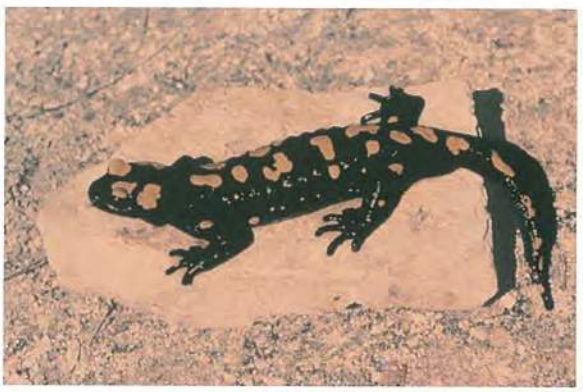


D. Horovitz/INPA

The Fire salamander.

A metapopulation* configuration is preferable to permit the long-term survival of the majority of species. It is important to maintain a high level of connectivity between the various aquatic sites. It should be emphasized that small sized wetlands are increasingly insular in character. They constitute an island towards which individuals can migrate more or less easily. This insular nature is more pronounced at the scale of human landscapes as towns and different urban and industrial zones, fields, farms and roads, etc, separate the wetlands.

64 - Degani & Kaplan (1999)

Acting on the terrestrial environment

To our knowledge no restoration operation has been undertaken for the terrestrial environment with the sole objective of supporting amphibian or reptile population dynamics. Indeed, any open environment species benefits from ecosystem management operations that oppose the closing of the environment by forestation. Thus, the maintenance of moors, wetlands and marshes is favourable for them. However, the type of ground traversed as well as the distance separating two habitats influences amphibian and reptile mobility. For example, newts move more quickly through a forest than an open environment[67].

Generally most protection programmes focus on the protection of wetlands surrounded, in the best of cases, by a small area of terrestrial environment called a buffer zone. Information on the quality and quantity of this terrestrial area is too often missing from management considerations. Far from being anecdotal, this information is fundamental. Moreover, not only do managers need to take into account the surface area and type of terrestrial environment around the wetland, but also the animals' movements[68]. During their life cycle these animals do not move randomly but choose certain directions, either towards their hibernation site, or towards their reproduction site... Displacement is often difficult and the distance over which they disperse is limited because of biological constraints, namely: a low physiological resistance to desiccation, restricted aptitude for mobility or a relative sedentariness.

T. Naziridis

Water snake, *Natrix spp.*, in a Greek wetland.

67 - Joly & Miaud (1989)
68 - Dodd & Cade (1998)

The metapopulation: an important concept for habitats and species management

The increasing fragmentation of habitats and the subsequent effects on populations are relatively recent subjects for study. Both amphibians and reptiles are particularly sensitive to this phenomenon as they are faithful to their reproduction site and have a low capacity for dispersion.

According to the colonizing aptitudes of the species being considered and the degree of habitat fragmentation, several different responses can be observed.

- Even if they are partially fragmented, when there are significant fluxes of individuals most amphibian and reptile populations are not likely to disappear. In this case the populations are continuous and function as a demographic metapopulation, i.e. a network of subdivided populations maintaining exchanges of individuals and thus exchanges of genetic information.

- If the capacity for dispersion is about equivalent to the distance between populations, there are exchanges of individuals between the various fragments of the landscape. The extinction of a local population can thus be compensated for by the immigration of individuals from a neighbouring population. These populations are particularly vulnerable. Such systems often function as a "source-sink": growth rates are higher than 1 in the source population, and lower than 1 in the sink population, so the survival of the sink populations requires constant restocking from the neighbouring sources.

- When populations are isolated, they function autonomously as their dispersing capacities are considerably lower than the distance that separates them from their neighbours. In such a configuration, the risk of extinction of the isolated populations is enormous and very often permanent.

Today scientists and the media attribute significant importance to the causes of amphibian and reptile decline on a global scale. Sound information at the habitat scale is urgently needed on the annual movements of these animals, the distances over which they disperse and their daily displacements.

Reintroducing and strengthening populations

It seems very idealistic to expect amphibian and reptile species to recolonise areas from which they have disappeared. This is a very different situation to that with birds or mammals that can move easily.

Birds and mammals can leave a limited zone and gradually increase the extent of their distribution by conquering new habitats, whereas amphibians and most reptiles can only move over a few hundred metres, or at most a few kilometres.

Only voluntary reintroductions (with all their accompanying problems) can overcome these limitations. This needs to be done very carefully.

Reintroduction of an autochthonous species and strengthening of populations

To our knowledge, few projects for reintroducing indigenous species or for strengthening populations have been carried out for these groups, either because information on certain operations remains confidential, or because of the lack of monitoring that prevents projects from being published and evaluated on the basis of reliable results.

Populations of the European tree frog are declining in all of northwest Europe[69]. In the municipality of Aarhus in Denmark, in an intensively cultivated landscape, a reintroduction program of Tree frogs has been launched, given the complete disappearance of the original population, which became extinct between 1950 and 1960. This disappearance was due to the degradation of the ponds used for reproduction. European tree frogs were taken from other sites, approximately 60 km away, and their eggs were reared (approximately 150 clutches) under controlled conditions and at various temperatures, enabling more than 6,000 juveniles of between 1 to 2 months age to be released in the natural environment between 1985 and 1987. In 1986 about twenty singing males were heard but no clutches or tadpoles were found. In 1987, 4 clutches of eggs were discovered attesting to the success of reproduction. Approximately fifty singing males were also heard.

The Italian eastern spadefoot toad *(Pelobates fuscus insubricus)* disappeared from the Po plain about twenty years ago[70]. A project was started in 1988 under the auspices of WWF-Italy to raise Spadefoot tadpoles when an area of land favourable to this species was classified as a reserve. Starting with 150 adults in 1992, 6,000 eggs were reared, and then in 1993, 10,000 eggs gave rise to tadpoles, of which more than 2,700 were released into the natural environment. Although the number of adults and of clutches detected is relatively low compared to the number of juveniles or tadpoles released, the first results seem encouraging. As this type of project is very expensive both in time and manpower, before starting the coordinators need to be sure about the long-term success of the project (quality of sites, metapopulation configuration, terrestrial refuges...).

69 - Corbett (1989)
70 - Andreone et al. (1993)

Informing and increasing awareness of herpetological fauna

Protecting and managing wetlands are obviously top priorities. But can protection be effectively long-lasting without the consent of the local population and of decision makers?

In inhabited areas, if there is not always someone present to protect the environment, one can only hope that the wetlands are not visited or even taken from the primary objectives of reptile and amphibian conservation. Scientists and managers are gradually recognizing that education about the environment and teaching activities related to this are also a top priority. It is of primary importance to show people what needs protecting, to explain what are the threats to these zoological groups, to present the results of intervention projects and to explain the challenges for management.

F. Gilson/Bios

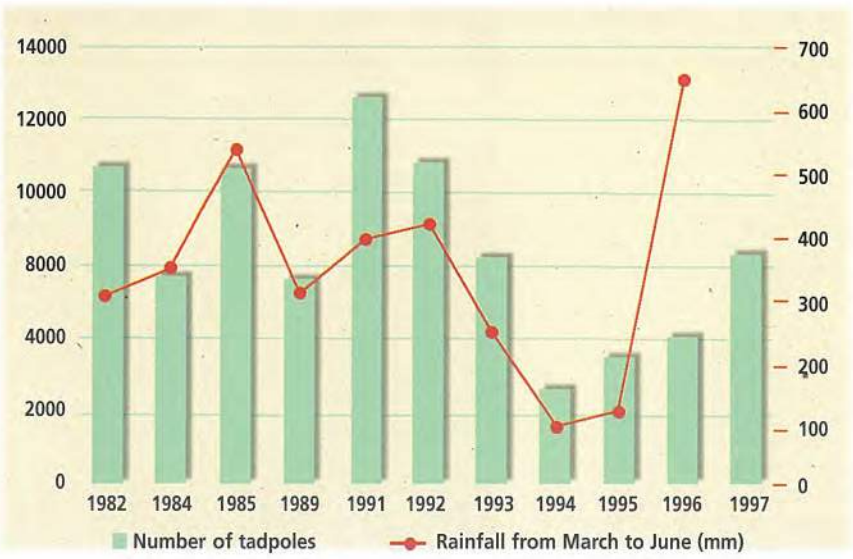
It is also a good idea to meet and touch the animals of which one is afraid of, such as snakes. These cold-blooded animals have smooth and silky skin, which is not sticky like one often imagines. Not all snakes are dangerous and they reveal attractive characteristics to those who know how to observe them.

A plan of action for a living fossil: the Mallorcan midwife toad *(Alytes mulentensis)*[70]

The major interest of the Balearic Islands is the discovery by Bosca of an endemic amphibian mentioned under the name of Alytes obstetricans at the end of the 19th Century. In the second half of the 1970's this species was described in the fossil state on the islands of Minorca and Majorca. A few years later this species was found alive on a limited portion of the island of Majorca, though it had disappeared from Minorca about 250 years B.C., probably due to human activities. The Mallorcan midwife toad or ferreret (in Catalan) was at risk of extinction until conservation measures were set up, in particular the PRF program (plan de recuperacion del Ferreret). Development on the already scarce wetlands on Majorca constituted a serious threat. Scientists and the Majorcan naturalists showed that the Viperine snake, the Iberian water frog, the cat and the weasel, all introduced species, dangerously reduce populations. Larval predation by aquatic invertebrates (dytiscidae and dragonfly larvae, notonectae), kingfishers and seagulls, as well as landslides and floods, are other known causes of mortality.

The climate of the island is Mediterranean; rainfall (on average 1,000 mm/year) is concentrated over a few months of the year and the low and xerophilous vegetation can evolve to oak forest. The ferreret occupies the karstic landscape, where it reproduces in all surface streams or at up to 60 metres depth at the bottom of canyons, permanent or temporary basins, and even in artificial wells.

Similarly to continental Midwife toads, the male transports the clutch of eggs wound around his rear legs until the time of hatching approaches. The female can be fertile for between 4 and 5 years, and thus produces on average 385 eggs during her life.



Relationship between the demography of larval populations and average rainfall.

71 - Roman & Mayol (1997)

J.M. Borrero/Bios

Generally the males carry the clutch safely for three weeks, unless they have multiple spawnings, a relatively rare occurrence for the ferreret.

Fecundity is distributed across the whole reproduction season, and in captivity up to 7 spawnings per season have been obtained, at an interval of 22 days between spawnings.

Information on the life and ecology of this small "false toad" of the primitive Discoglossidae family are essential to be able to protect it and to save its preferential habitats. Within the framework of the PRF, a programme financed by the European Community, precise monitoring of the state of its populations was carried out. When certain populations became vulnerable due to their small size, the specialists decided to reintroduce individuals from growing-on centres. A general rule was laid out whereby individuals should not be taken from other natural populations, even if they are large.

The new plan of action (1998-2002) aims to obtain the long-term and durable autonomy of the populations. Many points remain to be considered and are the object of recent research. For example, the dispersion of the adults is shown to be very weak around the reproduction zone (less than 250 metres). Nevertheless, the longitudinal distribution of this species along the watercourses raises questions about the modes of dispersion. Is the dispersion passive by the tadpoles? Do floods transport the adults during rainy periods? The creation of reproduction sites at more than 70 localities on the island and the failure of reintroduction programs attest to the hypothesis of strong sedentariness and a weak aptitude for dispersion.

Finally, in parallel to the scientific activities and to the protection actions in the field (creation of wetlands, strengthening of populations, predator control) a certain number of pedagogical activities have been developed. Information pamphlets, articles in the press, activities aimed at different groups of the general public are carried out throughout the year; they contribute to the development of an interest in the conservation of this amphibian.

Hopefully from now on the future of this emblematic species is no longer in danger.

Distribution of the Alytes genus on the Iberian Peninsular and the Balearic Islands.

A. Morand

Technical fact-sheets

- Creating and maintaining a pond for amphibians
- A threatened species : the European tree frog
- A vulnerable species : the Marbled newt
- A vulnerable species : the European pond terrapin
- Sampling amphibians and reptiles

Mating of Natterjack.

Creating and maintaining a pond for amphibians

The aquatic environment

Creating, restoring and maintaining a water body is a practical and efficient means of compensating for the disappearance of natural wetlands. Nevertheless, all aspects of the project must be taken into consideration before the project is implemented, in order to avoid committing errors during digging operations and so as not to encounter problems, which would be impossible to resolve once the pond is filled.

A certain number of questions must be asked, including: where will the water body be richest and most beneficial? Is the distance between this water body and neighbouring sites reasonable given what we know about the dispersing capacities of the species in the region? These questions must be answered bearing in mind, in particular, knowledge of the area (soil, hydrology...), and the natural and human context at both the local and landscape scale...

In all cases, the following must be taken into account:
– security rules (water attracts young children, so be careful...),
– the multiple user-groups (fishing, hunting, leisure, conservation...) and possible future users groups in order arrive at a long-lasting agreement, and to avoid user conflicts,
– the natural populations in the surrounding and regional environment must be assessed in order to consider the global evolution of one's own site and, if possible, favour the site's integration and how it complements other aquatic sites.

Once the site location has been chosen, generally near to known, existing reproduction sites, the variables listed below need to be considered, as they have already been proven to be decisive. All sites can potentially be considered, but, at what cost? The engineer and ecologist together must look for the best compromise, i.e.: the site most adapted to receiving amphibians with the best cost-benefit relationship.

Number

One or two main ponds accompanied by a chain of ponds and pools seems ideal (continent-archipelago model).

Surface area

This depends on the target number of species and size of populations. A minimum surface area of about one hundred square metres is

necessary for amphibians. There is no upper limit, except that large ponds are likely to create envy, and may lead to fish stocking projects, which in turn lead to the problems already mentioned in the preceding chapters.

Depth and volume

This variable is related to the length of time the pond needs to be flooded for the development of the target species. For certain species such as the Crested newt, Marbled newt or the Western spadefoot toad, a maximum depth of between 1.20 m to 1.50 m is desirable. For species with rapid development (Natterjack, Parsley frogs...) fairly shallow pools between 15 and 30 cm are sufficient.

Hydroperiod

The temporary nature of a water body is not a limiting factor if water is guaranteed until the larvae metamorphose. A reduction in depth leads to reduction in volume and consequently the warming of the water, which accelerates larvae growth. However, problems may exist for certain species when larval development takes a particularly long time. For example, the Western spadefoot toad needs 4 months or more to complete metamorphosis, depending on natural conditions[72]. Drying out needs to be tightly controlled, but can also be desirable, depending on the environment and the species. Indeed, at the end of the summer the site can be drained in order to naturally destroy any fish populations. However, the complete drainage of the water can have a disastrous effect on other species, in particular dragonfly larvae that live on the bottom and spend the winter there.

Slope of the banks

Ideally the banks should slope gently to allow a gradation of ecological conditions. This sloping is absolutely essential in a covered pond: slopes of between 5° and 15° help avoid the accumulation of sand and clay at the bottom of the pond; they also support the development of vegetation, which will make it more difficult for any fish to find the tadpoles or eggs. Gentle slopes also facilitate entering and leaving the pond for the adults and juveniles. However, in order to diversify the habitat zones, it can be beneficial, in particular for certain aquatic insects, to envisage abrupt banks on part of the pond's circumference.

Shape and length of the shore, presence of islets

If the objective is to create many different microhabitats, it is important to consider the shape of the pond. In particular, what is a suitable length for the banks? The sinuosity of the banks and the presence of islets favour the presence of ecotones* and refuges (coves, peninsulas), which are also desirable for amphibians. In all cases, over

72 - Cei et Crespo (1971)

the years, the shape of the water body will be modelled by the development of vegetation growing on the gently sloping banks.

Nature of the substrate

The nature of the substrate influences the impermeability of the water body. It also conditions the development of benthic invertebrates, which feed on Caudata larvae and the abundance of periphyton on which the tadpoles feed. When the geological nature of the bedrock is not known, finding what it is must be the first task of the construction work. It is highly likely that thick layers of impermeable clay will be found at the bottom of valleys. For covered ponds, a layer of clay of about thirty centimetres is often enough to prevent leakages.

Water availability

The available water supply will determine what type of development can be considered. Knowledge of hydrological and hydro-geological data for the area is essential. Different water supplies that are adequate include filling exclusively by rainwater, a mix of rainwater and infiltrations, surface waters from a connected watercourse... If the water table is permanently close to the surface, this can be sufficient, and an artificial supply is not needed. Such places can be located by inspecting the ground as these areas are constantly waterlogged.

Sun exposure and temperature

When the pond is not very deep, the sun heats the water strongly in the spring, so that algae and tadpoles develop more quickly and under better conditions. Luminosity is one effect of warming, and also of

A. Morand

The Brook-dwelling Spanish frog ***Rana iberica.***

oxygenation. However, a too high algae production can lead to eutrophication, whereby the surplus organic matter degrades and the consumption of dissolved oxygen by aquatic organisms increases.

pH, oxygen concentration and salinity

The pH and oxygen concentrations are seldom limiting factors in nature. These species, and in particular their larvae, need sufficient oxygen in the water. Most species have a fairly broad tolerance for pH ($6.5 < pH < 10$). Daily variations in temperature and oxygen, particularly noticeable in water bodies with a low volume of water, make evaluating the pH in the natural environment difficult. Finally, it should be remembered that amphibians do not support high salinities (in general < 4-5 g/l NaCl).

Aquatic vegetation

The introduction of aquatic vegetation is often not necessary insofar as colonisation is natural and relatively fast. Several pioneer species (Natterjack, Green toad, Tree frogs) benefit from this gradual development. Transfers of plants from other locations can be justified if the colonisation needs to be accelerated, or if a rare species is to be conserved.

Management and maintenance of a water body

A fundamental element to be taken into account by the international community is the qualitative and quantitative management of water resources[73].

The rapid degradation of water quality (eutrophication) and processes of sedimentation mean that this type of environment has a short life expectancy. In many situations, the decomposition of organic material (e.g.: dead leaves...) leads to excess nutrients. Agricultural fertilisers and toxic elements from rainwater add to these natural inputs. Restoration of the water quality and management of the water level are crucially important for the viability of both the site and the populations. Various solutions have been tested; generally rehabilitation scenarios aim to attain a former state or perpetuate the present state. However, nutrients and toxins of the water are increasingly difficult to eliminate. It is thus desirable to act directly on the sources of pollution by decreasing, for example, the quantity of excess matter introduced:
– controlling vegetation by cutting it and clearing undergrowth, followed by the removal of this matter by grazing, managing the water level or by burning it outside the reproduction season.
– preventing domestic animals from trampling the banks and polluting the water body with their excretion when they use the pond for drinking. The shore can be fenced with a single access arranged in order to limit their impacts. An efficient alternative to livestock using the amphibian pond is the creation of a basin (tank, reservoir) supplied with water by gravity, and located downstream from the pond.
– taking action to clear accumulated detritus and plant material, as

73 - Acreman (2000)

well as the elimination of invading plants from the water's surface... This problem can often be solved in a few days by setting up a one-off clearing operation, and at the same time providing training on the protection and the management of the environment.

The terrestrial environment

Both the immediate and regional environments need to be considered. The composition of vegetation belts, their extent and growth dynamics, the interactions between the various plant groups, particularly between the fields, wastelands and woods all need to be evaluated.

Both amphibians and reptiles are sensitive to how open their environment is. Some amphibians (Common toad, Yellow-bellied toad, salamander...) prefer forest ponds for reproduction. Newts and the Agile frog also need a forest environment during their terrestrial life. Bushes surrounding the pond can be favourable to some species for their life cycle. They act as refuges or as a hunting ground for the arboreal species (Tree frogs, Parsley frogs...). On the other hand, forests can make movement difficult for species with terrestrial mobility specific to the open environment (dunes...) such as the Green toad. This species is extremely mobile and actively hunts in open areas, but is not so mobile in the forest.

When choosing the location for a pond, the requirements of the species that one wishes to support need to be taken into account.

The creation of a pond directly under trees is risky as there is a high danger of the rapid asphyxiation and exposure to toxic substances. The accumulation of dead leaves reduces environmental oxygen and in the long term the site can even be filled if the leaves are not cleared. Ideally therefore, the pond should have some natural shade, but sufficient illumination needs to be ensured. Nearby cultivated grounds mean that stream waters are charged with fertilisers and pesticides, which leads to the deterioration of the water quality. In a similar way, plantations of coniferous tree around the aquatic environment will acidify water, which then ceases to be favourable for embryonic and larval development.

Finally, refuge zones that can, for example, be gravel slopes or stone banks used during the day and during the winter, and that are characteristically associated with the expected species also need to be preserved.

A threatened species : the European tree frog

Hyla arborea Linnaeus, 1758
Amphibian Anura
Hylidae
Bern Convention > annex II (strictly protected species)
Habitats, Fauna, Flora Directive > annex IV
IUCN Category > red list (LRnt)

Distribution

This species has a broad distribution, its distribution area covers all of Asia and Europe, south of 55th parallel, as well as North Africa. It is not present in the Mediterranean basin: where it is replaced by the Stripeless tree frog in the French and Spanish zones, by *Hyla sarda* in Corsica and Sardinia, by *Hyla intermedia* in Italy and by *Hyla savignyi* in Israel.

Biology

The European tree frog has smooth green skin, with a dark lateral line starting at the nostril and continuing towards the eye, then along the side, before forming a loop at the level of the hip. Similarly to other arboreal species, its body is slender and it has broad, disk-shaped suction cups on its fingers. Its eyes are located laterally and are directed towards the front, its vision extends downwards and it has binocular perspective. Furthermore, its characteristic song is powerful and fast (three to five calls a second).

A. Morand

Eggs of *Hyla arborea*.

A. Morand

Mating of *Hyla arborea*.

It reproduces once a year, but over a fairly prolonged period. In certain populations, the female reaches sexual maturity at between 1 and 2 years of age, and has an average life expectancy of between 3 to 5 years. She deposits several small clutches of eggs that she attaches to vegetation at the water's surface. Several spawnings can be carried out during a given reproduction season. Each female lays between approximately 700 and 1,900 eggs, each of which measures 1.5 mm in diameter. Tadpole development takes about six weeks when the water is hot; if the water is at average temperature only, development can take more than two and a half months.

Habitat

The European tree frog is found in still fresh waters (ponds, marshes, gravel pits) of variable size (from a few square metres to more than 4,000 square metres). It seems to prefer shallow water that is exposed to the sun and that has many aquatic plants. It needs good quality water at a high temperature in order to support the rapid development of its eggs and tadpoles. It preferentially occupies recently formed sites (less than about ten years old).

In such sites, both competition between amphibian species is lower and also structured fish communities are not present, as these sites generally dry out in the summer. Although water is essential for reproduction and the tadpole development, the Tree frog spends most of their life on dry ground. They feed in bushes or on wetlands, where they search for various insects, which they agilely catch. They wait at the water's edge and hibernate under moss at the foot of a tree or in cracks in a rock.

Principal threats

A group has been formed to investigate this species' disappearance from across Europe[74]. Of the many causes thought to have lead to the decline of the European tree frog, the destruction of spawning sites and fragmentation of wetlands are the main threats. Predation on the tadpoles by fish has also been shown to be a problem[75]. However, certain populations have disappeared for no apparent reason, despite the water body being seemingly favourable. A potential explanation could be the ageing of the ponds. This nomadic species needs sites that are poor in organic matter and with pioneer vegetation.

Management measures favourable to the species

To conserve the European tree frog firstly habitats favourable to their development need to be maintained and restored. This includes:
– maintaining biotopes and spawning sites, in particular, by ensuring the presence of macrophytes,
– favouring the alternation between a filled pond, and drying it out every couple of years or so, in order to eliminate fish,
– improving the water quality, and limiting organic pollution,
– maintaining alluvial forests and wetlands near the water body,
– favouring the construction of specific development projects that enable amphibians to pass, and that don't harm linear infrastructures.
Small isolated populations are particularly vulnerable. Certain researchers[76] have calculated by simulation that if the numbers of individuals of this species fall very low (less than 100), the decline in heterozygotic erosion (one parameter used to estimate genetic diversity) is foreseeable within a decade. A diversity of genetic characteristics is essential for the long-term stability of the population (adaptation to modifications in environmental conditions and resistance to local extinction processes).

This approach thus illustrates the need for preserving sufficient numbers of threatened species. Metapopulations, which result when favourable environments are inter-connected, constitute a guarantee against the risk of a reduction in genetic diversity. Strengthening the population by reintroduction operations using individuals from rearing centres is another solution.

74 - Stumpel & Tester (1993)
75 - Brönmark & Edenhamn (1994)
76 - Balletto & Giacoma (1993)

A vulnerable species : the Marbled newt

Triturus marmoratus marmoratus, Latreille 1800
Amphibian Caudata
Salamandridae

Habitats, Fauna, Flora Directive > annex IV

Biology

The Marbled newt is a large newt that can reach up to 16 cm in length. Its back is greenish-yellow and marbled with black. The species is currently found across the Iberian Peninsula and in all of Western France, to the west of a line from Cherbourg to Montpellier. It is an opportunist and a carnivore; the larvae feed on tadpoles and the larvae of other newts, but mainly on small shellfish (Cladocera, Ostracoda, Copepoda), aquatic insect larvae and gastropods. Once the newts become adult, they are more terrestrial. It is not an especially selective predator, as its diet seems only to be limited by the size of the prey. The adults migrate towards their reproduction sites starting in the autumn in the south. Total fecundity during the reproductive life span of about 4 years has been estimated at 1,700 eggs[77]. If mortality due to genetic defects, predation and other natural causes are considered, only 12 juveniles per year reach metamorphosis out of an average of 400 eggs laid per season. The time necessary for embryonic and larval development has been estimated in the south of Spain as 11 weeks on average[78]. This variable for development depends very

C. Jakob

Juvenile Marbled newt in an pond of Roque-Haute Nature Reserve, southern France.

77 - Arntzen & Hedlund (1990)
78 - Diaz-Paniagua (1992)

C. Jakob

Adult Marbled newt.

much on the water temperature, and unlike amphibians Anura, is not very flexible. This makes newts particularly vulnerable to the early drying out of reproduction ponds. The reproduction period can extend over several weeks. The maximum age reached varies greatly between populations. In the north of France and Portugal, the Marbled newt can reach an age of up to 13-14 years, but in hotter Mediterranean terrestrial habitats, such as Spain and the South of France its life span is shorter (8-10 years). However, in the south of France the newts reach sexual maturity more quickly, at between 2 and 4 years, compared to 3-5 years in the centre of France and in Portugal[79].

Habitat

The Marbled newt lives in various types of wetlands (forest ponds, drinking ponds, springs, etc), generally where fish are not present, and which have abundant aquatic vegetation. Adults and immature individuals spend most of their time in the terrestrial environment, a fact confirmed by the aposematic markings that are dorsal as opposed to ventral, and which warn potential predators that the animal is toxic. The juveniles of populations in Central France probably don't return to the water before maturity[80], whereas immature Marbled newts in the south of France use the aquatic habitat regularly, because of a high abundance of prey[81]. Globally, populations in the south of France seem to extend their aquatic phase longer than populations in zones with a less harsh climate. This is probably related to the severe summer climatic conditions. Once the newts reach their summer lodgings, they bury themselves in micro-mammals' tunnels, under tree stumps or stones in order to be protected from high temperatures and

79 - Francillon-Vieillot et al. (1990)
80 - Jehle & Arntzen (2000)
81 - Jakob (2001)

drought. Adequate available terrestrial microhabitats around the reproduction ponds are thus of great importance for the survival of individual Marbled newts in the Mediterranean.
Little is known about the terrestrial life of the majority of other amphibian species. Nevertheless, recent studies on the movements of the Marbled newt towards its terrestrial habitats have found that the microhabitats it occupies are generally less than 150 metres away from the reproduction pond (in the south this distance is less than 90 metres).

The Marbled newt lives in sympatry with the Crested newt in the northwest of France and in the Mayenne where the latter has hybridized to give the Blasius' newt.

Principal threats and limiting factors

The principal threats for the Marbled newt are similar to those of other amphibian species:
- the loss of aquatic and terrestrial habitats, and in particular to the south of its distribution, the terrestrial microhabitats adjacent to the reproduction pond, and the fragmentation of the environment;
- the decline in water quality;
- the introduction of exotic fish and other predators of amphibian larva;
- collection for pets has also been a threat. This has however been decreasing over recent years thanks to an increase in consciousness and the success of Marbled newt reproduction in captivity.

Management measures favourable to the species

No specific management program exists for Marbled newt populations, but it is fairly clear that that all measures and local management actions favourable to amphibians in general will also be favourable for the Marbled newt. The most important tasks must be the protection of both the terrestrial and aquatic habitats that are favourable to the species; the facilitation of its reproductive migrations; the creation of new spawning sites and even the displacement of populations in danger... Furthermore, it would be desirable to include broad "terrestrial buffer zones"[82] around the ponds during the protection of reproduction sites. These zones shelter newts and other amphibians during their terrestrial phase. This would be particularly necessary in the Mediterranean during the summer, when the terrestrial phase is most difficult and stressful for the Marbled newt.

82 - Semlitsch (1998)

A vulnerable species : the European pond terrapin

Emys orbicularis Linnaeus, 1758
Cheloniidae
Emydidae

Bern Convention > annex II (strictly protected species),
Habitats, Fauna, Flora Directive > annex II and IV

Biology

The European pond terrapin is an average sized turtle (up to 20 cm in length) that is found in Europe, North Africa (Morocco, Algeria) and to the east as far as the Aral Sea. Its shell is smooth and black, and is decorated with yellow marks. Its head is black with yellow dots. This fresh water turtle is a semi-aquatic carnivore that feeds on both live and dead invertebrates (molluscs, insects) and vertebrates (frogs, fish, rodents and small birds). Sexual maturity is reached at around 10 years for the females of Mediterranean populations, and a little earlier for the males. They lay between 4 and 12 large eggs with an average of 8 eggs per incubation period, which takes between 2 to 3 months. This low fecundity is compensated for by a long life span, which is estimated as eighty years, and up to one hundred years maximum. The time and frequency of spawning vary, and depend on climatic conditions.

The European pond terrapin hibernates buried in mud and reappears on the first days of good weather in the spring. Furthermore, it also over-summers to the south of its distribution, during years of harsh drought.

Habitat

Known as the "muddy turtle", the European pond terrapin lives in all aquatic environments, from still waters (ponds, flooded meadows, marshes and ditches) to rivers with weak currents, and is also found at the edge of large rivers in the Mediterranean basin. It can even adapt to slightly brackish water. They are found in stony bottomed sections and in hollows in the rocks in the clear waters of temporary or permanent wadis, where their bright colours and clean appearance surprise. They are found alongside the Spanish terrapin *(Mauremys leprosa)* in Spain[83] and North Africa and with the Caspian terrapin *(Mauremys caspica)* in Greece.

Principal threats

The state of populations of the European pond terrapin is still poorly known. It varies much from one country to the next. The loss of habitat and fragmentation of the environment are the most common causes of decline. The splitting up of populations reduces possibilities

83 - Keller (1997)

During the Middle Ages, the turtle was considered to be a fish. At this time it was a sought after delicacy during religious festivals when the consumption of red meat was banned. This lead to an intense seasonal trade in the turtle from the south to north. Collection of turtles for food, which is still carried out today, and more rarely collection for pet shops, also contributes to the reduction in populations.

for exchange. Sites are increasingly rare and are isolated from each other by cities, agricultural plains and roads.
At spawning time, the females become terrestrial, and are often crushed by vehicles. In farming zones, agricultural machinery kills the adults and destroys their eggs.
Despite being aquatic, European pond terrapins are destroyed by the frequent fires in the Mediterranean. The monitoring of a population, which were subjected to forest fires twice, showed a collapse of 60 to 70 % of individuals, high mortality of the very young individuals and a considerable drop in the average age of the population[84]. The impact of fires on the terrestrial environment is not negligible, in particular resulting in the loss of riparian* vegetation, accelerated filling of watercourses due to the effects of erosion and an increase in the torrential regime.
In Mediterranean areas, where water is scarce, the European pond terrapin is even more fragile. It is at the top of the food chain, and accumulates toxins from its prey in its tissue, which eventually poison it. In the aquatic environment the natural predator of young turtles is the pike, on the land foxes, wild boars, cats and increasing populations of rats further add to its destruction.
The Slider *(Trachemys scripta elegans)*, resulting from intensive culture, located mainly in Louisiana, are an alarming threat to the European pond terrapin, as over recent years thousands have been released into the wild. The Slider is larger and more aggressive than the European pond terrapin and can better resist the cold, even reproducing under certain conditions. Certain researchers have shown that when there is competition between the two species, the European pond terrapin seems to be at a disadvantage[85].

T. Naziridis

The European pond terrapin *(Emys orbicularis)* at lake Kerkini, Greece.

84 - Cheylan & Poitevin (1998)
85 - Ferri (1995)

Management measures favourable to the species

Scientists have been studying populations of the European pond terrapin for over ten years, so knowledge about this species, and in particular on its biological strategies, mean management recommendations can be proposed. It is important to conserve all populations and each one constitutes a case study from which a wealth of information can be drawn[86].

It is commonly agreed that the installation and then maintenance of a population of European pond terrapins in a region is dependant on factors related to habitat and to the microhabitat[87]:
- refuges against the cold (water which does not freeze, ...)
- spawning site (exposed site facing south to southeast)
- breeding site (shallow, warm water)
- feeding site
- sun bathing site

Action therefore needs to be taken in order to:

- improve water quality;
- maintain spawning sites in a reasonable state (avoid dredging water bodies and canals during the hibernation period);
- prevent fields and dry pastures from getting overgrown (the European pond terrapin needs area with short grass in order to lays its eggs);
- maintain solariums (river banks, dead trees...)
- use teams of specialists to increase public awareness about the problems of releasing Sliders into the wild, and encourage their recapture in order to limit their expansion. A recent European Directive, an extension of CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, prohibits the import of Sliders of less than 10 cm length into the European Union.

Within the framework of certain reintroduction or population strengthening programmes, the removal of eggs for artificial incubation is authorized in order to then release the juveniles in their natural environment. Thus, the "Lombardy Emys Project" in Italy, initiated by the SISN (Centro Studi Erpetologici) in Venice lagoon and in the Po Delta, aims to make a census of the European pond terrapin, carry out research, protect favourable habitats, assist reproduction with incubators and undertake site restoration...

86 - Mascort (1999)
87 - Snieshkus (1995)

Sampling amphibians and reptiles

Description of methodology and operating regime: when and how to sample?

When searching for amphibians, not only the aquatic environment, and in particular the coastal zones corresponding to the area in which the species has been detected, needs prospecting, but also the terrestrial environment which is more difficult to sample. Certain aquatic environments are more difficult to prospect because of their depth, turbidity, etc.

At present there is no standard method for studying herpetological fauna, as the behaviour and rhythm of activity of each species differs. Snakes and lizards can be captured using a cane with a slipknot attached to the end (a finer knot for small species) or by hand by the more experienced sampler. The use of binoculars to locate and count the fauna is also a solution, though is not as precise. For aquatic turtles, traps of various types, often with bait and partially out of the water, are used.

For amphibians, the identification of species relies on the detection of eggs, larvae or adults, and sampling can be carried out using a variety of different techniques and equipment:

- a fine meshed hand net can be used for the tadpoles and larvae of Caudata; a hand net, similar to that used in aquaculture can be used for adult newts; ballasted nets and aquatic luminous traps are other methods;
- one's senses (sight, hearing) can be used to estimate the number of singers in a population of Anura. Nocturnal visual observation is carried out using a powerful projector on a tripod, on foot, boat or by diving. When the clutches of Anura eggs are visible, they can also be counted for certain species.

The equipment needed is related to the techniques to be used, and also on the species that is being looked for (reptiles or amphibians).

The period to sample these animals that have a basically biphasic way of life is generally during the reproductive season. They are most easily detectable at this time, when the temperature increases and during rainy periods. In addition, sampling should be spread over the whole reproductive season and carried out at least once or twice a month in numbers proportional to the frequency in the environment in order to increase the probability of finding each species, whether they be early, late or flexible reproducers.

Identification to species level

Each observation should be identified precisely using guides or cassettes that are recognized as being correct dependant upon whether the morphology or song is used for identification...

For Anura or Caudata larvae a binocular microscope should be used, with identification keys, or a reference collection should be consulted...

Scientific practices of capturing, sampling, tagging and radio tracking are generally prohibited or require the authorisation of the competent State services in the field of the environment and wild fauna.

Identification is frequently confused despite the low number of species; it is therefore a good idea to enlist the help of recognized naturalists and scientists.

A photo is also a good means of later identifying a species found during prospecting.

Applicability, constraints and limit of validity

The amount of sampling work needed varies according to the degree of accuracy required (presence or absence of a species, number and identity, size of the populations or at least an estimate of relative abundance). In order to estimate the size of a population "mark-recapture" methods should be used. These are expensive techniques both in terms of cost and manpower, but provide a wealth of information (age structure of the population, rate of survival and other demographic parameters...).
The surface area, number and dispersion of sites in the sector under study play an important role in determining the duration and cost of the study. Furthermore, teams of at least 2 people should always carry out this work because of both the night work, at least for the study of the amphibians, and the risks presented by the terrain traversed (not always firm ground, risk of slipping in certain circumstances...).

A. Morand

Tapoles of Western spadefoot toad.

B. Bischoff/Bios

Conclusion

Many threats weigh on the reptiles and amphibians of the Mediterranean wetlands. They are discrete in the landscapes, but remarkable in their adaptations to the changes in the environment over millions of years. Will these species survive man?

The protected Mediterranean wetlands support the conservation of a great number of original species of both amphibians and reptiles. Some of them are the target of specific protection and monitoring measures, which are nevertheless insufficient as these species generally are still vulnerable or threatened with extinction.

There is no doubt that amphibians and reptiles are declining. The causes are many. The disappearance of wetlands in industrialized countries and processes of development are probably the most

The main problem : to survive...

significant factors. Construction, various forms of pollution and tourism have destroyed or considerably degraded spawning sites and their immediate surroundings. Populations in spaces that are taken over by man are increasingly split up, and the short-term disappearance of small populations that are too dispersed can easily be foreseen.

Nature protection and land development can no longer be satisfied with only conserving isolated organisms or landscapes. These issues need a global vision, founded on precise knowledge about the ecological requirements of each species and on how the ecosystem operates.

Furthermore, strict collaboration between scientists that are concerned about the future of wildlife, managers of the natural environment and the various user groups is necessary.

There is still reason to be optimistic about the conservation of amphibians and reptiles and the durable viability of their populations, in particular because of the changes in the opinion of wetland users. The dissemination of information and campaigns to increase public awareness about the natural environment and wildlife has lead the many actors involved to concerted collaboration with the professional conservationists.

List of amphibians and reptiles mentioned in the annexes of the "Habitats Directive" (European Union), of Bern Convention, of CITES and IUCN

Family	Taxa	Habitats Directive ann.II	Habitats Directive ann.IV	Bern Convention	CITES	IUCN
AMPHIBIANS	CAUDATA					
Salamandridae						
	Salamandra atra (Laurenti, 1768)		◆	◆		
	Salamandra atra aurorae (Trevisan, 1982)	◆	◆	◆		CR
	Salamandra lanzai (Nascetti, Andreone, Capula & Bullini, 1988)		◆			
	Mertensiella luschani (Steindachner, 1891)	◆	◆	◆		
	Salamandra terdigitata (Lacepède, 1788)	◆	◆	◆		
	Chioglossa lusitanica (Bocage, 1864)	◆	◆	◆		VU
	Euproctus asper (Dugès, 1852)		◆	◆		
	Euproctus montanus (Savi,1838)		◆	◆		
	Euproctus platycephalus (Gravenhorst, 1829)		◆	◆		CR
	Triturus cristatus (Laurenti, 1768)	◆	◆	◆		LR : cd
	Triturus carnifex (Laurenti, 1768)		◆	◆		
	Triturus dobrogicus (Kiritzescu, 1903)			◆		DD
	Triturus karelinii (Strauch, 1870)		◆	◆		
	Triturus marmoratus (Latreille, 1800)		◆			
	Triturus italicus (Peracca, 1898)		◆	◆		
	Triturus montandoni (Boulenger, 1880)			◆		
Plethodontidae						
	Speleomantes (Hydromantes) ambrosii (Lanza, 1955)	◆	◆			
	Speleomantes italicus (Dunn, 1923)		◆	◆		
	Speleomantes genei (Temminck & Schlegel, 1838)	◆	◆	◆		LR : nt
	Speleomantes flavus (Stefani, 1969)	◆	◆	◆		VU
	Speleomantes supramontis (Lanza, Nascetti & Bullini, 1986)	◆	◆	◆		LR : nt
	Speleomantes imperialis (Stefani,1969)	◆	◆	◆		LR : nt
	Speleomantes strinatii (S. italicus strinatii) (Aellen, 1958)	◆	◆	◆		
Proteidae						
	Proteus anguinus (Laurenti, 1768)	◆	◆	◆		VU
	ANURA					
Discoglossidae						
	Alytes obstetricans (Laurenti, 1768)		◆	◆		
	Alytes cisternasii (Bosca, 1879)		◆	◆		
	Alytes muletensis (Sanchiz & Alcover, 1977)	◆	◆	◆		CR
	Alytes dickbilleni (Arntzen & Garcia-Paris, 1995)					VU
	Bombina variegata (Linnaeus, 1758)	◆	◆	◆		
	Discoglossus pictus (Otth, 1837)		◆	◆		
	Discoglossus sardus (Tschudi, 1837)	◆	◆	◆		
	Discoglossus galganoi (Capula, Nascetti, Lanza, Bullini & Crespo, 1985)		◆	◆		
	Discoglossus (galganoi) jeanneae (Busack, 1986)	◆	◆	◆		
	Discoglossus montalentii (Lanza, Nascetti, Capula & Bullini, 1984)	◆	◆			VU
Bufonidae						
	Bufo calamita (Laurenti, 1768)		◆	◆		
	Bufo viridis (Laurenti, 1768)		◆	◆		
Pelobatidae						
	Pelobates cultripes (Cuvier, 1829)		◆	◆		
	Pelobates fuscus (Laurenti, 1768)		◆	◆		
	Pelobates fuscus insubricus (Cornalia, 1873)	◆	◆	◆		EN
	Pelobates syriacus (Boettger, 1889)		◆	◆		
Hylidae						
	Hyla arborea (Linnaeus, 1758)		◆	◆		LR : nt
	Hyla meridionalis (Boettger, 1874)		◆	◆		
	Hyla sarda (H. arborea sarda) (De Betta, 1857)		◆	◆		

Habitats directive (European union) = Annex II : Animal and plant species of community interest whose conservation requires the designation of special areas of conservation ; Annex IV : Animal and plant species of community interest in need of strict protection.
Bern convention = Appendix II : strictly protected fauna species.
CITES : Convention on International Trade in Endangered Species of Wild Fauna and Flora.
IUCN : World Conservation Union's Red Data Book :
EX (extinct) ; EW (extinct in the wild) ; CR (critically endangered) ; EN (endangered) ; VU (vulnerable) ; LR (lower risk) ; DD (data deficient) ; cd (conservation dependant) ; nt (near threatened) ; lc (least concern)

List of amphibians and reptiles mentioned in the annexes of the "Habitats Directive" (European Union), of Bern Convention, of CITES and IUCN

Family	Taxa	Habitats Directive ann.II	ann.IV	Bern convention	CITES	IUCN
Ranidae						
	Rana dalmatina (Bonaparte, 1838)		◆	◆		
	Rana arvalis (Nilsson, 1842)		◆	◆		
	Rana iberica (Boulenger, 1879)		◆	◆		
	Rana latastei (Boulenger, 1879)	◆	◆	◆		LR : nt
	Rana graeca (Boulenger, 1891)		◆			
	Rana lessonae (Camerano, 1882)		◆			
	Rana italica (Dubois, 1987)		◆	◆		
REPTILES	TESTUDINATA					
Emydidae						
	Emys orbicularis (Linnaeus, 1758)	◆	◆	◆		LR : nt
Bataguridae						
	Mauremys caspica (Gmelin, 1774)	◆	◆	◆		
	Mauremys leprosa (Schweigger, 1812)	◆	◆			
Cheloniidae						
	Chelonia mydas (Linnaeus, 1758)		◆	◆	I	EN
	Caretta caretta (Linnaeus, 1758)	◆	◆	◆	I	EN
Dermochelyidae						
	Dermochelys coriacea (Vandelli, 1761)			◆		
	SQUAMATA					
Colubridae						
	Natrix natrix cetti (Gené, 1938)		◆			CR
	Natrix natrix corsa		◆			
	Natrix natrix schweizeri (Müller, 1932)					CR
	Natrix tessellata (Laurenti, 1768)	◆	◆			
Lacertidae	*Lacerta (Zootoca) vivipara pannonica* (Lac & Cluch, 1968)					VU
	Lacerta schreiberi (Bedriaga, 1878)	◆	◆	◆		

Glossary

Allantoid: one of three embryonic appendices specific to higher vertebrates (reptiles, birds, mammals).
Allochthonous species: designates a foreign species in a given population, and one that has been introduced by man.
Amniotic cavity: the amnion is an embryonic envelope that delimits a cavity in higher vertebrates.
Anthropogenic: resulting from the influence of human beings on nature.
Artemia: lower crustacean with foliaceous members, found in salt-water marshes.
Autochthonous species (or indigenous): designates a species that is originally from the given area compared to an introduced species, known as an allochthonous species.
Biotope: a clearly defined geographical area, characterised by specific ecological conditions (soil type, temperature...).
Cloaca: common orifice of the urinary, intestinal and genital tracts of certain vertebrates (in particular in birds, amphibians and reptiles).
Community: group of species that belong to a given systematic group, and which occupy a common habitat (e.g.: a community of amphibians)
Competition: competition is made up of two different mechanisms: the first corresponds to the simultaneous exploitation of a single resource by several individuals; this does not involve direct interaction between the individuals. This is exploitation competition. The second type of competition is competitive interference, whereby a given individual influences the chances of survival or of reproducing of another individual by direct negative action. In certain amphibian larvae, this mechanism is exhibited when an algae living in the digestive canal leads to the inhibition of growth of the larvae.
Devonian: fourth geological period of the primary era (from 400 to 360 million years ago).
Ecological succession: this expression describes the series of natural processes by which an ecosystem that has been naturally or artificially altered or destroyed, spontaneously undertakes the task of reconstituting itself in order to attain a state that is a sort of carbon-copy of its initial state. This universal phenomenon can be triggered as a result of many situations: abandoned cultured lands, landslide, flooding, fire...
Ecotone: transition zone between one biocenosis and the next. The fauna is richer and more abundant than in the adjacent biocenoses, so the species mix to a greater or lesser extent. This effect is known as the edge effect.

Endemism: a taxon is said to be endemic of a region when its geographic distribution is limited exclusively to that region. A sub-endemic taxon is also found in a neighbouring region or regions. Experts consider endemism as being a type of vulnerability, and include these taxons on the threatened list, even if they are not really threatened. Nevertheless, the simple fact of having such a reduced distribution constitutes a threat.

Eutrophication: process of excessive enrichment of a water body, by the input of nutrients, and potentially leading to a decline in the level of dissolved oxygen and the death of fish.

Growth ring: concentric markings found on a tree's cross-section (the number of rings indicate the age of the tree).

Heterochronies: group of evolutionary changes influencing the chronology or speed of development.

Hydroperiod: period during which a site is flooded.

Hydrosystem (synonym: Ecocomplex of wetlands): group of semi-aquatic and aquatic ecosystems. This term can be used for rivers (fluvial hydrosystems), but a pond or large marsh is also a hydrosystem. A hydrosystem can be divided into smaller elements that function homogenously, ranging from functional units with homogenous abiotic characteristics to plant or animal populations.

Inlandsis: high latitude glacier that forms a huge dome, masking the landscape underneath.

Keratinised: in lower aquatic vertebrates (cyclostomes, fish and amphibian larvae) the epidermic cells are living throughout the whole layer of the epidermis, and are eliminated without undergoing any particular transformation. The epidermis is thin (5 to 9 cell layers), permeable and exchanges can occur (osmosis and ion exchanges) between the inner and outer environment. On the other hand, in higher terrestrial vertebrates (tetrapods) the outer layer of cells is impregnated with complex proteins, keratins, and then dies. In adult amphibians, which are still poorly adapted to life in the open air, the horny layer is thin and generally consists of a single layer of cells, which is periodically eliminated in sections (amphibian moulting). In this way, the epidermis remains permeable, which enables osmotic exchanges and cutaneous respiration.

Major bed of a river: area situated between the minor bed and the largest flood recorded in history.

Marismas: when translated literally, this word means marsh in Spanish. From this, Marismas is used to describe the whole region found at the mouth of the Guadalquivir.

Metamorphosis: important transformation of the body and lifestyle during the development of certain animals, such as amphibians and certain insects.

Metapopulation (synonym: sub-divided populations): a group of populations spatially divided, but which are inter-connected by exchanges of individuals, and therefore by exchanges of genetic information.

Microhabitat: specific local conditions when the overall habitat is heterogeneous, e.g.: islets of vegetation, muddy bottoms, dead leaves, riverbanks.
Minor bed of a river: submerged area, when the river is at full flow, but before flooding.
Oviparity: reproduction by eggs that are released either before or after fertilisation, but before hatching.
Ovoviviparous: an animal whose reproduction is by eggs, but which keeps the eggs in the genital tract until the young hatch. The embryo develops using only the reserves accumulated within the egg, in contrast to the embryo of viviparous organisms (mammals) which is fed by the mother via the placenta.
Periphyton: algae that grow around other plants.
Riparian forest: riparian forest along the banks of a stream or river.
Serum: liquid with a high level of anti-toxins, extracted from the blood of an animal, often from the horse, and used as a vaccine in man against a microbial illness, or against a toxin, which enables a rapid fight against the corresponding infection.
Speciation: appearance of differences between two neighbouring species, leading to their permanent separation.
Species richness: number of species that make up a community.
Spermatophore: organ containing the spermatozoids in various invertebrates and small vertebrates, and which these animals can detach and present to the female.
Skeletochronology: discipline that studies the age and growth of fish, amphibians and reptiles by studying parts of the skeleton.
Syntopy: describes a situation whereby a species is found in the same region as another species with which reproductive phenomena may exist.
Taxon: Concrete systematic entity from a given rank.
Tertiary: geological era that extended from 65 million years to 1.8 million years.

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Station Biologique de la Tour du Valat

Founded in 1954 by Luc Hoffmann, the Tour du Valat biological station is a private organization, managed by the Sansouire Foundation, whose work is recognized to be in the public interest. A team of approximately 80 people devotes itself to scientific activities, the management of the domain, and conservation actions.

An effective nature conservation policy must be based on scientific knowledge obtained from rigorous research. With this necessity in mind, the Tour du Valat has set up a research program on the functioning of wetlands, and more particularly that of reedbeds, temporary marshes, and rice paddies. It is also involved in long-term studies of colonial waterbirds in the Camargue and Mediterranean region. The conservation department makes great efforts to promote the transfer of knowledge obtained by researchers and managers by developing management plans for the Mediterranean wetlands, setting up training sessions, informing and supporting policies promoting the rational management of these resources, and publishing works of popularization.Within this context, the Tour du Valat has given itself the mission ***"of putting an end to the loss and degradation of Mediterranean wetlands and restoring them"***.

The MedWetCoast project

The MedWetCoast project aims at conserving the biodiversity of global and regional importance in 6 countries/authority in the Mediterranean basin: Albania, Egypt, Lebanon, Morocco, Palestinian Authority and Tunisia.

The project was developed by the Biological Station of Tour du Valat and the Conservatoire du Littoral in close collaboration with the countries involved. It is financed by the national contributions of these countries as well as the Global Environment Facility (GEF) through the United Nation Development Programme (UNDP) and the French Global Environment Facility (FGEF).

Launched in 1999, the project has a duration of 5 years and is based around three distinct and complementary actions; at local level, it aims at implementing sustainable and intersectoral management in 15 pilot sites (threatened wetlands and coastal areas); at national level, it calls for developing innovative legal frameworks for removing the causes of biodiversity degradation, reinforcing the institutions involved in the management of natural resources and promoting coordinated policies; finally at regional level, it strives for strengthening capacities through training and technical assistance and developing and sharing the Mediterranean experience through networking.

The MedWetCoast project is an integral part of the MedWet Initiative and operates in close collaboration with other regional initiatives and organizations, specifically the Mediterranean Action Plan (the Barcelona Convention).

In this part of the world where biodiversity stands among the richest and most threatened, MedWetCoast thus actively contributes to conserve biodiversity and to "close the Mediterranean circle".

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