characteristic species: the most widespread are *Culex, Aedes* and *Anopheles*. The last is very well-known, because in the past it carried the parasite which causes malaria in man, and was very frequent in the low-lying areas of Italy, like the Po Delta, Maremma, and the fertile plains south of Rome.
The larvae have respiratory siphons and may be numerous below the water surface. Female adults are particularly well-known to man because they are haematophagous and bite. An Asian species, known as tiger mosquito (*Aedes albopictus*) has recently been introduced into Italy, probably carried by tiny quantities of water adhering to the tyres of vehicles. It has spread quickly, especially in cities where the tiny collections of water in which they live are to be found everywhere (gutters, rainwater tanks, and even the dishes and saucers set under flowerpots). Extremely irritating and aggressive to man, these mosquitoes are dangerous because they carry several viruses and also filaria - showing how hazardous the introduction of alien species can be.
Although in Italy biting midges are very numerous in small bodies of water, little is known about them. They include the tiny, worm-shaped larvae of the genus *Dasyhelea*, which develop in rock pools and garden pools. Small bodies of water and marshes also contain crane flies, limoniids, hover flies, soldier flies and sciomyzids. The larvae of some large soldier flies (up to 40 mm) are easily identified by their long respiratory siphons, and are found in eutrophic pools.

Pupa of mosquito

Tardigrades (water bears). These are microscopic organisms with stumpy bodies and undefined segmentation. They have four pairs of legs ending in hooked claws.
Water bears move slowly like sloths on mosses, muddy bottoms and damp soil, and climb the stems of aquatic plants, the fluids of which they suck. They are very well adapted to difficult living conditions, and can spend lengthy periods encysted, in a state called cryptobiosis, which is ran almost complete arrest of metabolism in extreme environmental conditions. Several species live in these habitats, and the most common genera are *Macrobiotus, Echiniscus*, and *Hypsibius*.

Bryozoans. These sessile, colonial animals may form encrusting structures and straight tubules about 1 mm in diameter. At times, their colonies resemble masses of jelly, and are easily mistaken for algae.
The single animals composing a colony, called zooids, have a round, or horseshoe-shaped lophophore, i.e., a ridge from which the ciliated tentacles originate. The waving tentacles produce currents that carry tiny food particles (algae and protozoans) to their mouths. Among the most common Italian species are *Cristatella mucedo, Paludicella articulata* and *Fredericella sultana*.

Adult mosquito

Notonecta maculata

■ Survival strategies in astatic water

The calanoid *Arctodiaptomus wierzejskii*

In small bodies of water, the words *astatic* or *periodical* alone indicate severe environmental conditions, which can become extremely selective for invertebrates.

The species must therefore follow precise “rules” in order to survive. In the course of their evolution, all aquatic invertebrates have developed more or less complex adaptations that enable them to survive periods of drought, frost and lack of water, and to start their life-cycles again once water is available and conditions are favourable. Some of these adaptations are among the most extraordinary biological phenomena nature offers. Let us now examine those aiming at overcoming the worst condition - lack of water.

Invertebrates which leave their environment in periods of drought. There are several aquatic invertebrates that leave pools and marshes about to dry up. Among these are many adult aquatic insects capable of flying, such as bugs (water boatmen, back swimmers, water striders) and beetles (adephagans, like true water beetles, or hydrophiloideans, like water scavenger beetles and species of *Hydraena*), which generally spend dry periods in nearby permanent water, according to their flying capacities.

These insects quickly return to temporary bodies of water as soon as these fill up with spring or autumn rain. This behaviour elicits an obvious question: why do these animals return to their unsafe temporary pools, instead of staying in secure perennial ponds? The answer is that temporary pools have greater quantities of food than permanent ponds, where these insects are likely to be preyed on by fish.

Invertebrates which are aquatic only as larvae. This group includes many insects (mayflies, dragonflies and damselflies, alderflies and dobsonflies, beetles, caddis flies, flies and mosquitoes), the larvae of which grow in aquatic environments.

The adults (imagos) or subadults (subimagos of mayflies, or duns), spend the rest of their life-cycles in subaerial environments and can fly. Well-known examples are dragonflies and mosquitoes.

Their life-cycles depend on environmental conditions: the larvae develop slowly in favourable conditions and quickly in unfavourable ones. When

water dries up completely, these insects are already capable of flying, or else they pupate.

Invertebrates which burrow in mud without resting stages. Several animals never leave ponds, not even when drought sets in. Instead, they burrow deep down into the mud at the bottom and spend periods of adversity in waterlogged habitats. This is how many molluscs behave, such as gastropods (spiral-shelled snails and pond snails), bivalves, crustaceans (isopods and decapods) and beetles.

Although their metabolism slows down and some invertebrates envelope themselves in mucus cases at the bottom, they never quiesce. This mechanism is therefore inefficient, and can only be adopted for short periods of drought and in areas with suitable substrates.

Invertebrates with resting stages. Most invertebrates which are aquatic throughout their lives can withstand drought in resting stages, i.e., as resting eggs, or as cysts that contain their body fluids and prevent their evaporation. In these stages, animals can spend their lives in a latent state, sometimes even for years (up to 30, according to recent experiments). According to taxonomic group, dormancy occurs at different stages in life. Rotifers, for example, alternate the production of parthenogenetic eggs with resting ones, which are produced in unfavourable conditions by amphigonic (*mictic*)

The gastropod *Planorbis planorbis*

reproduction, and which can remain dormant in dry environments for several years, until water returns.

A similar situation occurs with cladocerans (water-fleas). In this case, one or two resting eggs (according to species) are enclosed in a protective membranous case (*ephippium*) which is shed when the animal moults.

Other crustaceans, like tadpole shrimps and fairy shrimps, produce resting forms, the former eggs, and the latter cysts, in which egg development stops after the initial cleavage (gastrula) stage.

Copepods have particular adaptations: some species produce resting eggs (especially calanoids); others arrest their development at the fourth copepodid stage, or at the adult stage (cyclopoids, harpacticoids). The animals burrow into sediment to spend their quiescent stages, which end as soon as water is available again.

■ Colonisation of ponds and pools

Ponds and pools which are either created by man or result from natural events are, as it were, “empty containers” waiting to be filled by living organisms. Colonisation occurs when fauna from other bodies of water settles in these small collections of water. We are not referring here to the event whereby a

A swamp near San Benedetto in Perillis (Abruzzo)

Pond in Castelporziano (Latium)

new body of water is created in a pre-existing wetland already hosting quiescent stages or aquatic animals. Obviously, the closer and more numerous the other bodies hosting colonising groups of animals, the quicker this process will be. Colonisation may be *active* or *passive*.

Active colonisation occurs when animals arrive by their own efforts, i.e., flying insects are active colonisers. This process is very rapid, and the first colonisers are bugs (water boatmen and water striders) and beetles (true water beetles and water scavenger beetles), which may occupy a new pond or pool within hours of its formation. Recent studies have shown that some of these insects (e.g., water striders) are visually attracted by the reflecting water surface of the ponds: simple experiments with mirrors have clearly demonstrated this phenomenon.

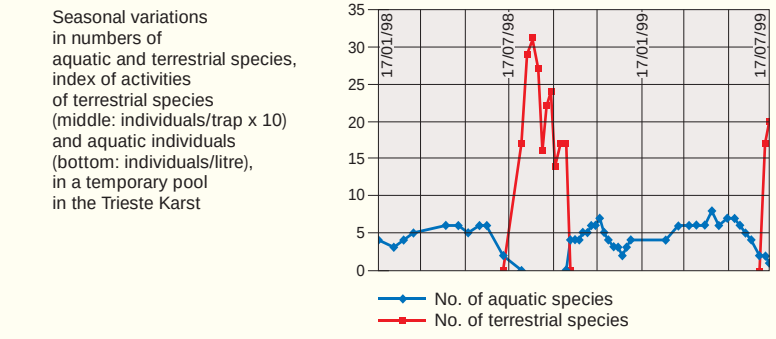
Passive colonisation occurs when animals are carried by the wind or trickling water, by other animals (even flying insects themselves, amphibians, drinking livestock) and man. At present, man plays an essential role in spreading fauna in small collections of water, either involuntarily, or by the voluntary introduction of fish and aquatic plants. Unfortunately, this has caused the arrival of many alien species, which do not belong to Italian fauna.

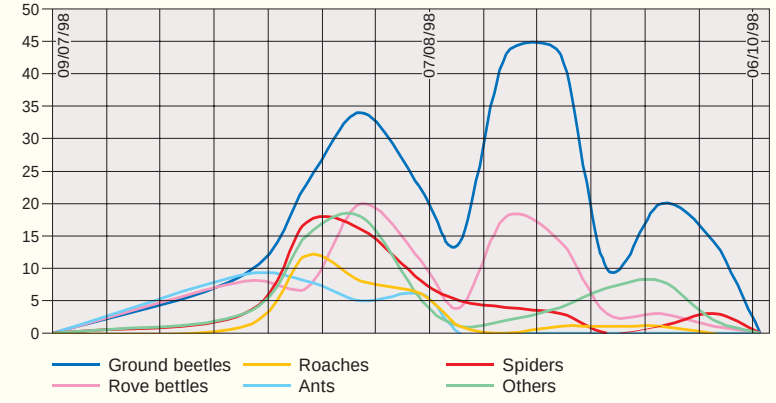
Insects and other invertebrates may passively transport quiescent forms and even adult animals. The method by which an animal clings to the body of a larger animal of another species and is carried some distance before releasing its grip and falling, is called *phoresy*.

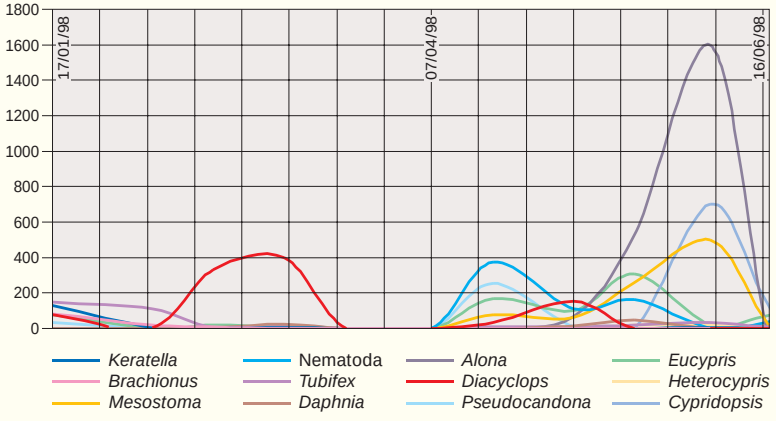
As soon as the initial colonising phase is over, invertebrate populations rapidly change, and several groups follow each other until the fauna becomes stable. Although chance and the timing of the arriving colonisers play important roles, the new body of water is generally colonised by species which are better suited to the new local environmental conditions. In the following months, the colonising species will be those adapted to unstable environments. This initial phase, dominated by complex interactions between competition, predation, and habitat requirements, is followed by a more stable phase.

However, colonisation does not affect only new bodies of water (*primary colonisation*); colonising animals continually settle in all pre-existing small water collections (*secondary colonisation*). Small and unstable habitats may therefore change their fauna completely in one year, giving rise to turnover which, many years ago, biogeographers had predicted would occur in island habitats. Obviously, turnover depends on the selection of species available, and therefore, environments which now lack water and contain few species are likely to host stable populations.

Seasonal variations
in numbers of
aquatic and terrestrial species,
index of activities
of terrestrial species
(middle: individuals/trap x 10)
and aquatic individuals
(bottom: individuals/litre),
in a temporary pool
in the Trieste Karst







■ The life-cycle of a temporary pool

The fascinating seasonal successions of invertebrates in temporary pools generally differ from one area to the next, and sometimes change over the years, according to climatic conditions. Although generalisation is impossible, thorough study enables us to provide examples showing the complexity of situations in even tiny environments.

In the Trieste Karst, the author of this chapter studied a pool (5 m wide, 40 cm deep) both at its maximum capacity and during drought, and was able to trace the exact succession of species and to divide the year into several periods. The following is a fascinating story, which begins with the return of water.

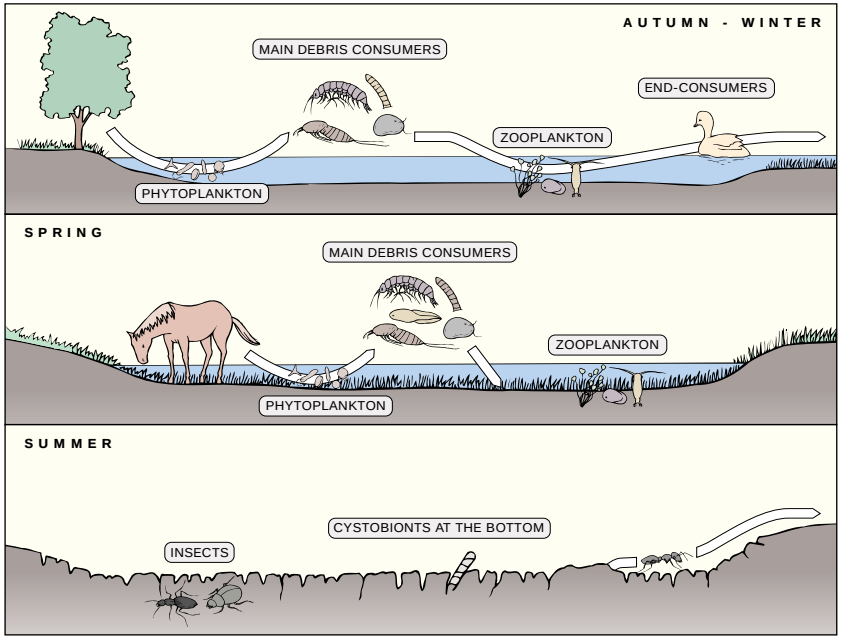
In early October, immediately after the early autumn rain, the pool is at its maximum capacity. Its bottom is inhabited by several roundworms, most of them semi-aquatic species living in damp soil, which unexpectedly found themselves in the water. They soon disappear and, in just a few days, the pool teems with tiny organisms which have emerged from their cysts (cyclopoids), or hatched from resting eggs on the bottom, like oligochaetes (*Tubifex tubifex*), mussel shrimps (three species of the genera *Eucypris, Pseudocandona, Heterocypris*) and cyclopoid copepods (*Diacyclops lubbocki*). They are soon followed by predators, e.g., turbellarian flatworms of the genus *Mesostoma*,

The dry bed of a temporary pool (Campo Felice, Abruzzi)

and by the tiny rotifers, which hatch from resting eggs (three species of the genera *Keratella, Testudinella* and *Brachionus*). These animals belong to “autumnal species”, the numbers of which peak in late October. Their development is short-lived, as by late November, when temperatures fall, the pond freezes completely. Although a few mussel shrimps and oligochaetes continue their slow-moving lives in mud under the thick layer of ice, all the other species present have to resort to quiescence to survive.

In early March, as soon as the temperature starts to rise, the ice melts and the pond bustles with new life once again. “Spring species” are, with few exceptions, the same as autumnal ones, with the addition of water-fleas (*Daphnia obtusa*). Spring species peak in April-May, with numbers doubling those in October. In this period, colonisers also visit the pool: water striders come flying in (*Gerris costai*), together with predatory beetles (true water beetles of the genera *Agabus* and *Hydroporus*), and phytophagans (*Helophorus, Hydraena*). The larvae of non-biting midges, mosquitoes, biting midges and limnephilid caddisflies hatch from their eggs.

Ideal growth conditions last until June, when a dramatic crisis occurs: rising



Life-cycle in a temporary pool; arrows indicate input and output of organic matter during different phases

Dragonfly nymph (genus *Aeshna*)

temperatures, reduced water volume, large numbers of predators, and a probable change in phytoplankton make spring species disappear, especially those of the genera *Daphnia, Eucypris* and *Diacyclops*, which are replaced by “summer species”, like other water-fleas (*Ceriodaphnia reticulata, Alona rectangula*) and ostracod crustaceans (*Cypridopsis elongata*). These changes occur very rapidly, in just a few days. The above species are even more numerous, twice as many as the spring species, but they do not last very long - after only two weeks, the pool is completely dry.

Dry, however, does not mean lifeless, because now terrestrial species start colonising the basin. They come from nearby woodland in search of food. More than 80 different terrestrial species move in, such as ground beetles, rove beetles, scarabeid beetles, roaches, flies, ants, springtails, centipedes, spiders and false scorpions. They are sometimes opportunistic animals and therefore only occasional visitors, but there are also stable populations that exploit the humidity of the area during summer, and predators which often visit the pool, like ground beetles (the large *Carabus, Abax, Pterostichus* and *Cychrus*, or the tiny, numerous *Aptinus bombarda*), some rove beetles (*Ocypus tenebricosus*), centipedes (*Lithobius, Strigamia*) and large numbers of spiders (mainly *Lepthyphantes* and *Pardosa*). Cycles follow each other very quickly, and once again, this group of terrestrial species will also leave the pool with the early autumn rain, and the aquatic fauna will begin the eternal cycle of life all over again.

Fish

SERGIO PARADISI

Lentic environments, classified generically as “minor water bodies”, have small size and shallow water in common: the fish colonising them most frequently therefore have to cope with a series of important limiting factors, and in fact less than a dozen species indigenous to Italy are to be found in them.

Tench (*Tinca tinca*) and carp (*Cyprinus carpio*) are probably the most characteristic fish of still waters. The latter, in the strictest sense of the word, should not be considered a native, coming originally from east Asia according to some scholars, or central-western Asia and the Danube basin in eastern Europe, according to others. Carp became acclimatised to Italian waters a very long time ago, probably being introduced in the 1st century A.D. by the troops of Imperial Rome. The gradual spread of the species through Western Europe during the Middle Ages can most probably be attributed to the monastic orders. Carp adapted well to being reared in the fish-ponds which were always constructed adjacent to monasteries, since the monks preached that no meat was to be eaten on Fridays, and at other periods, like Lent, when several proscriptions covered the practice of abstaining from meat, it was convenient to have a source of fresh protein nearby.

Tench and carp, although very different to look at, have morphological and behavioural traits in common, which testify to their adaptation to still or slow-moving waters with soft beds rich in vegetation, where these species pass the time grubbing around on the bottom. Both species have rather small protractile mouths and thick lips adorned with barbs (one pair in tench, two in carp), and these sensitive organs facilitate the search for food in sediments.

The diet of both tench and carp includes algae, aquatic macrophytes, and a wide range of benthic invertebrates; the young and sub-adults may also sometimes eat zooplankton. They search for food mainly during twilight hours and at night. Temperature also influences feeding behaviour: for example, carp feeds when temperatures are between 14 and 20°C.

During the winter months, these fish dramatically reduce their activity, remaining partly sunk in the mud on the bottom in a kind of semi-hibernation. By contrast, the high summer temperatures which are regularly reached in still

Young specimen of chub (*Leuiscus cephalus*)

waters - with consequent scarce oxygenation - does not represent a difficulty, as both species can tolerate values of dissolved oxygen close to 1 mg/l.
Water temperature also affects reproduction: depending on site, mating takes place from May to July, i.e., when threshold values of around 20°C are reached. Carp and tench deposit their eggs on aquatic macrophytes and the larvae, after hatching, remain attached to the plant until their yolk sacs have been reabsorbed. Vast numbers of eggs are laid - up to 200,000 per kg of live weight for carp, and up to 500,000 for tench. Laying a multitude of very small eggs - therefore with small yolks - is a perfect breeding strategy in these extremely productive environments which, although rich in nutriments for larvae and fry, are also full of hazards. Any type of parental care is rendered impossible by the huge numbers of eggs.
Both species are currently widespread in suitable waters throughout mainland Italy and on the larger islands, partly following releases of specimens for fishing. In Italian waters, tench grows to a length of 50 cm, and may weigh 2 kg, whereas carp may reach a length of more than 120 cm and weigh 30 kg.
The wild form of carp, known as “queen” carp, recognisable by the body completely covered in scales, is becoming rarer, being supplanted by types selected by breeding, known as “mirror” carp (with a few large scales on the flanks) and “leather” carp (entirely without scales). Because of this widespread

Tench (*Tinca tinca*)

practice of introducing reared animals, wild carp rarely has well-structured populations in Italian waters.
Very common in still waters throughout the peninsula, is rudd (*Scardinius erythrophthalmus*), a medium-sized fish which only exceptionally reaches more than 35 cm in length and 800 g in weight. Active also in winter, if the water temperature does not drop too low, it prefers well-vegetated littoral areas with muddy or sandy bottoms. However, its ecological range is wide, and it can also tolerate environments suffering from organic pollution due to urban or agricultural waste discharges. It is a gregarious species, especially during juvenile stages. Compared with the adults - which have a slightly stubby body, greenish-brown back, flanks with golden reflections, and reddish or greyish-brown fins - the young are more streamlined, with red fins, more silvery flanks, and a dark patch at the base of the tail.
In many lentic waters of northern Italy, rudd are often joined - in mixed shoals - by roach (*Rutilus erythrophthalmus*), a cyprinid which lays its eggs on plants and reaches a maximum of 20 cm in length and 130 g in weight, although it is usually smaller. In central-southern regions, a very similar species belonging to the same genus, “rovella” (*Rutilus rubilio*), is widespread. These two endemics, the former of the Po Valley and the latter of the whole Italian peninsula, were considered to be a single taxon, called *Rutilus rubilio*, until the

Rovella (*Rutilus rubilio*)

Rudd (*Scardinius erythrophthalmus*)

Roach (*Rutilus erythrophthalmus*)

Tench (*Tinca tinca*)

Carp (*Cyprinus carpio*)

early 1980s. The new species, “triotto” (*Rutilus erythrophthalmus*), was proposed after the identification of constant differences in livery and some morphometrical characteristics, and when research ascertained that the obvious reproductive barriers due to different provenance were also maintained in conditions of forced sympatry.

Common bleak (*Alburnus alburnus alborella*)

These facts have subsequently been confirmed by biochemical studies. The behavioural differences between the two species include the greater propensity of “rovella” to remain in contact with the bottom, and the more obvious gregariousness of “triotto”. Neither do their habitat preferences coincide: “rovella”, although it may be found in still-water biotopes, prefers waterways with a moderate current, sand or gravel substrates, and without much vegetation; this is also reflected in their reproduction habits, as eggs may be deposited on either plants or gravel.

A few other cyprinids indigenous to Italy may also be found in small, still-water biotopes. Examples are chub (*Leuciscus cephalus*) and common bleak, or blay (*Alburnus alburnus alborella*). These species, which lay their eggs on gravel, prefer clear well-oxygenated waters, and usually live in rivers or large lakes, but may also find small lentic environments with sand or gravel bottoms fed by groundwater suitable, such as recently formed oxbow lakes or flooded quarries, preferably with deep water. Chub is omnivorous, at home in a vast range of habitats, and can grow to more than 50 cm in length and 2 kg in weight. Instead, bleak is a quite small (at the most 15 cm), extremely gregarious fish. It too is omnivorous, and in closed basins often assumes an important trophic role, forming the link between zooplankton and piscivores. This subspecies should be considered sub-endemic to Italy, as its distribution area includes the northern regions of Italy and Dalmatia, and there are also many alien populations in southern Italy and Sardinia due to uncontrolled releases. This practice, in some environments, appears to be one of the causes of the decrease in numbers of Italian bleak (*Alburnus albidus*), an endemic (with scattered distribution) in an area covering Abruzzo, Campania and Basilicata.

Apart from cyprinids, there are few other native species in these environments. Gudgeon (*Cobitis taenia bilineata*) is sometimes found in clear water with active groundwater circulation, sandy or muddy bottoms, and not too dense

vegetation - such as recently-formed oxbow lakes. This small, very elusive benthic fish (maximum length 12 cm) is only active at twilight and during the night, passing the rest of the time hiding in the substrate, with only its head emerging, and burying itself completely if disturbed. It feeds by filtering organic particles aspirated from the bottom: its diet includes micro-organisms, small insect larvae (mainly *Chironomus*) and plant debris.

Small fish such as gudgeon, rudd, roach and common bleak fill the role of "foraging fish" in environments which are home to animals higher up in the food-chain. The predator *par excellence* of still or slow-moving waters is pike (*Esox lucius*): excluding juvenile stages, when young pike feed on zooplankton first and then on macroinvertebrates, the pike's diet is mainly other fish, and larger specimens also capture amphibians, small mammals and, exceptionally, water-bird chicks.

Like many other predators, pike was long considered a "harmful" species: in reality, its low population density and nutriment conversion ratio both mean that it certainly has no substantial effect on the numbers of other species.

On the contrary, many studies have recognised its role as a beneficial equilibrator of the structure of fish populations. The pike has several of the attributes of a predator: a large mouth armed with approximately 700 strong, sharp, inward-sloping teeth, and large eyes situated in a semi-frontal

Gudgeon (*Cobitis taenia bilineata*)

position, giving it at least partially stereoscopic vision and thus a better evaluation of the distance of its prey. Its livery is highly mimetic.

At around 30 years of age, the species may reach one and a half metres in length and 35 kg in weight, but this maximum has never been recorded in Italian waters.

The original distribution of pike in Italy, confined to districts in Veneto, Tuscany and Latium, has recently been modified by releases in various localities in the centre and south. Its ecological role, at the top of the food chain in freshwaters, seems to render it rather sensitive to environmental alterations, and it currently appears to be facing a clearcut decline in numbers over much of its Italian distribution area.

Another piscivorous predator forming part of the community in ponds is eel (*Anguilla anguilla*): large specimens include small fish in their diet. The ascent of this migrant from the sea involves practically all European flowing waterways, but eel are also sometimes found in ponds with no outlet. This is due to their capacity to cross stretches of land - as long as the environment is sufficiently damp - by breathing through their skin. This unusual behaviour, plus the fact that many points of the biology of this fish still require clarification, allow eel to maintain that aura of mystery, as yet not entirely dissipated, which surrounds many migrants.

Pike (*Esox lucius*)

Amphibians and reptiles

LUCA LAPINI

Marshes are ideal habitats for amphibians

Italian amphibians and reptiles are second- or third-level consumers, and invariably behave as predators, or super-predators.
The intricate trophic networks of temperate wetlands testify to the fact that there is a huge amount of energy available.
For this very reason, Italian marshlands contain a rich herpetological fauna, organised in very diverse communities, according to the various bioclimatic and biogeographical gradients in the mainland and islands. In these habitats, hygrophilous species tend naturally to predominate, associated with water for all kinds of trophic, physiological and reproductive motives.

■ Amphibians

These archaic vertebrates have either external fertilization, releasing their gametes directly into the water (anurans), or internal (urodeles), and in most cases they lay enormous numbers of eggs in breeding areas which also serve as nurseries where the tadpoles or larvae develop. These breeding grounds are usually bodies of still water, such as ponds and marshes, and are essential for the survival of amphibians. In the majority of cases, during their lengthy larval development, these animals undergo profound olfactory imprinting, which constrains them permanently to the place where they were born. For this reason, when they reach sexual maturity, they return to breed in the same locations where they completed their metamorphosis. This deep-rooted loyalty to their birthplace, known as philopatry, renders amphibian communities particularly fragile, as they are highly sensitive to any environmental changes which alter the size or structure of their breeding grounds.

Common toad (*Bufo bufo*) mating

Many terrestrial species do not live perennially associated with the water-bodies where they reproduce, and as adults tend to move away from the breeding grounds. Some may even travel many kilometres but, when the courtship season arrives (and also in autumn), they migrate back to the localities where they usually reproduce. In some species (e.g., *Bufo bufo*), the breeding season is very short, lasting around fifteen days, in others (*Bombina variegata*) it extends over most of the summer. In the former case, pre-breeding migrations are concentrated over a few days and are very spectacular, involving as they do most of the adults in a population, at times tens of thousands of animals. After mating, most of them embark once again on a post-breeding migration of similar proportions in the opposite direction.

Amphibian communities which live in Italian systems of pools, ponds and marshes roughly may be divided by geographical area. On the Alps and Pre-Alps, ponds and livestock watering-places are home to batrachian communities which are poor in species but high in numbers. Among the most common species in these areas are common toad (*Bufo bufo*), common frog (*Rana temporaria*) and Alpine newt (*Triturus alpestris*). They may be accompanied by yellow-bellied toad (*Bombina variegata*), Italian crested newt (*T. carnifex*) and Southern common newt (*T. vulgaris meridionalis*), which may be found higher than 1000 metres a.s.l. in the Alps. In some parts of the Julian and Carnian Alps (Friuli Venezia Giulia), ponds and marshes also host common

Group of yellow-bellied toads (*Bombina variegata*)

newt (*T. vulgaris vulgaris*), which in these environments often cohabits with European tree frog (*Hyla arborea*), in vulnerable mid-altitude populations which are unique in Italy. In the Po Plain, the situation changes dramatically, and aggregation parameters in the still available systems of pools, ponds and marshes differ greatly both qualitatively and quantitatively.

European tree frog (*Hyla arborea*) in song

Rana latastei mating

The dominant anurans everywhere are green frogs of the L-E genetic hybrid system (composed of varying percentages of *Rana lessonae* and *R.* klepton *esculenta*) which, in the rare, still naturally wooded areas, are accompanied by common toad, agile frog (*Rana dalmatina*), Italian tree frog (*Hyla intermedia*) and Lataste's frog (*Rana latastei*). More open areas are dominated by green toad (*Bufo viridis*), a steppe species with halophilous tendencies, which also attains high population densities in coastal regions, whereas spadefoot toad (*Pelobates fuscus insubricus*) has a very scattered distribution, for still poorly understood historical reasons. Italian crested newt chooses quite deep still waters. Southern common newt is widespread in any type of standing water.

On the margins of marshland areas in the low-lying Po plain, a deep, raucous, rhythmic croak can still be heard, vaguely similar to a roar - it is the powerful voice of the bullfrog (*Rana catesbeiana*), a North American species introduced into Italy in the early years of the last century. This large anuran may weigh more than a kilogram, and was imported into Italy for its much-vaunted gastronomic potential. The species is not in fact suitable for farming, because it has enormous territorial requirements, and at Italian latitudes its tadpoles need two or three years to complete their metamorphosis. Therefore, following the failure of the small private breeding companies, bullfrogs were released in many localities and are now irregularly scattered as far down as some of the marshes in southern Latium.

Still bodies of water in the northern Apennines are embellished by an attractive Italian endemic subspecies of Alpine newt (*Triturus alpestris apuanus*). It is

Sardinian tree frog (*Hyla sarda*)

again accompanied by Italian crested newt (*T. carnifex*), Southern common newt (*T. vulgaris meridionalis*), common toad (*Bufo bufo*) and common frog (*Rana temporaria*) which in the south reaches the Monti della Laga (Latium). In these environments, it may sometimes cohabit with another splendid Italian endemic, Italian frog (*Rana italica*), which lives along streams over much of the Apennine chain, often together with three-toed salamander (*Salamandrina terdigitata*), perhaps the most important endemic Apennine species.

Italian crested newt (*Triturus carnifex*)

Southern common newt (*Triturus vulgaris meridionalis*)

The fauna of these areas contains many endemics, including Apennine yellow-bellied toad (*Bombina pachypus*), which frequents the pools and temporary puddles which form along cart tracks and forest roads over most of the Italian peninsula. The green frogs of the central and southern mainland also belong to a specific genetic hybrid system (known as B-H) formed of two endemics, Berger's frog (*Rana bergeri*) and Uzzell's frog (*Rana* klepton *hispanica*). Further south, the picture again alters, with the appearance of Italian newt (*Triturus italicus*) - which in these areas replaces Southern common newt - and with the exceptional presence of unexpected Alpine newt (*Triturus alpestris inexpectatus*), endemic to the Calabrian coastal range.

In Sicily, amphibian communities are dominated by an aquatic anuran, painted frog (*Discoglossus pictus*), almost always flanked by Italian green frogs belonging to the B-H genetic hybrid system in the ponds, pools and marshes on the island.

The batrachian fauna in Sardinia is also embellished by numerous endemics, testifying to the long geographical isolation of the island. Tyrrhenian painted frog (*Discoglossus sardus*) is one of these, cohabiting with Sardinian tree frog (*Hyla sarda*) in many aquatic and marshland habitats. In some springs and streams of the island, one of the rarest Italian endemics, Sardinian mountain newt (*Euproctus platycephalus*), may also be found.

Dice snake (*Natrix tessellata*)

■ Reptiles

Young viviparous lizard (*Zootoca vivipara carniolica*) on newly-hatched eggs

Reptiles are a group of vertebrates well-adapted to reproduction in subaerial environments, and they are widespread in every available terrestrial habitat at Italian latitudes. The destruction and alteration of the habitat is the main risk factor for most reptilian fauna and occurs especially in areas of greatest interest to human economy. One factor of major disturbance for these animals is the direct pressure exerted on single populations by the constant attempts made by humans to eliminate them. The larger the reptile or the more contrasting its colours, the more merciless is this persecution, which is based on ignorance and on man's instinctive fear of, in particularl, snakes. Mortality on the roads is another major cause of the decline of reptile communities, the victims being snakes, lizards and tortoises.

The reptiles most closely associated with pools, ponds and wetlands are a few hygrophilous lizards, some snakes and European pond tortoises, which may at times reach high population densities in the major surface water systems. The first lizard to deserve mention is viviparous lizard (*Zootoca vivipara carniolica*) which, because of particular problems of evapotranspiration, sometimes chooses very small wet biotopes in which to live. In Italy, this species is especially widespread in the south-eastern Alps, but is also found in the lagoon reed-beds by the Adriatic and, in the Po Plain, in tiny isolated fragments of marshland. The snakes which prosper on the banks of still-water bodies and marshes are grass snakes, which are mainly associated with water for trophic reasons. Their hygrophilous level is quite variable, and alters not only depending on species but also according to the different age of the animals.

The species most closely associated with aquatic habitats that are well stocked with fish is certainly dice snake (*Natrix tessellata*), which is difficult to find at any distance from open water. This species mates on the ground and the females lay their eggs on the banks of watercourses, ponds and pools with an abundance of fish. Both adults and juveniles are piscivores, although they will also feed on amphibians and their larvae, and in some cases small aquatic mammals. They mate between April and May, when numerous small males gather together on the banks of ponds and pools, attracted by the odorous secretions of the few large females.

Grass snake (*Natrix natrix*) mates more or less in the same period, when as many as twenty males may become entwined around just one receptive female. Wreaths of animals form, continually intertwining and disentangling, in spectacular assemblies which may be made up of more than twenty snakes. These remarkable breeding spectacles, known as *nuptial balloons*, are the only period of the year when mature males and females come together. The small males are very hygrophilous and remain in the immediate surroundings of marshes, pools and ponds for much of the summer, whereas the large mature females move further away, sometimes for long distances. They inhabit very diverse forested areas, and in these circumstances feed mainly on large terrestrial anurans of the genus *Bufo*. The newly-hatched animals mainly eat small fish and tadpoles, and so tend to congregate around small and medium-sized bodies of still water, also taking advantage of smaller watering-places used by livestock. The grass snakes of Italy are divided into at least three subspecies: *Natrix natrix* lives in north-eastern Italy (Friuli Venezia Giulia, part of Veneto, and Emilia Romagna), the subspecies *N. n. helvetica* lives in mainland Italy and Sicily and Cetti's grass snake (*Natrix natrix cetti*) is endemic to the islands of Sardinia and Corsica.

Viperine snake (*Natrix maura*) lives in both Sardinia and Corsica, as well as in other regions of north-western Italy. This snake is adorned with a dorsal fret similar to that of adder (*Vipera berus*), but it is entirely innocuous. The species

Grass snake (*Natrix natrix*)

feeds on fish, tadpoles and frogs when near ponds, pools and marshes, and searches for lizards and small mammals when it lives in rocky environments.

European pond tortoise (*Emys orbicularis*) is the Italian reptile most closely associated with marshlands. The western populations of the Tyrrhenian are very different from those along the Adriatic. Although their taxonomic situation has never been entirely clarified, they are quite well characterised from the point of view of colour and markings. It is easy to ascertain their presence along the banks of ponds, pools and marshes, especially during springtime, when the animals collect together at their preferred basking sites. Pond tortoise nests are often subjected to predation by brown rats and other mammals associated with wetland environments, which dig up the tortoise eggs and eat them. The percentage of predation varies notably from one place to another, but in some cases more than fifty percent of the nests are destroyed.

European pond tortoise may find itself sharing its habitat with turtles released by the public. These are usually North American species sold as pets (*Trachemys scripta elegans*, *T. s. scripta*, *T. s. troosti*) which, when they grow above an acceptable size, are dumped by their owners in any nearby wetland environment. The fact that they compete with European pond tortoises for space and resources, to the detriment of the latter, means that legal steps should be taken to eradicate them.

European pond tortoise (*Emys orbicularis*)

Birds and mammals

LUCA LAPINI · SERGIO PARADISI

■ Birds

Moorhen (*Gallinula chloropus*)

In Italy, the distribution of nesting birds associated with still waters is affected by several factors, such as the natural state of the banks, the type of riparian vegetation, water depth, the presence of emerging aquatic plants, human disturbance, the state of adjacent areas, and naturally, the specific ecology of the bird species which prefer nesting sites associated with these environments.

The most widespread species is probably moorhen (*Gallinula chloropus*): this rail is at home in a vast range of habitats, even highly degraded and anthropogenic ones, and colonises practically all the wetland areas in the Italian peninsula, being restricted only by altitude and only found very occasionally above 600 m a.s.l. It also nests in very small ponds, as long as the vegetation cover of the banks is adequate (reed-beds, tall grass, shrubs). The smallest of the grebes, dabchick (*Tachybaptus ruficollis*) and coot (*Fulica atra*) have similar requirements. Both are uniformly distributed in the northern regions, but become increasingly rare and localised proceeding southwards. All three of these species nest very early in the season: dabchicks can be heard singing as early as February.

Another rail which lives in marshes and ponds bordered by dense cordons of *Phragmites*, *Typha* and *Carex* is water rail (*Rallus aquaticus*). It nests in all suitable wetland areas on the plains, but is an extremely shy bird, almost constantly skulking in reed-beds. Two regular migrants, spotted crake (*Porzana porzana*) and little crake (*Porzana parva*), are very similar. There are very few known nesting grounds, especially for spotted crake, which prefers habitats with extensive areas of sedges and very shallow water, nowadays very rare.

Great crested grebe (*Podiceps cristatus*) in courtship display

Grey heron (*Ardea cinerea*)

Night heron (*Nycticorax nycticorax*)

Besides dabchick, the other grebe nesting in Italy is great crested grebe (*Podiceps cristatus*). Its breeding grounds are scattered all over the country, but with higher concentrations in the Po Plain and central-southern Apennines. This bird lives in lake basins, ponds and wetlands with shallow water and an abundance of fish. In the breeding season, the pairs perform characteristic courtship dances in the water, close to the spot chosen for building their nest, which is floating and thus adjusts to varying water levels (this has also allowed the species to colonise artificial basins). The eggs hatch in late spring after being incubated by both sexes; the nestlings - despite being good swimmers from birth - are transported on their parents' backs for the first two months or so. A conspicuous contingent of winter visitors boosts great crested grebe populations during the cold season.

Biotopes of standing or slow-moving water are regularly visited, for feeding purposes, by members of the heron family or ardeids: the most common are little egret (*Egretta garzetta*), grey heron (*Ardea cinerea*) and night heron (*Nycticorax nycticorax*).

All these species have very densely populated breeding colonies in the rice-growing areas of Lombardy and Piedmont, and - partly because of their large size , which makes them easily visible - it may be said that they are an integral part of the landscape everywhere in the Po Plain. They nest in mixed colonies (heronries) in woods with tall and medium-height trees, particularly poplars, alders and willows, and are occasionally joined by squacco heron (*Ardeola ralloides*), a trans-Saharan migrant of which there are a few hundred pairs in Italy. More elusive, but nesting in suitable wet areas over all the peninsula and major islands is little bittern (*Ixobrychus minutus*), a small heron which prefers *Phragmites* and *Typha* communities, not necessarily extensive, with sparse trees and shrubs.

The best-known dabbling duck, mallard (*Anas platyrhynchos*) is widespread throughout Italy and particularly common in the Po Plain. This bird, which remains faithful to its nesting sites, is found over a vast range of freshwater and brackish water biotopes, from sea level up to around 1000 m, as long as the banks have fringes of natural vegetation. The eggs are usually laid in March-April, but laying may start as early as February in areas with a favourable climate. The enormous distribution of this duck is due not only to a great degree of tolerance to human disturbance, but also to the fact that it may lay more than one clutch if the first eggs are taken by predators.

The only other surface-feeding duck nesting regularly in freshwater wetland areas in Italy is garganey (*Anas querquedula*), which is a common sight during its migration flights from central Africa to its breeding grounds in Europe. It is quite well distributed in the Po Plain, but very localised in the centre-south, nesting mainly in lagoons and coastal wetlands. Pairs which nest inland frequent marshes, oxbow lakes, rice-paddies, springs and ponds of any size. In northern

Little bittern (*Ixobrychus minutus*)

Black-winged stilt (*Himantopus himantopus*)

and central Italy, teal (*Anas crecca*) may also sometimes nest in these habitats, but these are occasional events involving isolated pairs.

Whiskered tern (*Chlidonias hybridus*)

Wetland areas like the northern Italian rice-paddies are ideal for the needs of black-winged stilt (*Himantopus himantopus*). This wader, which has extended its breeding area and benefited from a significant population increase in recent years, also frequents lagoons, coastal ponds, salt-marshes, settling basins, overspill meadows, and in general any environment which guarantees large, permanent, very shallow feeding areas. Many examples of this species are to be found in the rice-paddies of the western Po Plain.

This area also hosts the most consistent nucleus of the Italian population of black tern (*Chlidonias niger*). However, this small marsh tern, because it builds a floating nest on rotting vegetation, must cope with farm mechanisation - most importantly, the draining of rice-paddies in late spring, an operation carried out in order to spread herbicides.

The rice-paddies around Vercelli have recently become the site of irregular nesting by a few pairs of white-winged tern (*Chlidonias leucopterus*). Whiskered tern (*Chlidonias hybridus*), although appearing quite regularly in the area, has never been known to breed. It is associated with the presence of extensive carpets of water-lilies, where it builds its floating nests. Italian breeding grounds are concentrated, at present, in a few wetlands in Emilia Romagna, in semi-natural freshwater environments like overspill meadows and fish-farm basins. All marsh terns are trans-Saharan migrants.

In recent years, the Piedmont rice-paddies have become home to breeding colonies of black-headed gull (*Larus ridibundus*), as well as the nesting site of some pairs of black-tailed godwit (*Limosa limosa*). This migrant nests on the edges of the paddies or neighbouring fields - like gulls - and is affected by ploughing and sowing operations, more than by water level, so that replacement clutches are frequent.

The belt of riparian vegetation which surrounds bodies of still water in natural conditions offers colonising opportunities to various species of warblers. Reed warbler (*Acrocephalus scirpaceus*) occupies very dense stretches of

Phragmites at the water's edge. Submerged reed-beds, which are mature, tall and with robust crowns for perching on, are preferred by great reed warbler (*Acrocephalus arundinaceus*). Where the banks are covered by tangled shrub vegetation alternating with stretches of sedges, Cetti's warbler (*Cettia cetti*) is particularly frequent. Marsh warbler (*Acrocephalus palustris*) is regularly found where the margins are slightly more open and support a tall dense cover of herbaceous plants, with scattered trees and shrubs to provide prominent singing-posts. More open marginal areas - water meadows, shallow marshes and peat-lands - are frequented by fan-tailed warbler (*Cisticola juncidis*). Reed warbler, great reed warbler and marsh warbler are all trans-Saharan migrants.

Very different from the warblers is the highly visible plumage and behaviour of kingfisher (*Alcedo atthis*), which builds its nest in tunnels burrowed in sandy, or crumbling clay banks. Kingfisher frequents both flowing and still waters. These need not be extensive, as long as they contain plenty of small fish, which the brightly plumaged bird captures in its beak by diving headlong from its perch above the water. A sedentary or short-range migrant, it is solitary except in the breeding season. The species is widely distributed in central-northern Italy, but is much rarer in the south and on the islands.

Penduline tit (*Remiz pendulinus*) builds its characteristic hanging nest on waterside trees. In northern Italy, the species breeds at altitudes of less than

Kingfisher (*Alcedo atthis*)

Marsh warbler (*Acrocephalus palustris*)

Reed bunting (*Emberiza schoeniclus*)

200 m a.s.l., this limit rising to over 400 m towards the south of the peninsula. It is absent from Sardinia. The flask-shaped nests are built only on branches overhanging water, and appear to be associated with specific trees: willows, poplars, common alders and tamarisks. Although migratory, penduline tit is also found in Italy in the cold season, with over-wintering contingents frequenting reed-beds. A reed-bed with scattered trees is also the preferred habitat of reed bunting (*Emberiza schoeniclus*): the Italian distribution area of this sedentary or partly migratory species is limited - with a few exceptions - to the Po Plain.

Interesting birds may be spotted even in the very tiniest of Italian wetland areas. In the coldest winters, greylag geese (*Anser anser*) and whooper swans (*Cygnus cygnus*) may appear, while in spring, noisy flocks of garganey (*Anas querquedula*) and teal (*Anas crecca*) are often accompanied by the elegant pintail (*Anas acuta*). In spring and autumn, marsh harrier (*Circus aeruginosus*) and hen-harrier (*Circus cyaneus*) can be observed gliding majestically over the waterside reed-beds, while the rare osprey (*Pandion haliaetus*), on migratory passage, scrutinises the surface of the water from an available perch above the more promising, well-stocked basins.

Ponds and marshlands are the elected resting places of many migrant species, some of which may remain throughout winter. In addition to the birds mentioned above, the majority of which nest in Italy and are therefore present during spring and summer, these environments offer further opportunities for spotting and watching rare birds during migration and the winter months. These wetlands, despite their small size, form a network of precious points of reference for birdlife in Italy.

Italian water vole (*Arvicola terrestris italicus*)

■ Mammals

Otter (*Lutra lutra*)

With rare exceptions, small water bodies are of relative importance to the economy of mammal populations. Despite the obvious need to drink, few species are truly associated with open waters, and in many cases require so much space that they are not often found in small wetland habitats. Despite this, otter (*Lutra lutra*) deserves a melancholy mention.
This large fish-eating mustelid was once widespread over most of Italy, but is today relegated to a few hydrographical systems in the south. In the majority of Italian pond and marshland systems, otter is no longer to be seen and it has not, as yet, been substituted by any other carnivore.
One of the most widespread mammals in wetlands is common rat (*Rattus norvegicus*), a medium-sized rodent originating from central-northern Asia, introduced accidentally by man, centuries ago. Rats travelled as stowaways in the baggage and saddlebags used by eastern merchants to carry their precious wares along the Silk Road and thence to Europe. Still today, rats behave as fellow guests of man, and mainly abound in urban and suburban neighbourhoods, colonising any rubbish-strewn environment which has some surface water.
Italian water vole (*Arvicola terrestris italicus*) lives on the banks of irrigation ditches and canals, feeding mainly on water-grasses, which it seeks out by swimming from one floating mass of vegetation to the other. The species prefers waters with slow-moving currents, but may also colonise still water - occasionally even small areas - as long as the environmental quality is reasonable. It usually digs systems of lairs along the banks, inside which it gives birth to and raises its young, but if it lives in marshy areas covered by extensive reed-beds, it may build curious nests above ground, which in some way recall beavers' lodges. The voles construct nests above the water surface by collecting and loosely weaving the stalks and leaves of common reeds, grasses and sedges. They are rather like small platforms within the tangle of the reed-bed, and are often so well anchored to the marsh reeds that, as the vegetation

grows and ripens, the nests may slowly rise a few centimetres above the water. In these environments, it is not unusual to discover Italian water vole together with two water shrews of the genus *Neomys*, tiny insectivores endowed with a venomous enzyme in their saliva that can paralyse small prey. These shrews weigh little more than 10 grams, are covered with a thick water-repellent coat, and have a characteristic way of dividing up their habitats. Water shrew (*Neomys fodiens*) prefers running water in the Alps and Apennines (south at least as far as Abruzzo) and is able to reach sources of food anchored to the bottom by swimming actively and diving down to half a metre. On the beds of mountain torrents and streams, it seeks various species of benthic invertebrates, but is also capable of paralysing small fish and amphibians with its venomous bite. The species also lives in marshes and mountain peat-bogs, but below 200 metres a.s.l. it is invariably supplanted by the smaller Miller's water shrew (*Neomys anomalus*), which is typical of ponds, pools and low-lying wetlands.

Miller's water shrew is a less active swimmer than water shrew and limits itself to capturing invertebrates living on the banks, in many cases moving about in areas covered with a fine film of water. Also unlike *N. fodiens*, Miller's water shrew is gregarious, tolerating the presence of moderate population densities of other animals. With increasing altitude, the species becomes noticeably rarer, but it may be found together with water shrew up to considerable altitudes, in both the Alps and Apennines. Its range extends down to the

Water shrew (*Neomys fodiens*) close to a *Viviparus contectus* shells

extreme south of Italy, but the specimens which live in the Calabrian mountains are enormous and particularly dichromatic, recalling many typical characteristics of water shrew. The large size and peculiar colouring of these animals has been interpreted in the light of the theory of *character displacement*, i.e., if two similar species occur together, their phenotype and ecology tend to become differentiated, whereas where they are separated geographically they are more similar. The Miller's shrews of the Calabrian chain may therefore be the product of an evolution independent of competition with water shrew.

An undesirable guest in small water bodies is coypu (*Myocastor coypus*) which, in recent decades, has become established in increasingly extensive areas. This large South American rodent, originally introduced into Europe to be bred for its fur - an initiative which met with some commercial success - unfortunately frequently escaped. Today the species is present practically throughout Italy, where it has also proven to be resistant to quite severe winters, populating small basins in the Central Alps. Coypu causes great damage because it digs deep burrows and tunnels which undermine the stability of the banks of drainage channels and waterways, and also for biological reasons. There are many reports of the damage caused by coypu to marsh and riparian plant and animal communities, and in several areas of Italy it is considered as vermin and systematic attempts are made at exterminating it.

Coypu (*Myocaster coypus*) foraging

Conservation and management

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■ Small water bodies: environments at risk of disappearing

Pond in limestone area (Friuli Venezia Giulia)

The smaller an environment, the more vulnerable it is to alteration or even extinction.
This simple rule effectively describes the risk of disappearance of small water bodies in Italy, a risk that should be considered very high throughout the country. The limited extent of wetlands in Italy means that small standing water ponds are a relatively rare resource, concentrated in the few naturally impermeable impluvia, or in artificial reservoirs created by man.
There are numerous environmental situations in which the presence of minuscule bodies of water is essential for the conservation of aquatic organisms. This is particularly evident in all well-drained mountainous regions, but is perhaps most typical in limestone areas, where there is no surface water. In these areas, natural surface water is limited almost exclusively to small rock-pools and transient rainwater puddles. These tiny natural bodies of rainwater are often accompanied by artificial ponds due to the centuries-old presence of man. Used in the past as watering-places for livestock, for washing clothes, or even for fish rearing, their presence is now often associated with wildlife hunting, modest farming, or occasional flooding - for instance, of quarries. As their survival requires maintenance by humans, the decline of many traditional occupations has led to an inexorable burial process and high rate of extinction for many ponds and pools, sometimes accelerated by the accidental or voluntary introduction of plant species, such as common cat-tail (*Typha latifolia*), which increase the speed of silting-up.
Nowadays, upkeep is generally only undertaken for game watering-holes and a few rare habitats inside protected areas, although some village ponds have

Wetlands covered in vegetation (Tuscany)

been restored for their historical value. Consequently, the majority of these environments are fated to meet with a rapid and definitive demise. Unfortunately, it is difficult to quantify exactly their rate of extinction in Italy, as there have been no nationwide censuses, partly due to the absence of any effective laws safeguarding small water bodies, which are neglected precisely because they are “small” - in size, not in importance.

To gain an idea of the scope of this phenomenon, a study carried out in the United Kingdom in 1986 demonstrated that, at one time, there must have been an enormous number of these tiny environments: it was calculated that in 1920 there were probably more than 800,000 ponds in England and Wales (partly natural, partly man-made, but always in very natural conditions), with an average density of 5.4 km^{-2} (this number is most certainly underestimated, because many of the smallest pools were probably overlooked in the analysis). No similar data are available for Italy, but in any case the density would have been lower, partly because of the different conditions obtaining in this country - lower rainfall and, in particular, a very different ratio between mountains and plains.

It may in any case be presumed that there were doubtless hundreds of thousands of ponds at the beginning of the last century. Almost nothing is known about the patrimony of small water bodies in Italy prior to the large-

Reservoir in the Trieste Karst (Friuli Venezia Giulia)

scale land reclamations and rapid spread of urbanisation and industrialisation throughout the 20th century, but our knowledge of the number of these environments which still exist is again almost nil.

A recent study of ponds and pools in the Trieste karst (an area covering approximately 200 km^2, with an average density of 0.73 bodies of water per km^2 in 1979) has demonstrated that about 70% of them disappeared during the later years of the last century (1979-1998). The rate of extinction was higher for pools - 78% of tiny areas between 2 and 20 m^2 and lower, at 66%, for ponds larger than 20 m^2. At this rate, it would seem that the demise of small water bodies in this territory is inevitable. However, the Trieste karst, being limestone, is not representative of the whole of Italy, and is also an area relatively untouched by man. The plains areas, where most of the small water bodies and marshes are concentrated, have certainly suffered higher degradation, and thus have a much faster rate of extinction, which is presumably lower in mountain regions. A figure close to 70% in thirty years would be a realistic national average, but is certainly incompatible with the continued conservation of these habitats.

Human interference is without doubt the main cause of the disappearance of small water bodies - urban sprawl, extending networks of roads, and intensive agriculture being the major threats. However, the other side of the coin is that

Karstic pool in the Monte Prât area (Carnian Prealps, Friuli Venezia Giulia)

many small water bodies have been created by man: village ponds and watering-places were once a precious commodity in rural areas. The decline in rural occupations and lack of maintenance have rapidly led to the disappearance of these environments by an inexorable and inevitable process of burial. In any case, man still continues to create small water bodies, either by chance (flooded quarries) or intentionally (small lakes for fishing, watering holes for game, reservoirs for fire-fighting services). These recently formed environments, which are still at the stage of achieving a natural state, may partly counter the rapid rate of extinction of others, but unfortunately the outcome is not generally of comparable quality to that lost. Furthermore, the management of these new areas, often stocked for fishing, is the prime cause of rapid degradation of their natural value.

It should also be mentioned that, in Italy, the environments with the highest rate of extinction are certainly transient waters, due to their often modest size. As mentioned in the previous chapters, these are the environments which host the most valuable fauna, formed of species exclusive to environments subject to periods of drying out. Sadly, the bitter conclusion is a strict correlation between the rate of extinction and the value of these environments and their populations: a trend which, if not inverted in the very near future, could lead to one of the worst examples of “mass extinction” in the history of Italy.

Pond in the Po Delta (Emilia Romagna)

■ Plants: rare and threatened species

Bogbean (*Menyanthes trifoliata*) is an increasingly rare species

Aquatic plant species generally have wide geographical distribution, many being truly cosmopolitan, i.e., plants geographically extending over most countries in the world.

It follows that these habitats are almost without endemic species, although there are some interesting exceptions. Nonetheless, because of the disappearance, contraction or excessive modification of wetland and water ecosystems, all these species are becoming increasingly rare, or even risk extinction. This is why aquatic species are well featured in the Italian and regional Red Lists.

Even some aquatic ferns are now at risk of extinction, mainly due to pollution of their habitats. Plants in danger include the quillwort *Isoetes velata*, confined to a few sites along the Tyrrhenean coast (Maremma in Tuscany and the Pontine Marshes), the edges of marshlands and seasonal pools in Sicily and Sardinia. Waterclover (*Marsilea quadrifolia*), which grows on a few sites in northern Italy and in Campania, and its related *Marsilea strigosa*, with Mediterranean distribution (areas near Foggia and in Lucania, some parts of Sardinia) are equally vulnerable.

Another member of the same family, which is now extremely difficult to find, is pillwort (*Pilularia globulifera*), whose few sites in still waters and rice-paddies in Italy are among the most southern of its sub-Atlantic distribution. Safeguarding of the related *Pilularia minuta*, with Mediterranean distribution, only found now in a few pools in Sicily and Sardinia, can only be achieved if the few wetland biotopes where it grows are preserved.

Strictly aquatic species include the rare blunt-leaved pondweed (*Potamogeton obtusifolius*), which is of enormous biogeographical interest, definitely growing only in one pond near Bolzano. Water soldier (*Stratiotes aloides*) is also endangered: at one time quite widespread in the Po Plain, it is now recorded in just one site near Varese.

Among aquatic buttercups, Rion’s buttercup (*Ranunculus rionii*) is of particular

Completely natural pond

biogeographical interest. Italy and Switzerland represent the western limit of its Asiatic and Eastern European distribution area, and it is recorded only in one site in Trentino-Alto Adige (South Tyrol). A report dating back to 1884 for Lake Garda has never been confirmed.

A member of the water plantain family, arrowhead (*Sagittaria sagittifolia*) is of special importance. This species, once quite diffuse, has suffered drastic reductions following alterations to its habitat; it is easily identified thanks to its arrow-shaped leaves and yellow-and-white inflorescences, both of which make it of ornamental value.

Another hydrophyte, Northern bur-reed (*Sparganium hyperboreum*), is worthy of mention: this Ice Age relict, typical of oligotrophic ponds up to high altitudes, in Italy only grows in one small pool near Bolzano.

The species of transient pools include the extremely rare buttercup *Ranunculus batrachioides*, a spring-flowering species growing in places inundated only in winter, for which only two European sites are known, one in Sardinia and one in Spain.

On the muddy banks of ponds and marshes on acid soil, as far up as 1000 m a.s.l., it is becoming increasingly difficult to find many-stemmed spike-rush (*Eleocharis multicaulis*), which today grows only in a few locations in Piedmont, Liguria, Tuscany, Emilia Romagna and Sardinia.

The rare mudwort (*Limosella aquatica*) grows in similar environments, but has now almost completely disappeared, following drainage and hydraulic works in the areas where it lives. Apart from old unconfirmed reports for the Po Plain, this species has recently been found on the banks of Lake Cecita in the Sila mountains in Calabria. Among waterside species with Mediterranean distribution is the rather rare sedge *Carex intricata*, found on the San Fratello Mountains (Messina) in ponds and pools on siliceous soil above 700 m a.s.l.. Fen ragwort (*Senecio paludosus*), indicated as under threat, appears to be more widespread in the few mesotrophic marshy areas of the north-eastern Po Plain.

■ Fish: the threat of alien species

The introduction of alien species is a major threat to the conservation of Italian fish fauna. Releases by man have progressively changed the overall picture in the last few decades, and it is now possible to find many more species in small water bodies than a few years ago, with an alarmingly increasing trend. With the exception of carp, whose arrival in Italian waters dates back to Roman times, the history of introductions of alien fish species into Italy began in the 19th century.

Largemouth bass (*Micropterus salmoides*) arrived from North America in 1898, and pumpkinseed (*Lepomis gibbosus*) in 1900. Black bullhead (*Ameiurus melas*) and brown bullhead (*A. nebulosus*), which first appeared in the early years of the twentieth century, came from the same source. In the 1920s, gambusia or mosquito-fish (*Gambusia holbrooki*), which feeds on mosquito larvae, was deliberately released into the waters of the Pontine Marshes, near Rome, with the aim of contributing towards eradicating malaria.

In the meantime, crucian carp (*Carassius carassius*) and goldfish (*C. auratus*) began to spread. The former is indigenous to central-northern Asia and eastern Europe, the latter to the Far East. Bred for ornamental purposes in aquaria and garden ponds, these species greatly increased in numbers in the second half of

Pumpkinseed (*Lepomis gibbosus*)

the last century. In the meantime, artificial stocking for fishing became increasingly widespread, especially in the Po Plain waters: in recent decades grass carp (*Ctenopharyngodon idella*) have been imported from Asia, bream (*Abramis brama*) from central-northern Europe, and roach (*Rutilus rutilus*) from eastern Europe. Mixed with released fry of the above-mentioned species, small fish such as bitterling (*Rhodeus sericeus*), also indigenous to eastern Europe, and the invasive stone moroko (*Pseudorasbora parva*) were accidentally introduced. The latter, originating from the Far East, was released into the Danube around 1960, whence it spread like wildfire in European waters, and has recently made its appearance in various locations in the Po Plain. The enormous sheat-fish (*Silurus glanis*), a Danubian predator which appeared in Italy in the 1950s, is now found throughout the Po basin. Reports are regularly made of single specimens, the result of illegal releases in ponds, flooded quarries and overspill basins. Another silurid introduced into the waters of the Veneto Region is North African catfish (*Clarias gariepinus*).

It should be pointed out that introduced species need not be exotic to create problems for the native fish fauna: it is sufficient for it to be a stranger to the system into which it is released, even only from an adjoining hydrographical basin, separated by a mountain ridge or an even lower barrier. Transfers within the country ("transfaunations") can also have major consequences.

Brown bullhead (*Ameiurus nebulosus*)

■ Amphibians: reasons for decline

Mating between different toad species (*Bufo bufo* and *Bufo viridis*) produces rare sterile hybrids

Italian herpetological fauna is not usually subjected to careful monitoring, and there are no censuses to produce significant estimates of population densities. With few exceptions, amphibians and reptiles are studied mainly from the biogeographical point of view, and atlases are produced, presenting the distribution of reports in the various mapping grids. The management of such fauna in Italy is therefore more or less consigned either to chance or to preservation of the habitat. Evaluation of the importance of conserving the various species and their overall natural value is, paradoxically, simpler and more objective, due to the existence of valid standard reference bases, both within the European Union and each member country.

These reference bases are represented, first of all, by several International Conventions, which have been ratified by most EU countries with appropriate national laws. These Conventions include lists of species to be assigned different levels of protection, and therefore represent a common basis for calibrating conservation measures and rendering them homogeneous and applicable in all EU states. The most important Conventions are those ratified by legal provisions armed with systems of sanctions - because this means that illegal acts are subject to prosecution - but it is also useful to bear in mind that international conservation lists, national reference checklists and Red Books do exist, and that they allow added biological value to be taken into account for many species not adequately covered by the International Conventions. The most important of these are:

- Berne Convention. Promulgated on 19.11.1979, it was ratified in Italy with law no. 503 of 5.8.1981. However, a wide margin of discretion was left to each region, many of which have never implemented legislation on the matter.
- Washington Convention (CITES: Convention on International Trade of Endangered Species). Promulgated on 3.3.1973, it was ratified in Italy with law no. 874 of 19.12.1975, although it had been respected in this country since

Destruction of small water bodies means the disappearance of important breeding grounds for amphibians

1972, followed by law no. 150 of 7.2.1992. It is an instrument specifically intended to limit and control trade in endangered animal and plant species.

- EU 92/43/EEC, known as the "Habitat Directive". Promulgated on 21.5.1992, with successive amendments, its application in Italy is through DPR no. 357 of 18.9.1997, amended and adapted to European regulations by DPR no. 120 of 12.3.2003.

Various Italian regional laws refer to and/or incorporate these International Conventions and Directives, aiming at the regulation and protection of herpetological fauna, for example, in South Tyrol, Liguria and Latium. But the principal legal instrument available to settle questions concerning the conservation of Italian amphibians and reptiles is still DPR 357/1997, amended by DPR 120/2003, which incorporates all the instances of protection included in the EU Habitat Directive. Although lacking detailed systems of sanctions, this legal instrument is of enormous value in matters of conservation. Every transgression (not only the collection, killing, capture or sale of specimens, but also damage to breeding grounds) is punishable by sanctions similar to those provided for in other Italian laws for damage to specimens or populations of homoiothermal species or the destruction of natural habitats.

The need to protect amphibians is not exaggerated, although the causes for the decline of these animals are still far from clear. In the majority of cases, the hazard comes from the physical alteration or destruction of natural habitats, environmental pollution (acid rain, increase in UV-B radiation), the introduction of aquatic predators into breeding grounds, viral, fungal and bacteriological epidemics or parasites, and the capture of animals by amateur enthusiasts or even as food.

The systematic alteration by man of terrestrial habitats stands accused of reduction in biodiversity worldwide, and therefore also of the decline in amphibians. Industrial development, intensive farming, the exponential increase in human populations and the scattered distribution of areas of urban and suburban housing have markedly reduced the size of many amphibian populations and eliminated numerous breeding grounds. Censuses of breeding habitats in other countries appear to indicate the increasingly fast disappearance of small and medium-sized bodies of water, which are those most suitable for amphibian reproduction. The fragmenting of populations owing to the scattering of buildings and intricate road infrastructures is particularly hazardous, as it lowers the genetic variability and overall state of health of many species, now isolated in tiny archipelagos of small populations at high risk of local extinction.

Splitting up breeding grounds therefore has an important effect on the survival of amphibian populations living in surface-water bodies, due both to isolation, which alone increases the level of consanguinity within populations, and to various reasons for mortality.

To give just one example, when a road made by man crosses the pre- and post-breeding migration routes of a population of amphibians, the adult mortality rate can be extremely high. The only way to reduce amphibian road deaths is to construct roadway underpasses, with fixed barriers on both sides, in order to guide the breeding animals in their direction. Suitable annual maintenance to avoid these underpasses becoming obstructed (by accumulations of vegetation or debris) can effectively guarantee their continued success.

Green frogs (*Rana* kl. *esculenta*)

Pollution further aggravates the situation. The most controversial phenomena linked to pollution on a global scale are acid rain, reduction of the atmospheric ozone layer, and the greenhouse effect. Since as early as the 1920s, it has been known that acid rain, largely due to the consumption of fossil fuels for domestic and industrial uses, has drastic effects on the environment. The progressive acidification of amphibian breeding grounds can place entire populations at risk, or cause alterations in their growth. Fluctuations of pH of between 3.8 and 7.3, recorded in the late 1980s in rice-paddies neighbouring the Ticino Nature Reserve (Piedmont-Lombardy) seem to have had serious repercussions on the breeding success of *Triturus carnifex*, *Bufo viridis* and *Pelobates fuscus insubricus*. Increased exposure to UV-B radiation due to the thinning of the ozone layer has more than once been blamed for the high incidence of malformations in newly metamorphosed specimens of North American anurans. More recent studies appear to have denied this causal link, blaming it rather on parasites of various types.

As regards the greenhouse effect, the results of long-term studies on English populations of *Triturus cristatus* and *Bufo bufo* indicate recent modifications to the annual reproductive phenology, perhaps caused by global warming.

Instead, agriculture is definitely to blame for the marked impoverishment of amphibian communities. Many agro-chemicals are directly implicated in the

Common toad (*Bufo bufo*) at the entrance to its natural den

Female Italian crested newt (*Triturus carnifex*)

fall in the numbers of these animals, especially through synergy and bio-accumulation, aided by the very long persistence of these products in the environment. All the organochloride pesticides (DDT, heptachlor, lindane, DDE, dieldrin, aldrin, etc.) are extremely stable in nature and may persist in the food chain for years on end. These products have been officially banned in the West, but are still used in many undeveloped or developing countries. Many other insecticides, vermicides and anticryptogamics widely used in agriculture are closely implicated in the reduction of amphibian populations all over the world, and this fact becomes even more evident when we consider that many of the substances necessary for their manufacture and nebulisation act directly on the animals' endocrine system, altering for instance, oogenesis (the production of eggs) and mechanisms of sexual differentiation. Numerous investigations have also demonstrated the danger of the majority of herbicides to amphibians both as larvae and adults, since their high toxicity has even led to some products being banned on a local scale. Some of the most widely-used fertilisers in agriculture in the latter half of the 20th century also certainly caused reductions in the numbers of amphibians. For example, nitrates in concentrations above 40 mg/litre reduce the hatching rate of eggs and survival of larval stages. Although it is always very difficult to establish to what extent bacterial, viral and fungal infections are enhanced by the vast and heterogeneous numbers of pollutants, it is by now certain that anurans suffer frequent epidemics (of *Herpes virus*, *Pox virus*, chytridiosis, mucormycosis and various parasite worm infestations), which are a local threat to survival.

Amphibians have many predators, the most dangerous of which are certainly aquatic, and fish species introduced by man, aliens or otherwise, are alone capable of annulling the breeding success of entire populations of amphibians. Numerous studies have demonstrated that small fish preying on the eggs of several urodeles can greatly limit their distribution, and may reduce the diversity of amphibian communities over vast areas.

Lastly, the collecting of specimens by amateurs or as food has often been indicated as an important cause of amphibians becoming rare, but it should more probably be considered secondary, or one which, on occasion, may badly affect single local populations.

■ Management and restoration of pools and small ponds: some examples

A great deal has been written about the management of wetlands, particularly marshlands. This often deals with bird conservation in protected areas, and ample treatment of these aspects is to be found in the volume in this series devoted to coastal lakes and brackish-water pools. Instead, very little has been done in Italy on the management of small ponds, pools and puddles, i.e., all those “small water bodies” for which many management studies exist, for example, in the United States (projects for “vernal pools”), and in Great Britain (where ponds are defined as “oases in the landscape”).

One interesting case of knowledge acquired for management plans is that of the Trieste Karst, where the Trieste City Museum of Natural History personnel began a census of ponds and reservoirs in 1969. In order to reduce, at least partially, the dramatic rate of extinction of these environments, the museum staff personally carried out maintenance work, and since April 2001 have co-ordinated a working group entitled “Karst Pond Wardens”. Its cohesion is guaranteed by series of conferences and training courses, and volunteers may also exchange information via the mailing list. Periodically the group organises small maintenance operations to keep water bodies open, both by removing rubbish and invading vegetation, and also by restoring some sites, or reducing

Example of pond degradation

the presence of alien species like goldfish (*Carassius auratus*), abandoned in the karstic ponds by visitors and day-trippers. American terrapins (*Trachemys scripta*) are also occasionally released in these environments, but tend to be drastically reduced by the rigours of winter on the Trieste plateau. As the alien fish are predators of tadpoles and amphibian spawn, they may also reduce the breeding success of species of high biogeographical value, such as the European tree frog and lake frog (*Rana ridibunda*).

It is a fact that predation of invertebrate communities in very small environments leads to striking ecological imbalances. Studies on the population diversity of microcrustaceans in some karstic ponds after removal of fish have demonstrated increases of between 50% and 800% in the number of species. Fortunately, the restoration of small ponds and pools has often been crowned with success. When undertaking this type of work, attention must be paid to:

- rendering the bottom impervious (e.g., using pressed clay, thus recuperating traditional rural techniques; concrete or PVC sheets may be used in certain conditions);
- the time of year in which to carry out restoration work - preferably in winter, when biodiversity is low and there are no amphibians breeding;
- where environments which are not yet completely buried are being restored, local specimens of active or dormant invertebrates, plants and amphibians should be stored in aquaria and then reintroduced, to accelerate re-colonisation.

■ Management of small water bodies: which law?

There are no specific conservation regulations, either Italian or European, for the protection of “small water bodies”. Although many overflow areas and extensive marshlands are included in protected areas, particularly for their botanical value, or because of the presence of species included in the EU Habitat Directive or Bird Directive, most small water bodies do not enjoy any form of protection. Emphasis should have been given to marshlands and other “minor” water bodies when the Water Framework Directive (2000/60/EU of 22.12.2000) was issued (but, at the time this volume went to press, it had not yet been adopted by Italy) and in the Guidelines for Wetlands, defined during 2003 by a group of experts of the member countries of the European Union. Unfortunately, EU Directive 2000/60 does not define either wetlands or small water bodies among the basic types forming the hydrographical network, despite the fact that the aim of the Directive (Art. 1a) was to set up a framework for the protection of *all* inland and coastal waters. Furthermore, the Directive does not propose size limits when classifying small water bodies. In addition, “minor” water bodies are

Invasive plants

Giuseppe Oriolo · Michela Tomasella

Man is a dominant ecological factor, acting on and altering the environment and thus the conditions necessary for the various ecosystems in it to develop. Man has also acted on differing spatial scales, becoming a conscious or unwitting agent in conveying animal and plant species from one continent to another. Many of these species are unable to survive, others manage to settle but, because of competition from native species, remain sporadic. Only a few spread and become aggressive, owing to efficient reproductive mechanisms or a lack of predators and competitors. These species are termed *adventitious*, and only rarely colonise natural or semi-natural environments. However, when they do, they become dangerous, as they may jeopardise the survival of spontaneous species with similar ecological niches.

In Italy, small still-water wetlands on the plains are the habitats most exposed to the disturbance that facilitates the arrival and stabilisation of adventitious plant species. Some of these are ornithocorous, i.e., readily carried by wading birds; others were accidentally introduced, having previously been cultivated in aquaria. Among non-rooting hydrophytes, the most invasive are water fern (*Azolla filiculoides*), indigenous to tropical environments, and least duckweed (*Lemna minuta*) which is spreading rapidly in the Po Plain, although it does not appear to be particularly competitive against native species. Water hyacinth (*Eichornia crassipes*) is rarer: this tropical species has been grown in the West as an ornamental, but it is less invasive in Italy than in central Europe.

Canadian waterweed (*Elodea canadensis*, see photo) is a rooting hydrophyte which has invaded practically all aquatic habitats in northern Italy, excluding Alpine tarns and springs, whereas it is rarer in the central and southern parts of the country. Indigenous to North America, it escaped from culture as an ornamental plant in botanical gardens towards the end of the 19th century, and is now common throughout Europe. Only female plants are reported, which means that it can only propagate by vegetative reproduction. Similar species, such as *Elodea densa*, *Elodea nuttallii* and *Lagarosiphon major*, are currently in expansion, but appear to be much less aggressive. Among not strictly aquatic species, but ones suited to wet muddy substrates, beggar tick (*Bidens frondosa*) from North America is perhaps the most aggressive and, in more disturbed areas, replaces the native trifid bur marigold (*B. tripartite*).

In Italy, the wetlands most badly affected by the invasion of alien species are rice-paddies, mostly concentrated in Piedmont. The list includes species confined to the rice-growing area, including bamboo plant (*Blyxa japonica*), grassy naiad (*Najas graminea*), slender water-nymph (*Najas gracillima*) and duck lettuce (*Ottelia alismoides*).

Pond at Pianella Zingaro (Sicily)

not included among the significant water bodies for which specific objectives are defined. The very definition of *wetlands* in the Guidelines (heterogeneous ecosystems, but with distinctive characteristics, dependent on shallow, < 2 m, constant, or recurrent inflows of fresh, brackish or salt waters) excludes the majority of small water bodies which are the subject of this volume. No importance is given to ponds, pools and marshes in Italian decree 152/1999 and successive amendments regarding the safeguarding of waters and their protection from pollution. In fact, “minor” water bodies are, obviously, excluded from the so-called “significant water bodies”, which for still waters include lakes “with a water surface area of 0.5 km^2 or more” when full. By law - by which we mean Italian law - most small water bodies are thus not “significant”, nor do they form part of wetlands as interpreted by current regulations operating on a European scale. While awaiting a hoped-for legislative “inversion of trend” and the adoption of specific measures suitable for taking censuses and monitoring these sometimes tiny areas, we note the urgent need for their conservation and suggest having recourse to other European Directives.

The Habitat Directive (92/43/EEC of 21.05.1992), as last amended by Council Directive 97/62/EC of 08.11.1997 and the Access Treaty of Austria, Finland and Sweden - adapted from decision 95/1/EC, Euratom, CECA, of the Council - published on 29.08.1994 and 01.01.1995, still remains the best instrument for the conservation of these environments and their fauna, integrated for marshlands by the Bird Directive (79/62/EEC of 25.04.1979). Annex IV, listing plant and amphibian species, is probably the most suitable instrument for safeguarding pools and small ponds (for example, as breeding grounds) from Italian DPR no. 120 of 12.03.2003, which contains amendments and integrations to DPR no. 357 of 08.09.1997. The habitats listed in Annex 1 include “Standing Waters” (code 31), a category which has “Mediterranean Temporary Ponds” (code 3170) as the only Italian priority habitat. The Italian translation of Annex 1 of the Habitat Directive unfortunately confuses the term “*torbiera* (peat bog)” with that of “*palude* (marsh)”, placing them in a single category (code 7). This does not cover the water bodies discussed in this volume, but only those in two other volumes of the Italian Habitats series: “Springs and spring watercourses” and “Mountain peat bogs”.

Suggestions for teaching

MARGHERITA SOLARI

■ Study of amphibians

Spawn of common toad

● Aims: to acquire the concepts of adaptation and evolution in relation to the environment; to develop capacities for observation, analysis and detailed comparison of the characteristics distinguishing amphibians and to understand metamorphosis by observing development.

● Level: schoolchildren of 11-16 years of age.

● Equipment: relevant literature, manuals for identifying amphibians; equipment for collecting and rearing tadpoles (nets and aquaria).

PRELIMINARY STAGE

1. Introduce work in class: discuss the characteristics of ponds and marshes with pupils, verifying what they already know, especially about the fauna of “small water bodies”.

2. Describe the differing lifestyles of aquatic, amphibian and hydrophilous fauna, using appropriate examples (both vertebrates and invertebrates: fish, frogs, snakes, birds, mammals, molluscs, insects, etc.). Define the terms “amphibian” and “amphibian life”, explaining that these animals are vertebrates.

3. Describe the characteristics of amphibians, giving details of their growth stages, particularly common toad (using illustrations), from laying eggs through to metamorphosis:

- deposition of eggs (spawn) in the water, in gelatinous strands
- development of embryoes in relation to temperature
- larvae (tadpoles): long shape, black colour, with tail, without legs, adhesive organs on the mouth for adhering to the substrate during early life stages

Pond in the Tagliamento morainic amphitheatre (Friuli Venezia Giulia)

- start of active life of swimming larvae, with a diet of plant matter scraped off with horny beak
- growth of back and front legs
- development of lungs, allowing the tadpole to breathe air
- metamorphosis, with reorganisation of the body and mechanisms of apoptosis (cell death), leading to re-absorption of the tail and shortening of the intestine.

Tadpoles of common toad (*Bufo bufo*)

CLASSWORK

4. Divide the class into groups for a literature search on an assigned family of amphibians, either tailed (newts, salamanders) or tailless (frogs, toads); study their habitat, diet, physical adaptations for jumping or swimming, winter habits, etc.
5. Analyse the primitive characteristics of amphibians and the salient characteristics which allowed them to colonise dry land, as the first vertebrates, between the Devonian and Carboniferous periods: strengthening of the spine, development of lungs, pectoral and pelvic girdle, organs of hearing, smell and sight. If possible, visit a palaeontology museum.
6. Summarise and describe the group work to the whole class, compare results; identify the most common species in local wetlands.

FIELD TRIP

7. Organise a field trip to a wetland during springtime. Collect some toad spawn - this is easily identifiable as it is laid in “strands”. Remember that it is forbidden by law to collect or rear the tadpoles of many species: the study should therefore be carried out using tadpoles of species which are not protected, i.e., common toad (*Bufo bufo*).

FURTHER CLASSWORK

8. Rear the spawn in a suitable environment (small plastic aquarium-terrarium for metamorphosis); observe stages of development and metamorphosis; data should be collected by students.
9. Take the newly-metamorphosed animals back to their original habitat and release them.
10. Summarise concepts and draw conclusions.

■ Pond vegetation

- Aims: to develop capacities for observation, analysis and comparison of the elements which characterise a plant species; to acquire basic concepts of phyto-ecology and phyto-sociology.
- Level: schoolchildren of 11-13 years of age; 8-10 years of age with simplifications.
- Equipment: suitable clothing for the field trip, camera, stationery for creating illustrated panels, relevant literature.
- Collaboration: a botanist or nature guide for the field trip.

PRELIMINARY STAGE

1. Identify a suitable pond and organise a field trip (in spring or autumn). Identify the most significant plant species.
2. Introduce the work in class: describe the abiotic factors of the pond and the most important animal and plant species.

CLASSWORK

3. Describe the concept of frequency distribution of vegetation with depth and in concentric bands around the basin. Explain the concept of plant association (the importance of analysing the group of species present, and not just the single components).

White water-lily (*Nymphaea alba*)

4. Create a panel with a diagram of pond plants, illustrating the concentric bands of plant associations: sedges, rushes and bulrushes towards the outer edge, where the soil is impregnated with water; common reeds and bulrushes where the water is deeper; submerged plants of the true water zone, with floating leaves and stems anchored to the bottom; in the centre of the pond, where the water is deepest, pondweed, water-lilies, water chestnut, bladderwort, waterweed, and various algae. Study the literature, especially descriptions of the various species. Show drawings of each plant, for the pupils to copy (in order to memorise their characteristics).
5. Describe the type of pond to be visited, with analysis of a map on a suitable scale (e.g., 1:5000). Study pictures of the surrounding environment.

FIELD TRIP

6. Field trip to the chosen environment with a naturalist guide. Divide the class into two or three groups; identify species with the expert's help.
7. Photograph the environment and vegetation at the most significant points.

CONCLUSION

8. Conclude classwork: create another panel illustrating the pond visited, with photographs and related comments.
9. Final discussion on the richness and complexity of the study environment.

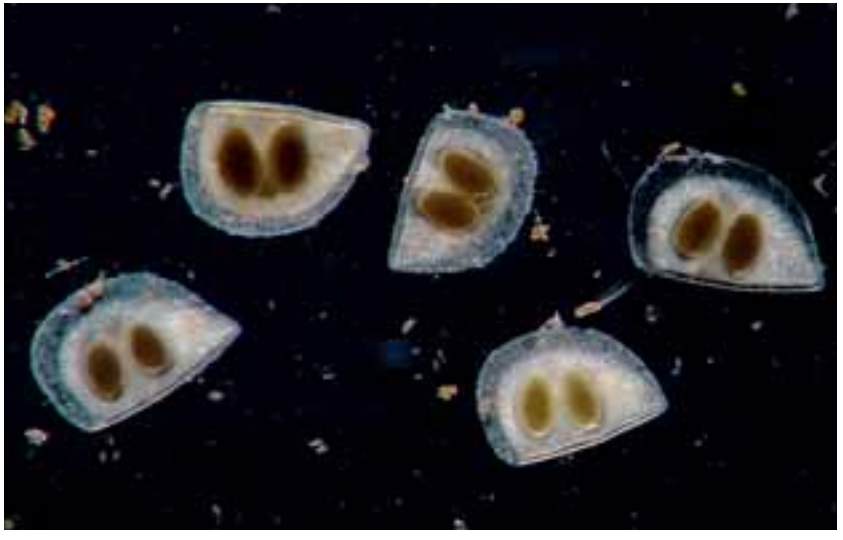
Pond with *Hottonia palustris*

■ Discovery of life in sediments

- Aims: to understand the phenomenon of dormancy by examining resistant forms, and learn about the ways and times taken for the various taxa to colonise temporary basins.
- Level: high school students.
- Collaboration: experts on the identification of freshwater taxa.
- Equipment: stereomicroscope, optical microscope, containers, taxonomic guides, laboratory glassware (Petri dishes, pipettes, glass slides), instruments for measuring basic physico-chemical parameters (temperature, conductivity, pH, dissolved oxygen).

PRELIMINARY STAGE

1. Clarify the concept of dormancy and the function of the quiescent forms produced by some taxa in an aquatic environment.
2. Identify an area of wetland where there are temporary pools.
3. Collect literature on the area, including the hydrological regime of reservoirs, and taxa present.
4. Choose, on the basis of acquired data, a temporary biotope which dries out for a minimum of 3-4 months per year, where the aquatic fauna is known, and possibly, although it is not essential, its population cycles.



Protective pouches for eggs (*Daphnia* ephippia)

Artificial pond in a botanical garden

FIELD TRIP

5. Organise a field trip during the summer, when the chosen reservoir is completely dry.
6. Collect a sample of dry sediment at a depth of 5 cm, if possible from the centre of the reservoir.

Field trip to a wetland area

LABORATORY WORK

7. Do preliminary screening under the microscope of a sub-sample of sediment and extract all quiescent forms present (resting eggs, cysts, larvae, pupae, cocoons, adults). With the aid of experts (or using simplified taxonomic keys), attribute each quiescent form to the taxon producing it, and compare the accuracy of these identifications with the data available in the literature on that environment.
8. Add water to the remaining sediment and, at regular intervals (e.g., every two days), measure its physico-chemical parameters (temperature, conductivity, pH, dissolved oxygen).
9. Take a sample of water at the same intervals to verify, with the naked eye and under the microscope, the presence of living organisms deriving from the progressive hatching out of quiescent forms.

CONCLUSION

10. Process collected data using graphs of the physico-chemical parameters and diagrams of the appearance of the various taxa over time, identifying any relationships.
11. Record the animal groups which, although found as quiescent forms in the screening of the sediment, have produced no vital populations after a suitable time-span in the laboratory, after water was added, and seek the causes with the aid of the literature.
12. Write a report in which the students describe all experimental phases, then interpret results, comparing laboratory observations with natural ones described in the literature; explain the concept of dormancy again, in the light of what has emerged.

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Glossary

> Allochthonous: an extraneous organism, originating from a place different from the one in which it is found; the terms “alien” and “exotic” are often used as synonyms.
> Amphigonic: sexual reproduction.
> Anoxia: lack of oxygen.
> Anthropic: associated with man and his activities.
> Autochthonous: adjective referring to living organisms which are natural members of the flora and fauna of a certain area; “indigenous” and “local” are often used as synonyms.
> Bacteriophagous: an organism that feeds on bacteria.
> Benthic: an organism associated with and living near the substrate.
> Coenosis: community of vegetal species and animals living in an environment.
> Cyanobacteria: bacteria containing chlorophyll *a* - like algae, mosses and higher plants - and the additional pigments provided by the blue phycobilin (phycocyanin) and red phycoerythrin proteins.
> Climax: the final evolutionary stage of an ecosystem in certain environmental conditions.
> Diploid: comprising twice the number of chromosomes present in typical gametes, as in somatic cells of metazoans and vascular plants.
> Dystrophic: an environment rich in humus and containing peat.
> Endemic: adjective used to describe species distributed over a relatively small geographic area, e.g., an island, a chain of mountains, or a more or less ample part of the territory; the corresponding phenomenon (geographic exclusivity of a species) is called endemism.
> Eutrophic: a nutrient-rich environment.
> Fossorial: organism adapted for digging the soil, where it usually lives.
> Hydrogamy: form of reproduction aided by water for transporting pollen.
> Homoeothermic: with constant temperature.
> Imprinting: form of early learning in young animals, mainly due to perception of visual, olfactory and acoustic stimuli.
> Klepton: first-generation hybrid able to behave as a genetic parasite, i.e., capable of using part of the genetic code of one parent to reproduce by mating with the other parent.
> Lentic: a typically standing water environment (lake, pond, pool, etc.).
> Limnetic: the area in more extensive and deeper freshwater ecosystems where vegetation is absent, as opposed to the littoral zone.
> Macrophyte: a higher plant (here, aquatic).
> Mesotrophic: applied to waters having constant average availability of nutrients.
> Oligotrophic: an environment poor in nutrients.
> Parthenogenesis: reproduction by females without intervention by males (e.g., rotifers, water-fleas, mussel shrimps).
> Periphyton: film composed of algae, bacteria and mucilage that soon forms on any submerged object.
> Photosynthesis: a process whereby the energy of sunlight, absorbed by chlorophyll, converts carbon dioxide and synthesises organic matter, releasing oxygen.
> Phytophagous: an organism feeding on plants.
> Plankton: an organism drifting with water movements.
> Resting stage a period of rest or reduced metabolic activity.
> Sciaphilous: an organism preferring shaded areas.
> Sympatric: two species are called sympatric when they live together in portions of their areas of distribution; if the two species are collected together at the same sampling station, they are called “syntopic”.
> Taxon (pl. taxa): any formal taxonomic category (e.g. class, order, family, genus, species, subspecies, etc.).
> Trophic: associated with food.

List of species

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