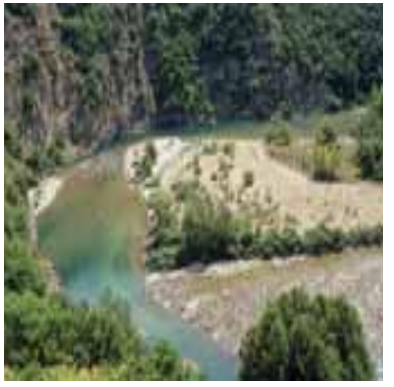
Terrestrial vertebrates

GIANCARLO FRACASSO



Rivers show a wide variety of environments (the Trebbia, Emilia Romagna)

If we were to take a transverse section of a watercourse and cross this transect from the median axis towards the external riverbanks, we would find a series of different and clearly well-characterised situations - from open water to bare shingle or sandy areas, from highly eutrophic pools to arid or temporarily marshy meadows, from pioneer patches of shrubs to more mature riparian woodland - each of these habitats being populated by specific animal communities. In some cases, these may be biotopes with very small areas; in others, they may be very extensive, if not in width, certainly in length. This latter aspect also has important consequences on animal populations. Most importantly, the characteristic of high continuity in at least some environmental types reduces fragmentation, possible isolation, and the consequent risk of extinction of individual populations.

The almost uninterrupted connection that a river establishes with other important environmental complexes is also a preferential route for colonisation or genetic exchanges between populations. Examples are the success of typically woodland species on the plain, starting from the extensive mountain forests or, at the other extreme, the penetration along these waterways by species characteristic of coastal water bodies. In addition, the prevalently lengthwise extension rather than width of the main river habitats means that ecotones are particularly well developed. These transition zones between different environments, thanks to the so-called “edge effect”, may host particularly rich communities. This is especially so nearer the river, where there is generally a more gradual transition between habitats, but less so towards the outer edges where, for hundreds of years, humans have been constructing levees. These have brusquely, and almost always definitively, interrupted the natural ecological succession.

Otter (*Lutra lutra*)

As amphibians almost invariably require still water for breeding purposes, they generally avoid watercourses in the strict sense of the term, because of the speed of the current, although this does slacken progressively in the lower reaches and especially near the mouth. The abundance of predatory fish also endangers both egg-laying and the larval stage of these vertebrates. Nevertheless, sufficiently good and sometimes even optimal, environmental conditions may be created in the wider floodplains, enabling sometimes large populations of some species to live in tranquillity.

Wide sandy riverbanks with little vegetation, where the recurrent transitory phenomena of high and low waters often create shallow, ephemeral pools, are the chosen breeding habitat of the green toad (*Bufo viridis*). This anuran, originally typical of steppe areas, often behaves as a pioneer species, so it is particularly adapt at colonising newly-formed temporary water bodies where there are no competitors or predators. To deal with these extreme situations, the green toad has distinctive reproductive strategies, such as a particularly long egg-laying season for an amphibian (March-August) and a relatively brief larval development (sometimes less than two months).

Although its conspicuous green and white dappled livery make it unmistakable, the toad is not easy to observe, as it is mainly active at night.

Green toad (*Bufo viridis*)

Newt larva

However, the frequent calls of the males do attract attention during the breeding season. They often “sing” in chorus, with characteristic trills lasting about ten seconds, repeated in long sequences at about four strophes a minute. These sounds should not be confused with the rather similar, but more continuous and shrill, chirruping of the mole cricket (*Gryllotalpa gryllotalpa*).

Larger stable bodies of eutrophic water are home to the inevitable “green frogs” throughout their period of activity. Green frogs are a group of animals represented by the genetic hybrid system composed of the edible frog (*Pelophylax* klepton *esculentus*) and pool frog (*P. lessonae*) mainly in Northern Italy, and by the Italian hybrid frog (*P.* kl. *hispanicus*) and Berger’s frog (*P. bergeri*) in Central and Southern Italy. Their favourite pools are those which, following occasional drying out, contain few fish whose predatory habits are often a limiting factor. They are used exclusively for reproduction by some urodeles, such as the smooth newt (*Lissotriton vulgaris*), largely replaced in Central-Southern Italy by the affine and endemic Italian newt (*L. italicus*). When the pools are relatively large and deep, the larger and more conspicuous Italian crested newt (*Triturus carniflex*) may also be found.

Riparian strips of shrubs and trees, with their cool, damp shady undergrowth and many hiding places, offer newts ideal living conditions during their terrestrial phase. Instead, tree canopies are ideal habitats for the Italian tree frog (*Hyla intermedia*), replaced by the Mediterranean tree frog (*H. meridionalis*) in Liguria, the Tyrrhenian version (*H. sarda*) in Sardinia and the Tuscan Archipelago and, in the extreme north-eastern part of Italy by the European tree frog (*H. arborea*), the most widespread species in Europe and the one in which the other forms found in Italy were incorporated until a few years ago.

Tree frogs are specialised anurans for their arboreal life during the adult phase, but they still require sunlit bodies of water for breeding. The brilliant green colour of this elegant amphibian often makes it almost invisible, but its

calls, which have the function of announcing its territory and attracting a mate, are unmistakable. Dozens of individuals may create an almost deafening crescendo, which becomes a distinctive element of the sounds to be heard in a riparian woodland, especially during still, damp spring and summer evenings.

Similarly associated for most of its active phase to damp woodlands on the plain, but in this case exclusively in the Po Valley and marginally on the surrounding hills, Lataste's frog (*Rana latastei*) is found regularly in riparian woodlands, as long as there are bodies of still water in the immediate vicinity. They must be neither too large nor too deep, but rich in submerged vegetation and preferably with few fish.

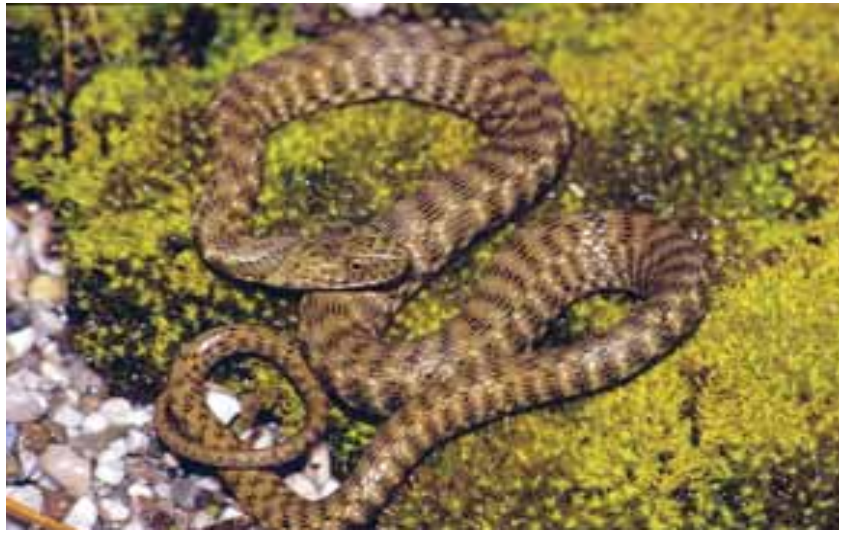
A member of the group of "red frogs", not always easy to distinguish from its congeners, except at very close quarters, is the agile frog (*R. dalmatina*), occasionally also found with the common frog (*R. temporaria*). However, at least during the initial stages of the mating season, Lataste's frog is recognisable by its unmistakable call. This may be heard easily from a long distance when, in the warmer, damp nights of February and March, males respond to one another with a brief, isolated but resonant sound, that seems to have little to do with the familiar, repetitive croaking of most anurans, the muffled cackling of the agile frog, or the deep, almost uniform muttering of the common frog.

Hyla sarda

It would be reasonable to expect that rivers in general would represent an ideal environment, at least for the three Italian species of grass snake, which are known to prefer various types of water bodies. In fact, waterways on the plains are the preferred or almost exclusive habitat of the checkered water snake (*Natrix tessellata*), which is widespread in mainland Italy. This colubrid, with its livery similar to that of an adder, causing it all too often to be unjustifiably killed, is active between March and October, feeding almost exclusively on fish.

Other small aquatic invertebrates only form a secondary part of its diet. Closely associated with both low altitudes and the surface water network, this grass snake occasionally ascends rivers along valleys, thus reaching hilly and mountain areas, although it is rarely found any higher than 600 m a.s.l.. At the opposite extreme, it may also regularly penetrate the brackish environments of river mouths and coastal lagoons. Although frequenting lake shores, it shows a marked preference for lotic rather than lentic environments.

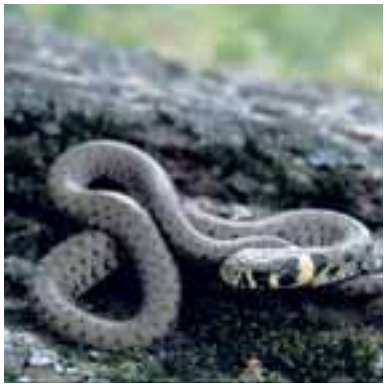
The opposite behaviour is observed in the more common grass snake (*N. natrix*), which is widespread throughout Italy, including the islands, from sea level up to more than 2000 m, although it is much more frequent below 1500



Checkered water snake (*Natrix tessellata*)

Pebbly riverbanks are sunlit, open areas

m a.s.l. Decidedly more eclectic and less aquatic than its congeners, especially in the case of the larger individuals - usually breeding females - it may also be found far from water. In wider riverbank areas with a variety of environments, particularly if there are many pools of different depths, this relatively confident and not very elusive reptile is a common sight during its long period of activity, from the end of February to the beginning of November.



Grass snake (*Natrix natrix*)

Equally associated with water, both still and flowing, but usually shallow, the viper snake (*N. maura*) is more frequent along seasonal watercourses, because its geographical distribution in Italy is limited mainly to Sardinia and the north-western sector of the Apennine chain; its presence on the plain is entirely marginal.

Among the many other snakes belonging to the Italian fauna that are easy to observe in riparian environments is the rat snake (*Hierophis viridiflavus*). It is ubiquitous throughout the peninsula and on the islands from sea level up to 2100 m, although rarely above 1500 m. It is a terrestrial species and finds its ideal habitat on wide riverbanks, composed of sunny, relatively dry, open areas alternating with stretches of tree and shrub cover that provide many hiding places.

The case of the Aesculapian snake (*Zamenis longissimus*) is different. This species is widespread in Northern and Central Italy, and is replaced in the south and on Sicily by the red-eye whip snake (*Z. lineatus*), which has only recently been classified as a species in its own right. This markedly arboreal, and therefore typically forest, snake is widespread in Italy, especially in the mesophile or moderately hygrophile woodlands of hill and sub-montane habitats. However, small populations do survive in the riparian woodlands along the major rivers, especially in the Po Valley, as relicts of a once much wider distribution on the plain, prior to the radical transformations at the hand of man.

Among the saurians, similar situations are found as for some of the snakes. Indeed, in the absence of species exclusive to river environments, it is easy to come across at least the more generalist and opportunistic species in these ecosystems, such as the common wall lizard (*Podarcis muralis*), which is

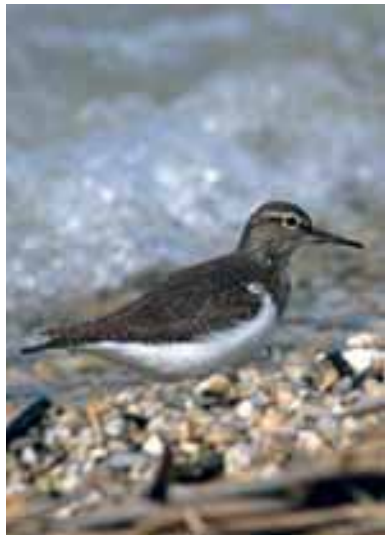
often found in northern and central regions, as well as in urban environments. This animal prefers margins between tree-shrub formations and more open areas, with alternating sunny areas and relatively damp substrates - a common situation along waterways.

Other very widespread but not equally adaptable species often find their only remaining suitable habitat in water-meadows, especially on the increasingly inhospitable plains. This is the case of the western green lizard (*Lacerta bilineata*), found mainly on the plains and hills of the mainland and Sicily. In the extreme north-east of Italy (Trieste karst and Julian pre-Alps) this lizard cohabits and partly hybridises with the eastern green lizard (*L. viridis*), a taxon with which it was aggregated until a few years ago. Wide riverbanks, at least partly covered by trees and shrubs interspersed with sunny, poorly vegetated areas, are optimal habitats for this typically ecotonal saurian, which is progressively disappearing from the increasingly banal agricultural ecosystems that now predominate on the Italian plains.

The extensive riverbanks of some watercourses on the Veneto plain, where herbaceous areas interrupt a mosaic of sandy beds with little vegetation, are the northern outposts of the distribution area of the Italian wall lizard (*Podarcis siculus*). This species is very common over a wide environmental spectrum on Sicily and in the peninsular regions, but it also reaches the sandy coasts of the Adriatic as far as the Friuli region.

Western green lizard (*Lacerta bilineata*)

■ Birds

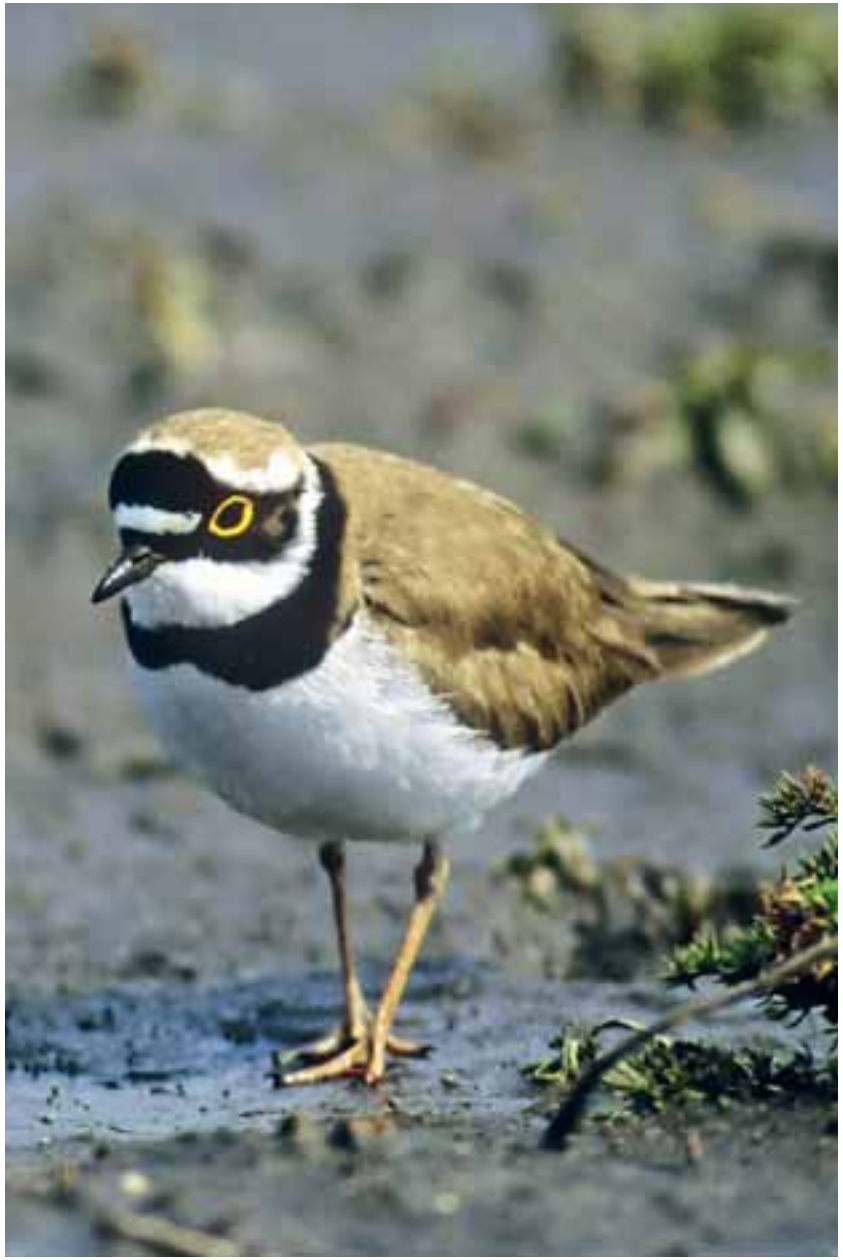


Common sandpiper (*Actitis hypoleucos*)

It would be practically impossible to list all the bird species which can be observed along the course of a river, as this would represent almost all the birdlife in Italy - with the exception of a few strictly sedentary species confined to the Alpine and mountain areas and those which are more decidedly pelagic. This is due both to the variety of environments available within riverside areas and the characteristic mobility of these vertebrates. As well as daily movements - which, although of short range, may mean that some species, although nesting well away from rivers, fly over or rest near them, or perhaps visit to find food or drink water - the important phenomenon of long-distance seasonal migrations must be taken into account. Although varying in intensity and regularity from species to species, these periodic events greatly enrich the bird fauna along waterways. The considerable energy expended on every continuous flight, which may extend for several hundred kilometres, means that migrating birds are forced to stop at regular intervals in a much wider variety of environments than during the breeding season, in order to recover the necessary strength for the next stages.

We thus limit ourselves here to mentioning only the few bird species most closely associated with riparian environments and which are therefore the most characteristic, especially during the nesting season.

Frequent guests of the wider riverbank stretches - at least in the spring and summer months, as they usually winter in Africa - are two small waders, which are very different, both in appearance and in choice of nesting habitat. The first, the common sandpiper (*Actitis hypoleucos*), is normally to be seen taking short rapid steps and bobbing its head, as it follows the course of the river, where the low water laps the sandy banks. Its flight is even more distinctive, being low over the water, and the bird flaps its wings with shallow, almost flickering movements, interspersed by brief glides with the wings arched downwards. Nesting pairs establish their territory in wide riverbanks, preferably in the upper plain areas, where the current is still quite fast and the



Little ringed plover (*Charadrius dubius*)

substrate is sandy and pebbly, with a mosaic of herbaceous vegetation and scattered shrubs. During courtship, the males display in zigzag nuptial flights, skimming low over the water or rising above the bushes while uttering their song, composed of a rapid cadenced series of acute and trilling notes. The females nest on the ground, almost always close to water, but on completely dry ground and often beneath the cover of a shrub. Present in breeding sites mainly between April and August, a few individuals of this wader regularly winter in Italy, but almost exclusively in coastal areas.

Nesting site of sand martin (*Riparia riparia*)

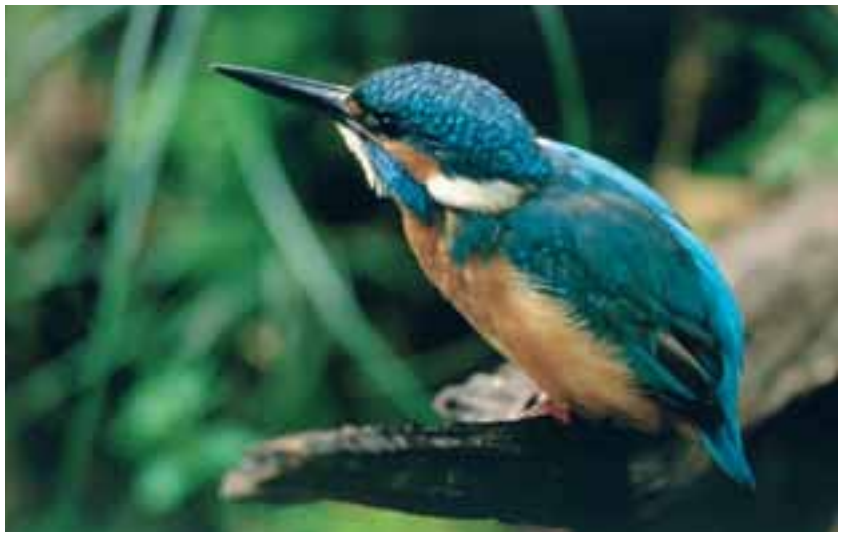
The other typical wader of river environments is the little ringed plover (*Charadrius dubius*). Although its plumage is mainly sober like that of the sandpiper, it is enlivened by contrasting black and white bands on its head and neck, which in fact make it more difficult to see when it is in its preferred habitat - wide stretches of shingle. In these areas it becomes almost entirely invisible against the variegated background, and proceeds with short forays followed by sudden, lengthy stops. It does not exploit this camouflage if a human approaches its territory, but does everything to distract the intruder from the eggs or chicks hidden nearby, by flying in wide circles and continually repeating its brief, lamenting alarm call. Only in situations of extreme danger for the nestlings does it resort to the pantomime known as “simulated injury”: pretending to be wounded and unable to fly, it attracts the attention of the possible predator to itself.

High, vertical sandy banks, which the natural action of the river creates here and there as it flows across the floodplains, offer the ideal nesting site for the sand martin (*Riparia riparia*). This is the most gregarious of the European swallows, and may form colonies of many hundreds of pairs. Even from a distance it is easy to identify these sites, not only by the frantic comings and goings of the adults, which accompany their flight with a continuous, reedy twittering, but also by the appearance of long stretches of riverbank riddled with holes. These are the nest openings: tunnels about 4 cm in diameter, dug by the males with their claws, they rise slightly inside the bank for a distance of

about 70 centimetres, and end in a slightly wider chamber, lined with plant material. It is here, in this dark and well-protected cover, that the eggs are hatched and chicks raised. Man's massive hydraulic works on the rivers of the Po Valley have rendered this spectacle increasingly rare. Although the sand martin has been able to cope with these drastic transformations at least partly by adapting itself to nesting in sand and gravel pits, quarrying often compromises the breeding success of entire colonies.

This species is also noted for being one of the first documented cases of a dramatic reduction in the populations of trans-Saharan migratory passerines nesting in western Europe, resulting from catastrophic events in their African wintering areas. In the case of the sand martin, the recurrent and prolonged droughts in the northern-tropical belt of the Sahel were responsible for hugely reduced numbers.

The plain brown and white plumage of the sand martin is in stark contrast with the brilliant blue and turquoise tones of the kingfisher (*Alcedo atthis*). However, both species partly share the same breeding habits, as kingfishers also nest in tunnels excavated in riverbanks, but they use their long, powerful beaks for the purpose. Unlike the sand martin, the kingfisher is a solitary bird and highly territorial. It can adapt to earthen banks and build its nest only a few inches above the water, as long as the banks are vertical and mostly bare of vegetation. This attractive bird is a predator specialised in catching small fish:



Kingfisher (*Alcedo atthis*)

waiting in ambush, immobile on a perch above the water, sometimes for long periods of time, it suddenly dives perpendicularly on its prey. It often passes unobserved despite its bright colours, which flash instantly, even only for a few seconds, in their unmistakable brilliance when it darts above the water with its low straight flight.

The dense vegetation of shrubs that grows along waterways on the plain are the chosen habitat of Cetti's warbler (*Cettia cetti*). This bird has colonised the Po Valley along these natural routes in the last half-century, favoured by the progressively milder winters, as it is particularly sensitive to extreme cold. Almost always hidden in the vegetation, it reveals its presence in almost every season of the year with its characteristic song, which is brief and yet explosive. Unlike that of most other songbirds, it is emitted by the male with a curious, unexpected irregularity as the bird moves almost invisibly from one perch to another within its territory. In more densely populated environments, it behaves as a polygamous species: a dominant male may breed in succession with up to five different females, to which it leaves the task of incubating the eggs and rearing the nestlings. Another peculiarity of this species is the colour of the eggs, which are a surprisingly uniform, bright brick-red, unique among Italian passerines.

Great reed warbler (*Acrocephalus arundinaceus*)

The great reed warbler (*Acrocephalus arundinaceus*) is also often polygamous, but clearly differs from Cetti's warbler in terms of habitat and behaviour. This relatively large silviid, which spends the winter south of the Sahara, establishes its breeding territories exclusively in large marshy reed-beds bordering the riverbanks and pools along the lower reaches of watercourses on the plain. Between April and August, the male is immediately recognisable when, perched in full view on the top of a reed, it may pass hours launched in its not particularly melodious and rather repetitive song, the sound quality of which is similar to that of an amphibian. The quite large nest, anchored between the stems of reeds, but not always well-hidden amongst the

Marsh warbler (*Acrocephalus palustris*)

Giancarlo Fracasso

From May to July, the herbaceous banks of watercourses in the Po Valley are enlivened by the unmistakable song of the nesting marsh warbler. Along riverbanks, it is easy to observe a male of this species which, from the top of a small shrub or a sufficiently robust herbaceous stem, launches its interminable full-throated song. This "conspicuous" acoustic is in great contrast to its totally insignificant plumage, olive-brown above and light buff below.
This means that this species is difficult to distinguish from other small passerines belonging to the same family (sylviids), especially from representatives of the genus *Hippolais*, or its own congeners.

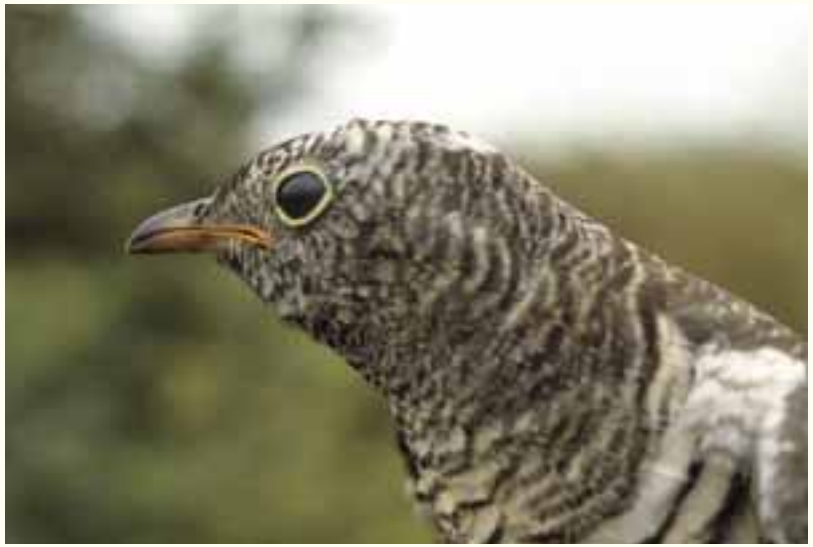
It is particularly difficult to distinguish the marsh warbler from the reed warbler (*Acrocephalus scirpaceus*), which is even more widespread in Italy but more associated with marshes. Even when an expert holds a specimen in the hand, identification is often based on the combination of a series of complex morphometrical measurements and sometimes - for instance with juveniles - it is even impossible. However, the males immediately reveal their true identity when they emit their territorial song. Whereas the reed warbler's song consists of a long, monotonous series of notes, rather harsh and strident, which follow one another rapidly and with little variation, those of its congener stand out for their sonority and variety.
The marsh warbler is an extraordinary imitator - to the point that its song, entirely lacking truly original and specific elements, is only composed of almost perfect copies of a large number of notes, although usually very short and mixed, of sounds made by many other birds, not only European, but also African.
Both these warblers are long-distance migratory birds which winter exclusively in Africa south of the Sahara. However the populations of *A. scirpaceus* of Central-Western Europe fly south-west at summer's end, crossing the Iberian Peninsula, whereas those of *A. palustris* follow an eastern route, crossing the Balkan Peninsula, Anatolia and the Near East, and reaching Africa between August and October by crossing the Sinai Peninsula and the Red Sea. Migration then slows, being protracted for some months along a relatively narrow corridor, with stages of different length affected mainly by the rainy seasons, across Ethiopia and Kenya and ends, in January, in south-eastern Africa, in the Cape Province (South Africa). The return journey, which is faster, begins in March-April, along the same route as the post-nesting migration, but the birds generally arrive in Europe only at the end of April or well into May.
Detailed knowledge of the very long migratory route of the marsh warbler has partly come from study of its vocal behaviour - in particular, its extraordinary imitative ability. The male acquires its song repertoire through a learning process that lasts only a few months, from when it hatches until it leaves its African wintering grounds, and then preserves it unchanged for the rest of its life.
The long strophes emitted by each individual may be composed of hundreds of motifs, constructed from the notes of around 80 different species.
Within the vast song repertoire of this warbler, imitations of at least 212 different species of birds have so far been identified, but items copied from African "models" exceed those of European sources (113 species against 99), and are often those of species with a relatively confined geographical distribution, thus revealing where this warbler has stopped during its transcontinental travels.

Marsh warbler's nest (*Acrocephalus palustris*)

Marsh warbler

The cuckoo (*Cuculus canorus*)

Although cuckoos frequent a very wide range of environments, from sea level up to the treeline, they are to be found at particularly high densities along waterways with at least a minimum level of natural conditions. Here, two fundamental requirements - food and the chance to breed - can be satisfied in relatively restricted areas.
The cuckoo's diet is based mainly on lepidopteran larvae, particularly on those that are covered by stinging hairs and live in colonies. These are more frequent in woodland margins and herbaceous formations, vegetation types that are usually well represented along rivers.
To reproduce, the cuckoo needs other birds, in whose nests it lays its eggs and to which it offloads the burden of rearing the young, to the detriment of their own. In Europe, although cuckoos' eggs have been found in the nests of more than a hundred species of passerines, it only regularly occurs in around thirty of these. Along a river, where extremely diversified environments may co-exist side by side, this "parasite" may find a particularly high number of potential hosts. Thus, the nests of white wagtail (*Motacilla alba*) and yellow wagtail (*M. flava*) are targeted on the more open riverbanks, the marsh warbler (*Acrocephalus palustris*) and whitethroat (*Sylvia communis*) along banks with tall grasses, the reed warbler (*A. scirpaceus*) and great reed warbler (*A. arundinaceus*) in reed-beds, the red-backed shrike (*Lanius collurio*) and barred warbler (*S. nisoria*) in scattered shrubs on pebbly riverbanks, and the nightingale (*Luscinia megarhynchos*), robin (*Erithacus rubecula*) and even wren (*Troglodytes troglodytes*) in riparian woodlands.



Cuckoo (*Cuculus canorus*)

The peculiar reproductive behaviour of the cuckoo is also reflected in its complex social system, territories being defended independently by both sexes, but limited to the breeding areas. These are almost always very distinct and also often a long way from feeding grounds. These breeding areas contain the territories of a few females, among which a hierarchy is established, so that the dominant female monopolises almost all the available nests of a certain host species. There is also strong competition among the males, but in this case for the opposite sex. Their territories may thus overlap those of more than one dominant female, with which each male will attempt to secure the greatest number of matings.
However, it is in the relationships with the host species that the cuckoo demonstrates its most surprising behaviour, moulded over time in response to its victims' attempts at defence, in a continual co-evolutionary "arms race". First, each female always tends to parasitise the nests of a specific host-species and the eggs that are laid are similar in colour and markings to those of the pre-designated victims. Groups - known as *gentes* - are thus formed of specialised females, which have maternal genetic links, as recently confirmed by DNA analyses. Cuckoos' eggs demonstrate further "offensive" adaptations: they are much smaller than expected from a bird of the cuckoo's size, thus being more similar, although generally slightly larger than those of the host. The shell is also particularly compact, thus offering greater resistance to the risk of breaking that might occur - both while being laid, often rather hurriedly, and any attempts at elimination by the host. During the breeding season, the dominant female cuckoos may lay up to twenty eggs, but only one per nest, at the same time removing one or two eggs of the host species. During this phase, the cuckoo also engages in sophisticated attack mechanisms: the female lays on alternate days, so that each egg undergoes a sort of pre-incubation in the maternal oviduct, and it is laid in the host's nest when the clutch of the latter is not yet complete, i.e., incubation has not yet begun. The alien egg therefore hatches before those of its stepbrothers and sisters and, at that point, the host's clutch is doomed: the baby cuckoo rapidly gets rid of the rightful occupants of the nest by energetically pushing eggs and babies out, and claims all the care of its adoptive parents.

Cuckoo in nest

Penduline tit (*Remiz pendulinus*)

vegetation, often plays host to the egg of a cuckoo (*Cuculus canorus*), a parasite of many species living along waterways on the plain.

Riparian woodlands, especially those which border rivers with weaker currents, oxbow lakes or pools, are often inhabited by the penduline tit (*Remiz pendulinus*), a tiny passerine with a characteristic black mask across its eyes. Its affinity with the tits is confirmed both by the agility with which it moves acrobatically between the outer fronds of the tree canopies, aided by its strong claws, or, especially in winter, along the vertical stems of reeds, in search of small insects and seeds, and by its social behaviour, which is territorial during the nesting season but gregarious during migration and in winter. However, its breeding habits are very different from those of tits. First of all, it does not nest in holes like tits, but builds a very unusual flask-shaped nest, with a tubular entrance on one side. This is lined with soft plant material, or animal hairs, and is suspended at the end of a flexible branch of willow or poplar, almost always hanging over the water. Its breeding partnerships are even more original, often being of extremely brief duration because both sexes may be serial polygamists.

The taller river woodlands, with their constant availability of marginal strips, offer particularly suitable conditions of relative humidity and luminosity for the golden oriole (*Oriolus oriolus*), a tree species the size of a blackbird, but not easily visible when it perches among the high branches of the tree canopy. The females and juveniles have mimetic green striped plumage, but the adult males vaunt one of the most conspicuous plumages in the Italian bird fauna, with bright yellow bodies and black wings. Between April and August, this migratory species - it winters south of the Sahara - is also easily recognisable by its unmistakable song, composed of short, liquid, fluting notes, well adapted to its appearance and its distant tropical origins. It is the only European representative of a genus that includes more than two dozen very similar species living in the equatorial forests of Africa and Asia.

■ Mammals

Otter tracks (*Lutra lutra*)

Within this class of vertebrates, the species that is probably most closely associated with rivers is the otter (*Lutra lutra*), although this semi-aquatic carnivore and opportunist also populates lakesides, marshes and coastlines over its vast Palaearctic distribution area. This flag-species of uncontaminated aquatic habitats and indicator of biological quality was chosen as the emblem of the 1979 Berne Convention for nature and wildlife conservation in Europe. In Italy, it currently survives almost exclusively along the middle-lower reaches of some Apennine rivers in southern Italy, especially in the Cilento, Basilicata and Calabria. The otter prefers very diversified riparian ecosystems, which offer an abundance of prey at all seasons (fish - especially small or medium-large ciprinids, but also amphibians, crustaceans, small mammals and birds). It seeks peaceful areas, both to spend the day (holes in the ground or tree stumps, beds of helophytes, etc.), and also to give birth and raise its young. It nests in dens close to the water, often with two entrances, one under water and one on land, protected landwards by dense vegetation.

Despite its respectable size - the average adult is more than a metre long and weighs almost 10 kilograms - the otter is difficult to observe because of its elusive behaviour and prevalently twilight or nocturnal activity, characteristics that have been reinforced by centuries of persecution by humans.

But various traces often reveal its presence to the eye - and the nose - of an expert. Footprints on the soft ground reveal the webbing between the five claws, and short nails: otter droppings are recognisable by the smell, which persists for weeks and is not unpleasant, likened to a mixture of honey and fish. Their long trails, traditionally used when moving between the water and dry land, are slightly meandering and do not entirely flatten the plants, because the animal normally proceeds with its belly and tail slightly raised from the ground. Then there are slides, for slipping quickly into the water down steep grassy slopes, or as a playground for the young; and grooming areas,

where the animal rids itself of the remains of food clinging to its fur by rubbing its body on the grass. Food leftovers are less diagnostic, as well as rare, as the otter tends to eat its prey whole.

An otter may occasionally be glimpsed while swimming, and mistaken for other aquatic mammals, none of them native: the mink (*Mustela vison*), a mustelid, escaped from captivity; the coypu (*Myocastor coypus*), a large South American rodent, by now naturalised and widespread in Italy, and the muskrat (*Ondatra zibethicus*), at present limited to some irrigated areas of Friuli Venezia Giulia. The mink, when swimming, may be recognised not only by its much smaller size but also by the fact that it keeps most of its back, from head to tail, above the water; the coypu keeps its head and most of its back emerged. But the otter leaves only its head, rump and tail in view above the water.

The western polecat (*Mustela putorius*) is another mustelid which, although markedly terrestrial and adaptable to a wide range of environmental conditions - from rural areas to forests and from sea level up to the Alpine valleys - shows a clear preference for generally damp habitats, and riparian environments in particular. In theory, it is widespread throughout the Italian peninsula, but its exact status is known only very approximately, and it is definitely rare in many regions, especially in the north. The western polecat is a solitary animal, mainly active at night, and has a strictly carnivorous diet. The range of prey is very

Coypu (*Myocastor coypus*)

varied, reflecting local and seasonal availability, and sometimes becoming highly specialised - for example, tiny mammals, hares or rabbits, or else almost exclusively anurans.

Northern water vole (*Arvicola terrestris*)

Among the many rodents that populate Italian riverbanks, at least two species are worthy of mention for the relative ease with which they can be recognised and observed. The first belongs to the voles, a group of tiny mammals of definitely fossorial habits, passing most of their life-cycle in tunnels dug just below the soil surface in meadows or woodlands, so they are not easily visible and often also not easily distinguishable on sight. The northern water vole (*Arvicola terrestris*) differs from the others because of its larger size, being more similar to the common rat (*Rattus norvegicus*). These two species may share habitats, but are easily identified, as the vole has a rounder shape, a blunt snout, smaller ears, thicker fur and relatively short tail with respect to the rat.

The systematic position of the various populations of voles living in the Italian peninsula (they are not found on the islands) has not yet been entirely clarified, but at least two forms are known, distinguished mainly by behaviour and environmental preferences. The northern water vole is aquatic and partly diurnal; the other, Scherman's field vole, is a grassland species widespread in central Europe but also on the Carnic Alps, with nocturnal and fossorial habits. The northern water vole prefers perennial watercourses, unpolluted and not too deep, situated mainly at low altitude and rich in hygrophile herbaceous vegetation (sedges, rushes, reeds, etc.) on which it feeds mainly between spring and autumn. In winter, it supplements its diet with roots, seeds and bark. It forms colonies and builds complex tunnel systems on riverbanks, with openings both below and above water level and different chambers used for storing food or raising its young.

Unmistakable with its eye-catching dark stripe running the length of its otherwise fawn back, the striped field mouse (*Apodemus agrarius*), unlike its congeners and other representatives of the murid family (excluding the common rat), may often be observed during the day, revealing its lack of fear

of humans. Found only in northern Italy (Friuli, Veneto, and western Lombardy), which constitutes the south-western limit of its vast distribution area, extending from Central Europe as far as China and Korea, it appears to have colonised Italy only relatively recently, as no traces have ever been found in the many fossil deposits dating to the Pleistocene. Although it may also live on farmland and relatively arid soils on hills, this rodent prefers damp habitats with diversified vegetation, which in the Po Valley - perhaps because of urbanisation and the intensification of agriculture - often coincide with riverbanks. Instances are the Ticino Valley, or along networks of smaller rivers and canals.

Among the insectivores, although various taxa may frequent river banks, only the two species of shrew belonging to the genus *Neomys* show a marked association with aquatic environments, the water shrew (*N. fodiens*) and Miller's water shrew (*N. anomalus*). At least in Northern Italy, the former mainly frequents mountain torrents, and the latter watercourses or damp environments on valley bottoms and plains. Recognisable, at least at generic level, for their striking appearance, black above and silvery-white below, both species are able swimmers and can dive under water to capture their prey. This consists not only of various aquatic invertebrates but also relatively large animals, such as fish and amphibians, which they kill with the aid of a poisonous substance in their saliva.

Water shrew (*Neomys fodiens*)

Noctule (*Nyctalus noctula*)

For the casual observer, it is almost always impossible to distinguish individual species of bats among the 30 taxa of the order of chiropterans in Italy, without having the animal either in one's hand or at least very close by. The situation is further complicated by the fact that, as bats are extremely mobile animals and at least partly migratory, covering considerable distances, many of their representatives may be encountered as they fly along a stretch of riverbank in the evenings, between spring and autumn. However, a more limited range of species finds suitable environments along riparian areas for hunting, and also winter and breeding refuges, and it is here that it becomes easier to observe them and, within certain limits, to identify them.

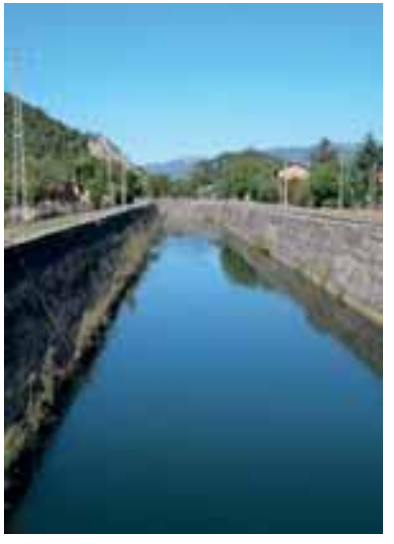
Wide rivers with slow-moving currents are the characteristic hunting ground for Daubenton's bat (*Myotis daubentonii*), which captures its prey, often with the aid of its rear claws, while skimming for long straight stretches very close to the water surface and usually well clear of the banks. Equally dependent on water for feeding is the long-fingered bat (*M. capaccinii*). Its hunting flight takes it higher above the water and it makes more frequent changes in direction with outstretched wings. Unlike Daubenton's bat, which uses holes in trees for breeding, the long-fingered bat is a strictly cave-dwelling species.

Natterer's bat (*M. nattereri*), which also hibernates in caves, is associated with water for hunting, and with woodlands for feeding and breeding. Even Geoffroy's bat (*M. emarginatus*), which winters and breeds in buildings or caves, can find ideal hunting grounds in riparian environments, usually within or at the edges of tree-shrub formations, as well as over water.

The more mature riparian woodlands offer environments, both for hunting and as ideal refuges (cavities), for the more markedly forest bats, such as the noctule (*Nyactalus noctula*) and Leisler's bat (*N. leisleri*). Both are relatively large species and can fly powerfully quite high above the ground, in the former case prevalently rectilinear, in the latter, more irregular. Another typically woodland species is Nathusius's pipistrelle (*Pipistrellus nathusii*) which, like the two noctules, migrates regularly over long distances - even around 2000 km - in a mainly NE-SW direction between Northern Europe and regions with milder winters, such as the Atlantic and Mediterranean coasts, including Italy.

Conservation and management

FRANCESCO BRACCO · GIANCARLO FRACASSO · ALESSANDRO MINELLI ·
FRANCESCO NONNIS MARZANO · MARIACRISTINA VILLANI



Canal for hydroelectric purposes (Umbria)

Man has exercised the most disparate forms of control on rivers over the centuries (building levees and weirs, or channelling and diverting their basins and beds, etc.). On one hand, the aim was to protect habitations and crops from floods and, on the other, to wrest new lands from the marshes created by natural river digressions. The resources provided by rivers were aimed at direct exploitation, first for water supplies for growing populations, but also to irrigate the land, to produce energy for industrial uses, facilitate the transport of men and goods, and obtain inert materials - and, of course, fish.

In more recent times, this uninterrupted process of alienation has reached its almost inevitable conclusion. In addition to their function as a bottomless well from which to continue drawing increasingly valuable goods, rivers have also become the collectors of the most disparate and sometimes the most hazardous residues deriving from human settlements and activities.

Some essential functions of rivers and their first bottoms are thus increasingly at risk, and in many cases have already been lost. Examples are water containment and slowing of discharges, transport of sediments, the capacity for self-purifying and breaking down potentially hazardous substances, and recharging the water table. Rivers are therefore a particularly sensitive element of the landscape because, although they directly involve only a very small part of the territory, they reflect the quality of its overall management.

Over time, various models have been proposed to explain the complexity of river ecology and the mechanisms that would make rivers an efficient natural purification system, with the contribution of physico-chemical and biological

Oxbow lake at Bernate (Ticino, Lombardy)

processes and the intervention of many plant and animal groups that sustain the food-chains which integrate with synergic effects.

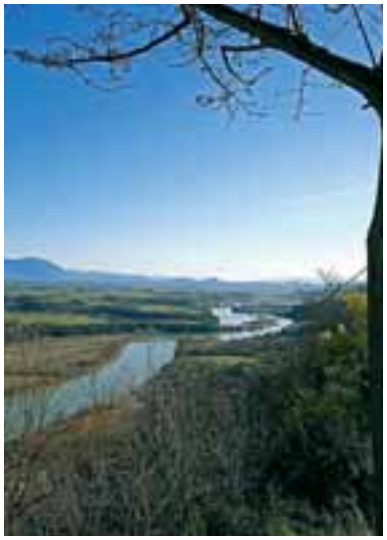
According to the *river continuum* concept, a river is a chain of ecosystems that follow and merge into one another from the source to the mouth. The concept stresses how the proper functioning of biological communities depends on the geomorphological and hydrological characteristics of the system and that a river must be examined in its entirety (see figure on page 12, and the Italian Habitats volume devoted to Mountain Streams).

The “nutrient spiralling” model links the processes whereby nutrients enter the cycle, i.e., their metabolising and chemical processing, and their transport downriver, which also involves the banks. The efficiency of these self-purifying processes is affected by the integrity of the fluvial ecosystem in all its dimensions: longitudinal (from the source to the mouth), vertical (from the water surface to the groundwater), lateral (from the centre of the channel to the riverbank), and temporal and territorial (relating not to the simple river corridor, but to the entire basin).

The conservation state of rivers is therefore influenced by types of crops, the existence of productive or urban settlements, and the quality of waste-water collection and treatment services. This effect is much more obvious when the natural belts of transitional environments along the riversides are destroyed or removed.

Livestock farm on the Po floodplain (Emilia Romagna)

■ European and Italian legislation



The Tiber at its confluence with the Farfa (Latium)

The need to control and manage water resources has been accepted by law, at all levels - European (Waters Directive 60/2000/EC, adopted in Italy with D.L. 152/00), national and regional. The species and habitats of the fluvial ecosystem are also protected from the perspective of biodiversity conservation. A major role has been played by the Birds Directive (79/409/EEC) and Habitats Directive (92/43/EEC), with later modifications and integrations, which have led to the identification of a European ecological network of sites (Natura Network 2000). These are the Areas of Special Protection (ASP) and Sites of Community Importance (SCI), particularly significant in terms of floral-faunal richness, where interventions that compromise their conservation are prohibited. In Italy, many corridors of the Natura 2000 network are waterways or river stretches in which alterations to riparian ecotones and adjacent areas have not yet compromised their original integrity or functionality. In all the biogeographical regions of Italy, habitats associated with flowing waters, identified according to the vegetation component, are constrained by the above Directives and considered worthy of conservation. Examples of these are the shrub formations with *Myricaria germanica* or *Salix eleagnos* of Alpine rivers, the seasonal-flow rivers in the Mediterranean region with *Agrostidetum* grasslands, the aquatic communities of flowing waters, the *Bidentetum* vegetation of wetlands, and nemoral communities with white willow. Many species of European interest, according to the Habitats Directive, are typically associated with fluvial and riparian environments. These include the unionid molluscs *Microcondylea compressa*, *Unio elongatulus* and *Margaritifera auricularia*, the crustacean *Austropotamobius pallipes*, the odonates *Ophiogomphus cecilia*, *Cordulegaster trinacriae* and *Oxygastra curtisi*, and the beetle *Osmoderma eremita*. Among vertebrates there are numerous Cyclostomes and fish (such as lampreys, sturgeons, whitefish, some trout, and many others), reptiles and amphibians. The most important mammal is the otter, whose presence in Italy is today limited to Basilicata, southern Campania and small strips of Calabria and Apulia.

■ Problems for flora and vegetation

In large valleys and on plains, a river often represents a discontinuity in the landscape, due to the existence of its channel and because of the accompanying, otherwise non-existent, types of vegetation (forest, shrub, herbaceous). However, this image of a fluvial belt with high plant biodiversity has recently been considerably re-scaled by converging processes, the result of which has been to subtract space from forms naturally modelled by the river morphogenesis and the vegetation that has become established there.

There is a general tendency to “rationalise” rivers, constraining them within levees and modifying the banks by defence works that fix the morphology. The banks have thus become steep slopes, and the many transitional environments that are an integral part of the river landscape have been eliminated. The strips where the river channel can meander, according to its erosion and sedimentation mechanisms, have been progressively restricted. In these regimented and canalised rivers, parts of the pebbly riverbanks disappear, but, more importantly, so have the raised pebbly riverbanks, intermediate terraces, and often also the systems of cyclically flooded hollows near the active channel.

This morphological simplification greatly reduces plant biodiversity. It does allow the survival of pioneer communities on the pebbly riverbanks, to a varying degree, but it drastically reduces the space available for all the other plant communities.

Riparian woodland at San Rossore (Arno, Tuscany)

The aquatic and marsh vegetation, xerophile herbaceous plant communities of raised pebbly riverbanks, and the whole series of woody shrub and tree riparian consortia suffer particularly badly.

The habit of canalising rivers, although understandable for the protection of the surrounding territory, tends to exacerbate negative trends that lead to morphological simplification. The bank defences permit widespread agricultural use of the first bottom.

Construction of a diversion channel

On one hand, this involves rigorous rationalisation of cultivated land areas, with the elimination of morphological discontinuities (depressions, terraces). On the other, it causes the replacement of natural or semi-natural plant cover by crops. This is why rivers are so often now reduced to mere channels between hybrid poplars or maize.

This situation has an undesirable effect on the trophic balance of watercourses - runoff waters leaving the surrounding cultivated land finish in the river directly, because a strip with well-grown vegetation no longer exists between the active bed and the crops. Simplification of fluvial morphology negatively affects the key role played by aquatic and riparian vegetation, not only in preventing erosion and decreasing discharge rates, and therefore controlling high water, but also the river’s filtering function - i.e., its capacity for mechanical retention and bio-accumulation of nutrients and pollutants. The reduction of this effect, consequent upon elimination of riparian vegetation, favours the increase of trophic loads in river waters.

Hydroelectric and irrigation schemes also greatly affect the carrying capacities of rivers, especially during the summer. Vegetation on pebbly riverbanks is not seriously affected by this, as it can adapt to cyclic variations in water availability, but the reduction in surface waters and lowering of the water table mean that the aquatic and marsh vegetation and hygrophile woodland suffer from the removal of fundamental water resources during the most critical period.

Exotic plants

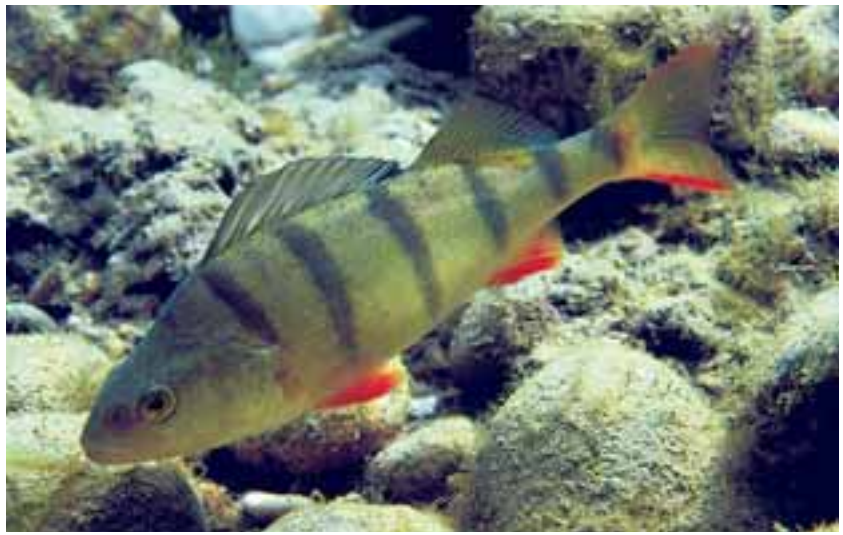
Mariacristina Villani · Francesco Bracco

The voluntary or accidental introduction of exotic species, also termed alien or allochthonous, i.e., spread by man outside their natural distribution area, is an ancient process. It was of positive importance in the past as it provided new sources of food for humans - many of the food plants used today in Europe have Asian or American origins.
However, the negative consequence is the aggressiveness exhibited by many exotic plants, which are in competition with the native species, and which accomplish mass invasions following their arrival in spontaneous communities. This is the case of the dense monophytic populations of amaranth (*Amaranthus chlorostachys*) on the banks of the Po, which have drastically reduced other annual plants typical of pebbly riverbanks, the vegetation dominated by early golden-rod (*Solidago gigantea*) or Canadian golden-rod (*S. Canadensis*) along the Adige and Po, and the shrub areas of indigo bush (*Amorpha fruticosa*) along river channels and banks. Less invasive, but extremely frequent, are common evening primrose (*Oenothera biennis*) and buddleia (*Buddleja davidii*), which have colonised the bare shingle along the Brenta and Piave, and many other Italian rivers.
Understanding the mechanisms which facilitate invasion is still incomplete, but rivers are certainly a chosen environment for exotic species. A recent study reports a list of 66 exotic species for the middle stretches of the Po, - almost 20% of the flora present. Several factors render rivers particularly suitable for exotic species: high water and nutrient availability - resources necessary for their survival; the ease of dispersal of fruits, seeds or propagules by water, which may transport them for long distances, making large-scale colonisation possible; and human intervention, particularly severe in both channel sand on banks, which alters the original environments, creating simplified contexts to which exotic species adapt better and faster.
The impact of exotic plants is one of the major causes of species extinction. The IUCN (International Union for the Conservation of Nature and Natural Resources), an international non-governmental association studying and monitoring species at risk, has set up a group of experts on exotic species, with the task of gaining knowledge on the problem, classifying the principal definitions, and throwing light on the mechanisms which make an exotic species more or less invasive. In 2004, Switzerland drew up a “black list”, including neophytes which cause damage in several environments, a “watch list” of potentially damaging species, and an identification key which permits a new exotic species to be inserted in one of the two lists. Italy also concluded a research project on the subject in 2007, preparing a catalogue of exotic species at both national and regional level, together with their relative impacts and new habitats.

Buddleia (*Buddleja davidii*)

■ Fish

Freshwater fish are currently the group of vertebrates most at risk in Europe: in Germany, 72% of species are considered under threat. At world level, the extinction of 29 species has been ascertained since 1600. The Italian situation is certainly one of the most complex at European level. The categories of the IUCN Red List, the appendices of the European Union Habitats Directive, and individual regional laws issued for the conservation and management of habitats and fauna, reveal that 47 of the 48 indigenous Italian taxa are considered at risk of extinction or seriously threatened - only the chub, at present, appears to be free of risk. The fish communities of Italian internal watercourses, particularly those in the hydrographical basin of the Po, have suffered profound modifications as a consequence of large-scale agro-industrial growth since the Second World War, and the many human activities connected with it, increased population density, alterations to channels, and water use for crop irrigation, hydroelectric power or drinking water.
As if this were not enough, the final blow has been inflicted during the last decade with the mass introduction of exotic species. Currently, this appears to be the most difficult problem to resolve, in view of the constant additional introductions, scanty scientific knowledge on the ecology of some of the introduced species and, most especially, the lack of willingness on the part of the management



Perch (*Perca fluviatilis*)

Fishing is linked to the introduction of exotic species

authorities to tackle the problem. For these reasons, a rapid decrease has recently been observed in the distribution of native species in Italian rivers, with the contemporary exponential increase of alien species, mostly from the Danube, which have rapidly colonised several ecological niches of the plain watercourses. Around 40 exotic species have been counted, but their number is continually growing. Some have rather limited distribution, but the majority are characterised by acclimatised populations, and they represent a considerable biomass. One example is the European catfish, and the problem of its widespread predatory impact on cyprinid populations. The impoverishment of fish resources and, in some cases, the disappearance of entire populations have led to the development of repopulation practices. This, although admirable in itself, has often been conducted with specimens incapable of maintaining the characteristic biodiversity of the basin and the genetic variation of its species. The use of non-native breeding stock or fry bought on the market, as in the case of many strains of Northern European salmonids, still used today for repopulating and artificial insemination, has led to the appearance of non-indigenous genotypes that may compete with or even replace wild ones, involving what zoologists call introgression, i.e., the acquisition of genetic characteristics originally not found in the population.

Genetic practices based on specimens taken from local waterways, although closer to the management and conservation requirements of the natural populations, are also not always carried out properly. The choice of breeding stock is often limited to a low number of specimens, selected subjectively, and therefore incapable of safeguarding genetic diversity. Artificial breeding and repopulating with material produced in an incubator, if not correctly managed, may create situations of “genetic drift”, with loss of variability due to the introduction of genetically very similar specimens, obtained from a very limited number of breeding stock. High levels of kinship can therefore lead to inbreeding, a phenomenon which tends to be revealed in reduced survival, greater predisposition to diseases, lack of growth, small-sized adults and, most importantly, poor breeding potential of sexually mature animals. It should also be remembered that the water in which imported fry are transported may also introduce other small alien fauna, although recent legislation has limited the accidental spread of exotic species.

■ Terrestrial vertebrates

Stone curlew (*Burhinus oedicnemus*)

The principal compromises that may be recorded along rivers regard the network of variability and environmental continuity of the two main directions, transversal and longitudinal, of the river channel, which basically characterise the ecology. In the first case, levees, which now harness the majority of rivers flowing across the plains, isolate riparian ecosystems almost completely from the surrounding territory and impede natural ecological successions. However, also within the overspill areas - between the hydrological axis in the strict sense and the dry banks - operations of regimenting, reshaping and channelling cancel the unique mosaic of habitats, more or less vegetated and wet or dry, which are the sources of extremely high biological diversity.

Some very rare or seriously threatened species of birds - especially in the Po Valley, because of the reduction of suitable habitats - find conditions which are still suitable to sustain small nesting populations along the wider banks. For example, wide pebbly riverbanks with sparse vegetation may host the stone curlew (*Burhinus oedicnemus*), nightjar (*Caprimulgus europaeus*) and short-toed lark (*Calandrella brachydactyla*), and areas of shrub provide refuge for the red-backed shrike (*Lanius collurio*) and barred warbler (*Sylvia nisoria*).

Widespread straightening operations further simplify watercourses by eliminating meanders and loops. In these sections, the water’s actions of erosion and deposition on the sides opposite the curve previously created favourable habitats for more typically riverside birds - vertical banks free of vegetation suitable for the nests of the kingfisher (*Alcedo atthis*) and sand martin (*Riparia riparia*), and areas of sand and shingle with few plants that were suitable for the little ringed plover (*Charadrius dubius*) and common sandpiper (*Actitis hypoleucos*), which nest on the ground.

But even more serious is the damage inflicted on animal communities by works, such as building dykes or eradicating vegetation, which interrupt habitat continuity for long stretches in a longitudinal direction. This affects not only the biocenoses between riverbanks, which are obviously totally wiped but also, indirectly, communities living in habitats outside the river channels, which are often reduced to small islands in an increasingly uniform and over-simplified environment.

Long-tailed tit (*Aegithalos caudatus*) at its nest

It might be useful to interpret these situations in terms of metapopulations, fragmentation of habitats and ecological networks, concepts that have recently appeared in both theoretical and applied conservation biology.

Sparrowhawk (*Accipiter nisus*)

Species associated with woodland environments or marshlands, although relatively widespread, are in fact often only present as archipelagos of fragmented populations, increasingly small and further apart, especially if the territory is severely degraded from the environmental viewpoint, like plains. These animals are thus particularly exposed to the risk of local extinction. Within the metapopulation dynamics, this phenomenon could be offset by the arrival of new individuals from other local, more successful, breeding populations. To guarantee the survival of these species in a given geographical area, the whole territorial system must be properly planned according to a logic of networks of areas which, although differently managed and more or less intensively subjected to human intervention, can somehow be connected, and thus allow these exchanges to take place. An important role in this is played by *faunal corridors*, i.e., those sections of the territory which facilitate the movements of individuals of a species between its various sub-populations. Waterways are ideal candidates for this ecological function, because the continuity of their associated habitats (aquatic, woodland, etc.) has not been excessively compromised.

The positive role played by the belts of tree and shrub vegetation - which recently appear to have increased along riverbanks, at least partly inverting the widespread deforestation that has involved especially the Po Valley since the Second World War - is confirmed by the expansion of a number of species characteristic of woodland environments on the plains. This is especially evident among birds, which can move so much more easily. For example, the sparrowhawk (*Accipiter nisus*), woodpigeon (*Columba palumbus*), tawny owl (*Strix aluco*), pied woodpecker (*Dendrocopos major*), long-tailed tit (*Aegithalos caudatus*), blue tit (*Cyanistes caeruleus*) and jay (*Garrulus glandarius*) are spreading over wide areas of the Po Valley, an area from which they had

Jay (*Garrulus glandarius*)

previously disappeared or become extremely rare.

Similarly, some mammals, such as the roe deer (*Capreolus capreolus*), squirrel (*Sciurus vulgaris*) and pine marten (*Martes martes*), are increasingly being observed on the plain. The recent expansion of the porcupine (*Hystrix cristata*) north of the Apennine chain may also have been aided by the natural corridors formed by riparian woodlands.

Favourable situations for fauna may also be observed where man's direct interventions, to regiment the water-courses or exploit their resources, have not been too radical or prolonged over time, thus allowing the river to remodel its bed physically and provide conditions for the re-establishment of complex plant and animal communities reasonably similar to the original ones. However, this regained naturalness of the river landscape, albeit partial and limited, is often paradoxically perceived as a sign of abandonment - even more so, because it is on public land. This appears to be taken as a justification for carrying out activities which, if not entirely illegal, are more or less uncontrolled, and may be damaging or wholly incompatible with conservation of the flora and fauna. For example, allowing public events, the passage of off-the-road vehicles, grazing of livestock or temporary encampments to occupy, however briefly, such delicate land greatly disturbs the birdlife, especially resting migrating aquatic species.

The breeding success of species particularly exposed to this type of pressure may also be compromised, victims being ground-nesting birds (common sandpiper, little ringed plover, stone curlew, nightjar) or those using low shrubs (red-backed shrike, barred warbler, etc.). There is also the tendency to transform riparian ecosystems into recreation areas for use by the human population. Although this is understandable within an urban area or very close to one, they suffer from the lack of interest of the local authorities in the natural dynamics of these sites. One of the most conspicuous examples of this is the introduction of plant and animal species entirely foreign to the territorial context.

■ Problems and prospects

The difficulties of managing a complex ecosystem like a river environment are the result of an often unilateral view of the problems involved. They are sometimes considered exclusively as a source of risk, to be minimised at all costs, as providers of resources to be exploited to the maximum, or, in the worst cases, as dumps for wastes or residues from the most varied human activities.

In general, however, the purely hydraulic approach still predominates, reinforced by growing awareness of the progressive dwindling of water resources and their sources of supply. It would be better if this vision of a river as a simple conduit for a liquid, the discharge of which is controlled, could change to a global geomorphological approach which takes into account the space-time evolution of the entire hydrographical basin. In this way, a reduced discharge rate (and thus the energy of the flowing water) and the magnitude of high water peaks, could both be achieved simply, rather than through works of forced regimentation. This would allow the river to regain sufficient space to reform its loops and wide water meadows in which to meander and regulate periods of high water through extensive, controlled overflows. This is an innovative management policy which, benefiting from the principles already adopted in many other countries, may be called "river re-qualification". This multilateral and multidisciplinary approach aims to satisfy many social and economic requirements in a sustainable way,

Gravel extraction in the Po channel

through structural and planned interventions. It would allow maintenance or restoration of ecological functions, naturalness, biodiversity, landscape, and the recreational value of watercourses to be integrated. In addition, hydrological requirements, which aim to protect the territory, regulate transport and rationalise the exploitation of resources, and administrative-institutional regulations on land use, could all be improved by drawing up economic and financial measures for territorial planning and coordinating the various management initiatives.

The Italian media regularly report natural disasters, which are generally the consequence of weather events - not always particularly intense. There are countless floods and landslides in this country which, unfortunately, shows a certain predisposition to these phenomena due to its peculiar hydro-geological state. Some of these dramatic events can be ascribed to the characteristics of the country, but it is also true that human intervention has played an important role in amplifying and worsening them. It is true that the Apennine and many Alpine rivers have what are called “juvenile” characteristics and are still causing erosion, but the only solution is reclamation of the basins, where possible, to restore the original conditions and avoid “bottling” the rivers into narrower channels - in other words, to control and not to modify their natural tendencies. Rivers overflow by their very nature - this is how the invaluable plains were formed. We must therefore learn to use the areas closest to the banks with extreme caution (building on overspill areas is a very short-sighted strategy!).

The Po at Turin

The exploitation of rivers has also led to significant quantities of their waters being trapped - Italy has more than one thousand dams, used by industry, or deviated into canals, etc. The final result is that, in periods of drought, some channels are more like deserts than riverbeds. The fauna, especially fish which cannot survive in small pools, therefore show obvious signs of suffering: this is why the idea of a “minimal viable discharge rate” has gained consensus, since it guarantees a minimum water level in case of drought, to the partial disadvantage of human exploitation. These changes, of a prevalently cultural type, are also opposed by the existence of a plethora of public and private authorities involved in river management - Civil Engineering Corps, Reclamation and Drainage Consortia, Basin Authorities, Associations of Municipalities in mountain areas, Local Councils with their respective Territorial Plans, business categories, and cultural associations, etc. Their widely differing expertise and interests are not only reflected in delays, inadequacies, or uncoordinated interventions: they often result in open conflict - confrontations between hydrological safety measures, requirements for building areas or materials and environmental management or, more simply, greater respect for the landscape. Added to this is the chronic lack of planning, which only exacerbates the gravity of the situation. The end-result is often a forced management policy, carried out on the basis of absolute urgency, if not of outright emergency - in other words, too late.

Farming on the Tiber floodplain (Latium)

Teaching suggestions

MARGHERITA SOLARI

■ Dragonflies

Onychogomphus forcipatus

● Aims: to learn the main characteristics of the order of odonates; to understand the differences in the development of holometabolic and ametabolic insects; to learn how to identify some species of odonates which are typical of riparian environments; to develop the capacity for observation and comparison; to encourage an interest in recognising insects.

● Level: secondary-school pupils between 14 and 18 years of age.

● Equipment: literature; insect identification guides; insectarium, to observe prepared specimens; proper clothing for the field trip; equipment for capturing adult insects or nymphs (butterfly net, fine-mesh fishing net); camera.

● Possible collaborators: a nature guide or expert entomologist.

PRELIMINARY STAGE (FOR TEACHERS)

1. Choose an area for an excursion in an easily accessible riparian environment, not overly changed by man, where it will be possible to see dragonflies. Prepare literature.

CLASSWORK

2. Study the class of insects: morphology, habits, diffusion, particular adaptations, developmental stages, hints on systematics (see pp. 58-61).

3. Conduct a literature search, in groups, on the characteristics that distinguish the order of the odonates. They are particularly interesting as regards appearance, colour, shape of the head with short antennae and very well-developed compound eyes (for a wide field of vision), strong mouth

Farming on the Tiber floodplain (Latium)

Odonate nymphs

Ivo Pecile

The odonates, better known as dragonflies, are insects with incomplete metamorphosis, whose pre-imago stages conduct an aquatic life until they are transformed into flying adult insects. The adults, with their large eyes and formidable muscular apparatus directly connected to the wings, are predators of many other species of insects. As juveniles, they feed on aquatic invertebrates, which they ambush suddenly, using a peculiar organ folded beneath the head - the mask.
When the nymph has reached maturity, it leaves the water and attaches itself to the stem of a plant where, completely defenceless, it awaits metamorphosis. The cuticle then splits down the back to allow the adult insect to emerge. During this phase, dragonflies have a “diaphanous” appearance and are unable to fly, so that any unexpected event, such as an attack by ants or even a simple fall into the water, would be lethal.
Dragonflies can easily be bred in controlled conditions in a small glass aquarium (30x20x30 cm). First of all, it is necessary to reconstruct the natural habitat of the insect. This can be done by simply raking the bottom of any pool with a bucket to gather material from the bed (mud, detritus and plants, etc.). This is poured into the aquarium, leaving about two-thirds empty for water. The aquatic plants should be suitably arranged so that they protrude from the water surface, to allow the mature dragonfly nymphs to climb out and attach themselves.
When the aquarium has been prepared, nymphs can be collected in a sieve, gently lowered below the surface waters of the pool. Once liberated in the aquarium, they will feed on the invertebrates contained in the mud.
Large anisopterans, such as *Anax* or *Aeshna*, also prey willingly on small tadpoles, so these may also be added to the aquarium.
When the dragonfly nymphs are close to maturity, the aquarium should be covered with a light tulle cloth to prevent the adults from flying away.

Gomphus nymph

Sympetrum nymph hiding in the mud

Aeshna mixta

parts, large, transparent, membranous wings, and a slim, elongated abdomen. Regarding habits, mention their skilled flight, which allows swift manoeuvring and good hunting ability, thus allowing this voracious predator to feed on insects; territorial habits (males do not tolerate the arrival of other males of the same species); the typical courtship of the males, mating phases (first forming the so-called “mating chain”, with the male in front and the female behind, and then the “mating wheel”, in which the two insects form a sort of circle); and the various methods of egg-laying, on plants or in the water. As regards development, enlarge on the characteristics of the nymphs: voracious predators of small arthropods, oligochaetes and tadpoles, which are captured with a mouth apparatus, the *mask*, the only one of its kind in the insect world. Note the many mutations during the juvenile stages, leading to the final mutation of the nymph which produces the adult insect.

4. Observe specimens of adult dragonflies under a low-powered microscope; study the systematics, expanding on the typical families of riparian environments where the field excursion will be held (middle or potomal reaches).

5. Construct an aquarium for rearing dragonflies: arrange mud, soil and plant matter collected from a pool on the bottom of a small, plastic or glass container. Insert a few small marsh plants (*Carex*, *Juncus*, or *Myriophyllum*); fill with water; cover the aquarium with a tulle net, supported by a wooden frame (see box on p.144).

FIELD EXCURSION

6. Excursion to the chosen stretch of river. Divide the class into small groups to observe different sections of the riverbank. Take photographs of the environment. Catch dragonflies with the net, observe them (perhaps placing one specimen in a small plastic box with air holes in it), then release them.

7. Collect animals at the pre-imago stages from the riverbed, using a fishing net or a sieve. This should be done at the river’s edge where the water is rich

in vegetation, or in the mud on the bottom of stretches of slower-moving water; it should be possible to select various specimens caught in the net with the aid of pincers. Odonate nymphs may be put temporarily in water-filled glass containers, separating the larger from the smaller species, until they can be placed in the school aquarium (see box on p. 144). Particular attention should be paid to avoiding collecting protected species (see p. 129).

ONGOING CLASSWORK

8. The material collected from a pool will contain many organisms, especially larvae of other insects, which are food for dragonflies. However, it is worthwhile providing food (insects, aquatic molluscs, tadpoles, etc.). Metamorphosis usually occurs during the night or at dawn: if direct observation is not possible, a camera could be set up, programmed to take time-lapse photographs. In general, but especially during metamorphosis, the insects should be observed quietly, taking care that the pupils do not crowd round too much. Adult specimens should be released, after observations, in the environment where the nymphs were collected.
9. Hold a final discussion in class on what the pupils have learned, with concluding remarks on the satisfaction that the recognition of insect orders and families can give attentive observers.

River Taro (Emilia Romagna)

■ Puppet shows with an environmental theme

- Aims: to develop the capacity for expression and play-acting; to understand the ecological relationships which link the various elements of a trophic network and the concept of habitat; to learn the main characteristics of a river environment.
- Level: primary-school pupils between 8 and 10 years of age.
- Equipment: literature; multimedia material; stout cardboard and other stationery goods for building stage sets; furry toy animals or puppets.
- Possible collaborator: teacher with experience in theatricals.

PRELIMINARY STAGE

1. Introduce the pupils to ecology: the concepts of population, communities, food chains, predator-prey relationships, competition, commensalism and parasitism; ecological niches and habitats. This may be aided by texts for pupils' use or specific literature aids. Give examples of a food chain in various environments, such as woodland, meadows, pools and rivers.
2. Study the river environment; its channel, riparian zones, weirs, etc.
3. Divide the class into groups to prepare cards on the most representative animals connected with the problems of management and conservation of river environments: otter, vole, penduline tit, kingfisher, sand martin, trout, and perhaps a few plants typical of the riparian belt, e.g., water speedwell or willow.
4. Examine, through a class discussion, man's interventions on rivers which alter fluvial morphology and compromise the delicate natural equilibria of ecosystems; levees, dams, channelling, excessive water removal, release of inadequately treated wastes, etc. Hold a discussion on the situation of the river best known to the pupils, of which they may have direct experience.

THEATRICALS

5. In groups, write a story-line with an ecological setting, in which the various characters are called before a competent authority, to explain their ecological requirements and their difficulties in surviving in an altered environment (e.g., levees do not allow kingfishers to nest, the destruction of riverside vegetation in order to grow crops does not allow penduline tits to build their nests, the excessive removal of water causes problems for fish, etc.). In the story-line, include a moment of confrontation between the requirements of the animals and plants and man's interventions of environmental development and defence.
6. Build stage sets: tarpaulins and large blocks (if a theatrical performance has been chosen), in which the pupils play the roles of the various animals; more

detailed painted backdrops for the puppets. Many animal puppets are on sale in shops, others can be made with readily available materials. Cloth or fur animals, also easily found in the shops, are equally suitable for the purpose.

7. Final performance by the pupils, perhaps inviting their parents, or other pupils in the school.

8. Final discussion on the experience, on territorial management and conservation methods in environments of fundamental importance, such as rivers.

■ Geomorphological and environmental study of a river

- Aims: to understand the main characteristics of a watercourse; to encourage awareness of the environment; to learn how to use maps, construct profiles and carry out environmental analysis; to develop the capacity for observation and comparison of data; to develop knowledge through research and verification of theories.
- Level: secondary-school pupils between 12 and 15 years of age.
- Equipment: literature; proper clothing for field trips; camera; material and equipment for drawing profiles (metric rope and perhaps a graduated pole or rod), maps (scale 1:100,000 or less), thermometer and instruments for measuring water flow.
- Possible collaborator: nature guide.

Stretches of rivers may also form gorges on the plain (Natisone, Friuli)

PRELIMINARY STAGE IN CLASS

1. The teacher should select two particularly significant stretches of the river to study (e.g., an upper stretch on the mountains and one on the plain), surveyed by the same class or different classes (perhaps from other schools for a joint project).

2. Introduce the work in class: presentation of the project, discussion on rivers and how the pupils relate to them; testing of their prior knowledge and direct experience.

Study the characteristics of a typical river in a temperate region: concepts of discharge and regimen, processes of erosion, transport and deposition, shape of the channel in the various stretches (Alpine, pre-Alpine, hill, upper and lower plain, terminal); units of the river environment: valleys, loops, terraces, normal erosional processes and equilibrium profiles; human actions: embankments, dams, canalising, removal of water and gravel, discharge of wastes. Types of vegetation in the various longitudinal belts.

3. Examine the regional maps and smaller-scale maps. Draw up a longitudinal profile of the river: construct the course from the source to the mouth, calculate the maximum drop and average gradient; choose a suitable scale to represent gradients and distances on a graph of adequate size (e.g., A3 graph paper); draw the graph.

4. Study a geological map, to identify the main types of outcrops in the catchment area.

Wide pebbly bed furrowed by the channels of a braided river

5. Compile survey cards to build up the transversal profiles. Divide the class into groups and assign to each one a stretch of river in which they should create the profile (e.g., every 30-50 metres: this division is not for the purpose of taking different profiles, but to involve all pupils directly in the work).
6. Compile cards for the observation of the environment.
General observations: approximate width and course of the channel (straight; with loops, single riverbed or branched, with abandoned beds), profile (wide and shallow, wide and deep, narrow and shallow, narrow and deep), average depth in the median stretch, presence of canals, terraces, natural or artificial riverbanks. Type of bed (pebbles, gravel, coarse sand, fine sand, loam, clay). Presence of clear cut signs of erosion (e.g., on banks) or deposits (e.g., organic matter).
Observations of vegetation: presence of riparian woodland (absent, spontaneous, plantation); presence of crops on the first bottom (monocultures, vineyards, hay meadows). Presence of longitudinal strips of vegetation, parallel to the watercourse: riverbed with plants in the flowing water (more or less slow) joined in clumps, with submerged stems and perhaps flowers above the water surface (water crowfoot, water chestnut, frogbit); riverbed exposed at low water, with annual ruderal herbaceous species of nitrophilous tendencies; riverbed submerged for short periods, with shrub and stoloniferous species, strongly rooted, capable of

Vegetation on river islets

regenerating from deposits after periods of submersion; strip of woody shrub vegetation (shrub willows, sea-buckthorn), strip of tree vegetation (with poplars and alders).
Observations of fauna: signs or tracks of animals, presence of aquatic invertebrates, etc.
Observation of river pebbles and identification of main rock types.
List of visible human works and artefacts: dykes, dams, bridges, quarries, roads, waste dumps, houses, straightening of river inlets, excavation of shores, ballast or cement riverbanks.

FIELD EXCURSION

7. Choosing a suitable season, when the water level is average, arrange an excursion to construct a river profile and make environmental observations. The excursion may be repeated after six months or a year, to check any changes.
8. Take measurements for constructing the channel profile: take depth measurements approximately every 50 cm with a metric rope, inclinometer and pole; perhaps also create bank profiles.
9. Measure water discharge with an appropriate instrument (e.g., a current meter). Alternatively, take an empirical measurement, assessing the speed of the water in the middle of the watercourse and multiplying this figure for the section.
10. Measure water transparency with a Secchi disc tied to a cord: allow the disc to settle on the riverbed or at mid-depth, and evaluate how clearly it can be seen (optimal, good, poor, nil transparency). Measure the temperature. Perhaps also measure chemical parameters, using water analysis kits easily found on the market (pH, phosphates, nitrates, hardness).
11. Make observations on the environment and vegetation, compiling the cards already prepared in class.

ONGOING CLASSWORK

12. Write a report in groups on the fieldwork, with a summary of the results and personal comments.
13. Conduct a class discussion on the complexity of the river environment, and on the precariousness of the equilibria regulating it, reflected in the mobility of the structures and life-cycles of the organisms living in it.
14. Comment on the natural or degraded conditions of the observed river environment, the need for conservation, and the synergy between the various authorities involved in its management, aimed at protecting the environment in general and riparian ecosystems in particular.

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Glossary

> Adventitious root: a root which grows from the main stem or branches of a plant.
> Allochthonous: refers to species of fauna or flora not indigenous to a given area, which arrived through direct or indirect human intervention.
> Anadromous: applied to fish which pass their growth stages at sea, and then migrate to reproduce in freshwaters.
> Biocenosis: set of interdependent animal and plant species within the same ecosystem.
> Bryophyte: a division of green plants, including the mosses and liverworts.
> Catabolite: residual product of an organism's cellular metabolism.
> Catadromous: applied to fish which pass their growth stages in freshwaters, and then migrate to reproduce at sea.
> Crenon: biocenosis living in the source zone of a river.
> Diadromous: applied to fish which pass their life-cycle partly at sea and partly in freshwaters.
> Ecological niche: functional position of an organism in its environment, comprising its habitat, the periods during which it occurs, and the resources it obtains.
> Ecotone: transition belt between two ecosystems.
> Edaphic: referring to the soil.
> Endemic: with distribution limited to a particular geographical region.
> Euryecious: having a wide range of habitats.
> Euryhaline: able to tolerate a wide range of degrees of salinity.
> Eutrophic: applied to nutrient-rich waters with high primary productivity.
> Gall: anomalous growth of a plant organ (branch or leaf) due to a substance introduced into the tissues by a parasite, usually an insect.
> Heliophile: preferring sunny environments.
> Helophyte: perennial plant with roots, stolons and rhizomes growing in submerged or wet soil.
> Hydrophyte: a plant adapted morphologically and/or physiologically to grow in water or very wet environments.
> Imago: insect in its final adult stage, sexually mature, and usually winged.
> Indehiscent: describing a fruit or fruiting body that does not open to disperse its contents. The seeds are released either when the surrounding wall decays or when it is eaten by an animal.
> Introgression: incorporation of genes of one species into the gene pool of another.
> Lapidicolous: living under a stone, used especially of an insect.
> Lentic: applied to a freshwater habitat characterised by calm or standing water.
> Lenticel: small pore in the woody stem of trees and shrubs, which permits gaseous exchange between atmosphere and plant.
> Lotic: applied to a freshwater habitat characterised by flowing water.
> Macrophyte: macroscopic plant growing in or near freshwater.
> Mesophile: organism that grows best at moderate temperatures.
> Monophytic: vegetation cover formed of a single plant species.
> Panmictic: applied to a population of animals in which mating is completely random.
> Phenology: the relation between climate and periodic biological phenomena.
> Phytophage: organism which feeds on plants.
> Polyphage: organism which feeds on a wide variety of plants.
> Potamon: the part of a river in which the water is typically slow-moving, deep, and relatively warm.
> Potamodrous: applied to fish that undertake regular migrations in large freshwater systems.
> Propagule: any structure that functions in propagation and dispersal (e.g., a spore or seed).
> Psammophile: an organism that prefers to live in sandy soils or areas.
> Rithron: the part of a river in which the water is typically fast-moving, shallow, and relatively cold.
> Saprophage: organism which feeds on decomposing organic matter.
> Stenoecious: applied to an organism that can live in only a restricted range of habitats.
> Stenohaline: very sensitive to changes in salinity.
> Taxon: a group of organisms of any taxonomic rank, e.g., family, genus or species.
> Taxonomy: the scientific classification of organisms.
> Thalassic: applied to the migration of fish from a river to the sea.
> Thermophile: an organism which grows best at relatively high temperatures.
> Tomentous: having a thick covering of very short hairs.
> Transfaunation: the release by humans of fish belonging to the same species, but coming from a different water basin.
> Trophic: referring to nutrients.
> Trophic load: the quantity of plant nutrients, particularly nitrates and phosphates, dissolved in water.
> Trophic stage: growth stage in the life-cycle when an organism grows by feeding.
> Xerophile: a plant preferring dry or arid environments.
> Xylophage: organism which feeds on wood.

List of species

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