

third year. The metamorphosed young move into brackish and fresh waters, where they remain feeding on benthic invertebrates and exploiting the trophic richness of these environments for rapid growth (they reach around 15 cm by the following autumn). Their ability to swim upriver is notable, although nowadays it is somewhat limited by pollution, the presence of weirs and environmental modifications in general: at the end of the 19th century, the species was regularly caught in the lower stretches of the Mincio and Secchia rivers. In autumn, they return to the sea, an over-wintering migration which is also reproductive for the mature adults. In Italy, plaice is only found in the Adriatic, being particularly common in the Veneto and Friuli lagoons and brackish inlets of the Po Delta, where it is fished for its delicious flesh. It is absent along the Tyrrhenian and Ionian coasts of the peninsula and those of the main islands.

As already stated, the fish mentioned up to now breed in coastal marine waters. There are, however, a handful of other species which normally spawn at sea or in brackish waters, but on occasion may complete their entire life-cycle in fresh waters: these include whitebait, pipefish, South European toothcarp, and two miniscule gobiids, Canestrini's goby and its close relative *Knipowitschia panizzae*. Whitebait (*Atherina boyeri*) is a small, extremely gregarious fish, abundant all along the Italian coastline. This distinctly euryecious species, in addition to the open sea and in brackish waters, can form stable populations in freshwater habitats like watercourses with a weak or moderate current near the sea. It has been permanently acclimatised for many years in Lake Trasimeno (Umbria), having been accidentally introduced in 1920, in Lake Bolsena and Lake Bracciano (both in the province of Rome, Latium), as well as in many others in central-southern Italy and the islands. It feeds on plankton and benthos, demonstrating a marked dietary opportunism in the various habitats colonised. It spawns from late spring until autumn, with a pause during the hottest periods; one peculiarity is the development of only the right-hand gonad in both sexes. Whitebait has some commercial value and is marketed both fresh, as the main ingredient of a deep-fried mixed fish dish called *fritto misto*, and preserved in various ways.

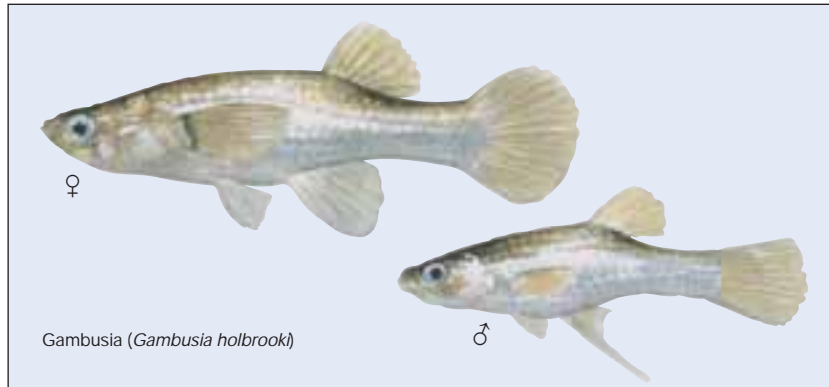
Pipefish (*Syngnathus abaster*) is also able to breed in fresh waters. It is a coastal marine species found at shallow depths on sandy and muddy bottoms, preferably with good vegetation cover. It happily penetrates brackish waters, where it forms stable populations, not requiring over-wintering migration. It has an unusual appearance that betrays its kinship with seahorses: the body is covered by carinated bony rings, which give a polygonal cross-section; the snout is tubular, with a tiny mouth; the ventral fins are absent, the caudal fin is



Pipefish (*Syngnathus abaster*)

very small, and the anal fin smaller still. Its diet is based on plankton, growth is quite rapid, maximum length reached is around 20 cm, and it appears not to live longer than three years. Reproduction involves a sort of mating, the genital openings of the two sexes being placed in contact. The fertilised eggs are then carried by the male in a brooding pouch lined with many well-vascularised folds of skin, where they remain until hatching. The related species *Syngnathus acus* also frequently penetrates brackish water, but is less tolerant of low salinity and temperature. Pipefish are of no commercial value.

The South European toothcarp (*Aphanius fasciatus*) is a small species (max. 6-7 cm in females) found in dense shoals at the edges of all brackish water bodies. Its tolerance to wide excursions in salinity, temperature and dissolved oxygen mean that it may also survive comfortably in "extreme" environments, such as salt-pans and tidal ponds in lagoons. It rarely colonises fresh waters but, when it does, it is still able to reproduce. Spawning takes place in spring – there appears to be a large preponderance of females in the populations, so there is strong competition among males to fertilise the eggs. There is conspicuous sexual dimorphism: the males have dark, brown-olive or bluish backs, and 7-15 vertical stripes of the same colour which stand out on the silver flanks; the females are larger and lighter in colour, with narrower stripes on the flanks. Fins are yellowish in the male, off-white in the female; the dorsal, caudal and anal fins are proportionately more developed in the male, the frontal upper edge of the dorsal fin is black and there is often a dark stripe on the caudal fin. The flesh of the South European toothcarp, wrongly considered toxic, is bitter and so does not appear on our tables. There are, however, some



reports of the species being eaten in some parts of Italy in the past; because of its abundance, it was also locally used as a fertilizer.

In brackish environments the South European toothcarp sometimes suffers from the presence of gambusia or mosquito-fish (*Gambusia holbrooki*), which replaces it in less salty areas. *Gambusia* is an allochthonous species of small dimensions (max. 5 cm in the females), introduced into Italy for the first time in 1922 in the Pontine marshes (south of Rome) as part of Mussolini's campaign against malaria, because it feeds on mosquito larvae. Its contribution to the disappearance of malaria was probably slight, notwithstanding the fact that this attempt at biological warfare was conducted on a large scale. This is also testified by the discontinuous but widespread presence of sometimes locally abundant populations, especially in coastal regions of the peninsula and on the main islands, where in the past malaria was endemic.

*Gambusia* can live in waters with a salt content of up to 20‰, but what is really remarkable is its tolerance to high temperatures and low dissolved oxygen levels: it can colonise thermal waters with a temperature of up to 40 °C, but tolerates cold badly. It is also worth mentioning for another peculiarity: it is the only fish living in Italian freshwaters that reproduces by internal fecundation; the anal fin of the male is modified to form a copulating organ called a gonopod. The fertilised eggs are not ejected - they have very small amounts of yolk, so the forming embryos are nourished by means of a secretion from the ovary walls. The rut takes place from April to August, and at around thirty days after fertilisation the female gives birth to a few dozen already developed and independent young. As the sperm is stored in the oviducts, a single copulation produces more than one parturition (up to six), which follow one another at monthly intervals. The species originates from the eastern United States,



chiefly the coastal plains facing the Atlantic between Florida and North Carolina. One of the best-represented families of brackish-water fish fauna is that of the gobiids, better known as gobies. They are all small, with a quite homogeneous appearance: a rather stubby, spindle-shaped body without a lateral line, a large broad head, protruding eyes situated high up, a short snout with thick lips and swollen cheeks, and fanlike pectoral fins. The ventral fins are characteristic, being fused together to form a pelvic disc which, acting like a sucker, may have the function of an adhering organ. They are sedentary benthic fish, with a dietary range that includes small invertebrates living on the bottom, plus fish eggs and larvae. Seven of the almost forty species of gobies – both freshwater and marine – which form part of the Italian fish fauna are to be found in lagoons, brackish-water inlets and coastal lakes. Marbled goby (*Pomatoschistus marmoratus*) and sand goby (*P. minutus*) are widespread in shallow waters on sandy bottoms along the entire Italian coastline, from where they enter brackish-water environments, the former having a higher tolerance to low salt contents. Widely euryhaline, but with a much more limited distribution, are Canestrini's goby (*P. canestrini*) and *Knipowitschia panizzae*. The former is found along the coasts of the Northern Adriatic and at the mouth of the Sinni (Gulf of Taranto), the latter with the same northern Adriatic diffusion to which are added reports for Lake Lesina (Apulia), Mar Piccolo at Taranto, and the lagoons of Orbetello and Burano (Tuscany). *P. tortonesei* is extremely local: this minute species, the biology of which is still unknown, was described in 1968 on the basis of a few specimens caught in the Stagnone di Marsala (Sicily). The species mentioned are all very small - the largest is *P. marmoratus*, which reaches barely 10 cm in length - and almost always have an annual life-cycle (at most biennial in *P. marmoratus* and *P. minutus*). Black goby (*Gobius niger*) is

larger, reaching 15 cm in length, and grass goby (*Zosterisessor ophiocephalus*) may reach even 25 cm. The latter is the only one with any economic value, as its flesh is generally appreciated. Both have life-cycles which may reach five years. Black goby lives in coastal marine waters on sandy bottoms to a depth of around 80 metres, but it can also tolerate quite low salinity levels, to around 6‰, and it therefore also forms sizeable populations in brackish waters. Grass goby requires saltier waters and mainly frequents muddy bottoms with meadows of eel-grass and *Posidonia*. Of all the species mentioned, only *P. minutus* appears to be able to live in brackish waters, but is obliged to return to the sea to spawn; instead, *P. canestrini* and *K. panizzae* may occasionally complete their entire life-cycle in fresh waters.

Sexual dimorphism in gobies is frequent, if only as regards courtship livery. The males also display territorial behaviour during the breeding season. A nest is normally prepared using shells, pebbles, or other solid fragments, beneath which the male hollows out a cavity to attract the female by his courtship display. When spawned, the eggs adhere to the ceiling or sides of these nests, and are guarded and fanned by the male until they hatch. The grass goby does not use shells or other objects to prepare a nest, but digs tunnels in the mud, among the roots of aquatic phanerogams: this species does not just prepare a breeding nest, but also over-wintering tunnels and summer refuges, of different shapes. Of great interest is the fact that, in many species of goby, grass goby and black goby, for example, courtship and aggressive territorial behaviour are accompanied by the emission of sounds of varying frequencies.



The small goby *Knipowitschia panizzae*

To conclude this overview of the fish in brackish waters, mention should be made of two small blenniids (blennies), rather similar to one another and related not just morphologically, but also by various aspects of their biology - these are freshwater blenny (*Salaria fluviatilis*) and peacock blenny (*S. pavo*). They both have a long body without scales, compressed laterally and covered in mucus, a tall head with a short snout, and long dorsal and anal fins. The absence of an air bladder testifies to their benthic habits; they barely reach 15 cm, and in some populations remain even smaller. In both species, the two sexes display territorial behaviour. The males are more brightly coloured and have an obvious fleshy occipital crest. The females lay eggs which adhere to the interior of the male's refuge, and he guards them until they hatch. A male may attract more than one female and thus find himself having to look after eggs at different stages of development.



Peacock blenny (*Salaria pavo*)



Freshwater blenny (*Salaria fluviatilis*)

Peacock blenny is widespread all along the Italian coastline, preferring shallow rocky bottoms and the hard beds of harbours. It may penetrate into brackish waters with a reasonable salt content and also colonise soft bottoms, as long as there are submerged objects available which can be used as refuges. Freshwater blenny is irregularly distributed in the rivers and lakes of the Mediterranean basin, preferring clear, well-oxygenated waters. In Italy, it can be found in Lakes Garda and Maggiore, in Liguria, Tuscany and Latium, in the southern regions and on the islands. It is very widespread in Sardinia, being most abundant in coastal lakes and brackish lagoons. In some cases - the lower stretches of the river Magra east of La Spezia, the port of Cagliari, the lakes of Patria north of Pozzuoli and Fondi near Terracina - the two species are sympatric. Some authors hypothesise that *Salaria fluviatilis* is descended from *S. pavo*, following the latter's invasion of the freshwaters around the Mediterranean. Others suggest that a more likely hypothesis is the existence of a euryhaline and eurythermal ancestor common to both species, which lived in the sea.



## Amphibians and reptiles

LUCA LAPINI

### ■ Amphibians

Closeness to the sea, exposure to the sun, and frequent flows of brackish water all greatly influence the biological and ecological parameters of brackish-water areas. The varying geomorphological conditions give rise to varying hydrology, and physical-chemical parameters include the warm, eutrophic freshwaters of a few retrodunal lakes in Tuscany (Burano, Massaciuccoli), as well as the extreme conditions encountered in salt-pans and some brackish Sardinian marshes, where salinity is very high.

The diversity of batrachians (frogs and toads) in these environments is deeply affected by the presence of freshwater, which contributes to the creation of ideal settings for their courtship parades and sometimes deafening choruses of croaks and gurgles, but also enables the development of their larvae and tadpoles.

For example, the small, retrodunal freshwater ponds of the Po Delta, and the lagoons of Venice and Grado host various animals, including those endemic to northern Italy (*Triturus vulgaris meridionalis*, *Rana latastei*, *Pelobates fuscus insubricus*), a very rich faunal complex similar to that of the Po valley marshes inland.

However, the largest Italian coastal lakes do not host large numbers of amphibians, as they usually live in areas with greater freshwater supplies, where their larvae may survive and metamorphose. The species which is best suited to living in low salinity conditions is certainly green toad (*Bufo viridis*) which, along coasts, may wander as far as the shoreline, and breeds in small,



Coastal wetlands host many differing amphibians

Green toad (*Bufo viridis*)

90 freshwater ponds near coastal lakes, sometimes even in moderately brackish environments. This is actually a colonising species, which often breeds in ephemeral ponds that rapidly dry up in hot sun. This is why, in coastal environments, the reproductive capacity of green toad is influenced by annual rainfall, which does not always support the development of tadpoles until they metamorphose.

Reeds growing in freshwater surrounding marshes resound with the loud cry of small Italian tree-toad (*Hyla intermedia*) which, in Sardinia, is replaced by Sardinian tree-toad (*Hyla sarda*), with its typical spotted back.

In spring, these aquatic environments containing freshwater from the watertable or surface supply, host various species of newt. The most frequent is small spotted newt (*Triturus vulgaris meridionalis*) which, in southern Italy, is replaced by Italian newt (*Triturus italicus*), endemic to Italy and also living in very shallow water. Italian warty newt (*Triturus carnifex*) is also found in these habitats, but generally prefers deep ponds with abundant aquatic vegetation. Despite the thermally favourable conditions, once their mating season is over, these species abandon the warm water where they laid their eggs and live on land for the rest of the year.



Tree-toad (*Hyla intermedia*)

91 Among frequently found anurans in coastal ponds are some discoglossids exclusive to Italian fauna. Painted frog (*Discoglossus pictus*) swims and reproduces in a few Sicilian coastal lakes; Tyrrhenian painted frog (*Discoglossus sardus*) lives near some Sardinian coastal ponds, but a few specimens have also been found in lakes on the Argentario promontory in Tuscany. The species is common in several areas in Sardinia, where it lives in water.

However, the most frequent and widespread species in central-southern Italian freshwater habitats are the green frogs of the complex hybridogenetic group *Rana bergeri-Rana hispanica*, endemic to Italy. Their croaks may only be heard if they are numerous, which is hardly ever the case in Italian coastal lakes. In these environments, they usually live in lateral ponds and canals colonised by reed (*Phragmites australis*). Here are also the small, black tadpoles of common toad (*Bufo bufo*) and agile frog (*Rana dalmatina*), the adults of which live inland, especially where woodland is densely tangled. The bodies of common toads in central-southern Italy are covered by sharp, thorny warts, and they are so large that they were long considered to be a typical southern European subspecies (*Bufo bufo spinosus*).



Common frog (*Rana bergeri-Rana hispanica*)



Checkered water snake (*Natrix tessellata*)

## ■ Reptiles

These terrestrial vertebrates are very tolerant of salinity, and are found in large numbers along the banks of the largest Italian coastal lakes. However, reptile communities are not specifically associated with these environments, but are divided into cortège species which are either typical of damp, inland habitats, or of xero-thermal coastal environments.

Reptiles living in small, freshwater retrodunal ponds near the Po Delta, in the lagoons of Venice, Marano and Grado (Veneto and Friuli), feature the same cortège species found in karstic spring habitats and Po valley marshes inland.

Thus, along sedge and reed fields bordering retrodunal and lagoon ponds in north-eastern Italy, there may be European pond turtle (*Emys orbicularis*), Western green lizard (*Lacerta bilineata*), Italian wall lizard (*Podarcis sicula*), wall lizard (*Podarcis muralis*), Carniola viviparous lizard (*Zootoca vivipara carniolica*, so far only found in a few freshwater shoals in the lagoon of Marano, Udine), grass snake (*Natrix natrix natrix*), checkered water snake (*Natrix tessellata*) and common adder (*Vipera aspis*).

However, habitats surrounding Italian coastal lakes resemble Mediterranean maquis and, together with garrigue, host the typical subspecies of Hermann's tortoise (*Testudo hermanni hermanni*) which, although not closely associated with water, constitutes a very important autochthonous population.

The tortoise species of the Mediterranean have been seriously endangered, both by introducing Hermann's tortoises of uncertain provenance and taxonomical status (see the population of Bosco della Mesola), and other allochthonous species, which in some areas are able to reproduce (*Testudo marginata*, *Testudo graeca*); they can mate with Hermann's tortoises and produce sterile hybrids.

European pond turtle (*Emys orbicularis*) is quite common in most coastal lakes, as it finds food even in brackish water, sometimes as far as the open sea. This species may be locally numerous and in spring, large groups may be seen basking in the sun. Although it is a generally carnivorous species, it is often necrophagous, feeding on small carrion.



Italian wall lizard (*Podarcis sicula*)



Hermann's tortoise (*Testudo hermanni*)



European pond turtle (*Emys orbicularis*)



Red-eared turtle (*Trachemys scripta elegans*)

In other Italian lakes, this animal lives with red-eared turtle (*Trachemys scripta elegans*) the young of which used to be sold in pet shops until recently. Native to North American marshland, this terrapin hardly ever reaches the adult stage in captivity. Juveniles bred in terrariums generally face critical periods in their development at the age of two, when lack of sunlight causes their growing carapaces to decalcify. This, together with bacterial and fungal infections due to lack of hygiene, are responsible for their mortality, which is well over 90% in pets. However, when survivors are about two and half years old, they develop rapidly, becoming 15-20 cm long in 4-5 years. When they reach this stage, they are too large to be kept and are often abandoned in marshes and ponds, where they compete with European pond turtle for space and resources.

To prevent their naturalisation, sale of these animals was recently banned. At present, little is known of their autonomous reproduction in southern Europe, perhaps because male specimens are rare. In their native habitats, the temperature at which the eggs are subjected before they hatch determines the sex of turtles. The embryos become male at low temperatures, and females at high ones. In artificial conditions, turtle and terrapin eggs are incubated at a high temperature to accelerate hatching, and thus most of the newborn are females.

In 1997, the European Union banned importation of these animals in all EU countries, but the market promptly reacted by offering European customers juveniles of other pond turtles, bred and sold by US farms. Recently, new terrapins have been sold (*Trachemys ornata*, etc.) which have different colours and carapaces, but similar ecology to red-eared turtle. Although they are seldom seen in the wild, they are likely to replace the small populations of red-eared turtle which still live in Italian marshland.

In central-southern Italy, the grassy banks of some coastal lakes host slowworm (*Anguis fragilis*) and the swift-wriggling cylindrical skink (*Chalcides chalcides*), a silvery, snake-shaped saurian with extremely small limbs. In Sicilian and Sardinian brackish marshland and ponds, eyed skink (*Chalcides ocellatus*) is very frequent, a stocky scincid with contrasting brownish-red colours.

The most frequently found reptiles around coastal lakes are grassland lizards, which are generally streaked green, such as Italian wall lizard (*Podarcis sicula*). This species is endemic to Italy and Istria, and is therefore widespread along all Italian, Istrian and Dalmatian coasts, but was introduced by man into Spain, the Balearic Islands and Florida, where it has naturalised.



Cylindrical skink (*Chalcides chalcides*)

Along Italian coastal lakes, it lives with common wall lizard (*Podarcis muralis*), with which it competes for food. Actually, these are generalist animals that share the same habitats, trying to limit food competition: in syntopic conditions, common wall lizard prefers rocks, ruins and buildings, whereas Italian wall lizard mostly lives on grassland. In Sicily, common wall lizard is replaced by a similar endemic species, Sicilian wall lizard (*Podarcis wagleriana*) and in Sardinia, by Tyrrhenian wall lizard (*Podarcis tiliguerta*), which may be found in any cliff environment. Western green lizard (*Lacerta bilineata*) lives on grassland, and is often found on the grassy banks of Italian coastal lakes.

Among the snakes living in maquis surrounding coastal lakes in central-northern Italy is the large Aesculapian snake (*Elaphe longissima*), which is replaced by its red-eyed relative (*Elaphe lineata*) in southern Italy. The latter species is exclusive to southern Italy, and until recently was considered to be a subspecies of Aesculapian snake, which was then called *E. l. romana*. Aesculapian snakes generally live on trees; they feed on other reptiles, small mammals and birds, and avoid direct sunlight. They bask in the sun only on humid, sultry days.



Tyrrhenian wall lizard (*Podarcis tiliguerta*)

The largest snake in these environments is four-lined snake (*Elaphe quatuorlineata*), found in cliff areas covered by trees, where it feeds on small mammals and birds. The colour of this large coluber undergoes a particular ontogenetic evolution. In young specimens it is mother-of-pearl white, with many black or blackish spots on the back and sides, whereas adults are yellowish-brown, with four black lines running all along their bodies. Although they are frequent in central-southern Italy, these giants - which may be 2.60 m long - are elusive and rarely seen.

The most typical snakes along Italian coastal lakes are grass or water snakes. They are aquatic or half-aquatic and feed on amphibians and fish. Grass snake (*Natrix natrix*) is the most common and widespread. In Italy, there are various subspecies, many of which are highly differentiated but still poorly known. The most typical along central-southern coastal lakes is *Natrix natrix helvetica*, which is easily identified by a black collar on its nape and large transversal black lines on its back and sides. Although its young are associated with aquatic environments, older specimens live far from the water, and feed on large terrestrial anurans.

The margins of Sardinian swamps and brackish marshland host Cetti's grass



Grass snake (*Natrix natrix*), a female of an Apulian population

snake (*Natrix natrix cetti*), which is endemic to Sardinia and Corsica and not associated with water. This species is easily recognised by its particularly large, transversal black stripes, which wrap it in dark and lighter rings of varying thickness.

In these environments, Cetti's grass snake lives with viper snake (*Natrix maura*), which is identified by the gaudy, zig-zagging fret on its back and the long series of spots along its sides. Its vague resemblance to Mediterranean adders is emphasised by the mimicry of this animal which, when in danger, flattens its head and springs forward hissing furiously, but without biting.

The most typical grass snake along Italian coastal lakes and ponds is checkered water snake (*Natrix tessellata*), which searches for food as far as the open sea.

The shrubby banks of coastal lakes house the large, widespread rat snake (*Hierophis viridiflavus*). It is the most common terrestrial snake in Italy; very quick, agile and aggressive, it feeds on saurians and other snakes. Its colours, ranging from green, yellow and black, vary according both to the distribution of the various populations and to its ontogenetic development. Until the age of three, the young are greenish, with black and yellow-striped heads, but when



Head of a large Sardinian rat snake (*Hierophis viridiflavus*)

they exceed 80 cm, they turn black, with a greenish-yellow overall pattern. Instead, populations in north-eastern and southern Italy (Apulia and Calabria) and Sicily become totally black at the age of three, and in the past were included in the subspecies *carbonarius*, which today is considered to be a chromatic variety of little taxonomical importance.

Horseshoe snake (*Haemorrhois hippocrepis*) is sometimes found in a few Sardinian coastal areas. It is a large terrestrial snake, similar to rat snake in both behaviour and ecology. It is of North African origin, and was probably imported to the island by man during the Neolithic epoch.

The only poisonous snakes found along Italian coastal lakes are a few adders. Until a short time ago, they were all considered to be common adders, but recent morphological, bio-chemical and genetic studies have revealed that they actually belong to different species. The banks of coastal lakes in central-southern Italy are inhabited both by common adder (*Vipera aspis*), typical of central-northern Italy and central-western France, and by the beautiful Hugu's adder (*Vipera hugyi*), widespread in southern Italy and Sicily. This species also lives on the island of Montecristo (Tyrrhenian), to which it was probably brought by the Phoenicians.



Hugu's adder (*Vipera hugyi*)

## Birds and mammals

LORENZO SERRA

### ■ Birds

Birds can adapt to differing habitats and ecological conditions, thanks to their great physiological and behavioural flexibility.

Migrations are certainly the best-known and most evocative example of this extraordinary adaptability, which has enabled them to colonise various environments, both aquatic and terrestrial. Italy hosts many migrants, due to its central position in the Mediterranean and its latitudes. Most

Italian birds belong to migrant species that cross the peninsula to breed and winter, either coming from or flying to more northerly latitudes.

The checklist of Italian birds contains 500 species, most of which may be found along coastal lakes and brackish ponds. Although many of them are associated with the typical environments of these areas, such as reed, rush and glasswort meadows, or open waters of varying salinity, probably none of them is exclusive to these habitats.

Nevertheless, birds are certainly among the most important animal species from the ecological and conservational viewpoints, thanks to their large numbers, top position in the food chain, and their ancient, close association with man and his culture.

In the coastal wetlands, various species of birds spend important stages of their life-cycles which, at Italian latitudes, are associated with the changing of the seasons, such as breeding in spring-summer, moulting in summer-autumn, resting during migration in spring and autumn, and wintering. Other differences in the use of habitats by birds regards their daily life. Classic examples are their circadian feeding and roosting rhythms which, in some species, occur in different habitats.



Reed-beds are ideal shelters for birds



Flight of flamingos (*Phoenicopterus ruber*)



Male (above) and female (below) of bearded tit (*Panurus biarmicus*)

**Breeding.** There are many types of birds nesting along coastal lakes and brackish ponds, mainly because varying water salinity gives rise to different phytocenoses. No bird species breed exclusively in these areas, although many depend on them.

Where salinity is low and vegetation is composed of reeds, either alone or associated with *Typha* (cattail) and other helophytes (bog plants) there are rush perching birds, such as great reed warbler (*Acrocephalus arundinaceus*) and reed warbler (*Acrocephalus scirpaceus*), both trans-Siberian migrants. They reach their breeding grounds between April and May and gradually leave them in late July. The

first ones to migrate to winter locations are adults which have finished breeding, followed by the young of the first clutch and adults with late clutches. Some individuals do not migrate until early October, partially or totally moulting near their breeding grounds.

Recently, a very small community of reed warblers was found to be resident in Sardinian ponds, i.e., they have lost their migrating capacity. This confirms that migration is genetically determined behaviour that may change in even a few generations, enabling animals to adapt to climatic and distributional variations.

The nests of the two species in question are perched on reed stalks, where reeds are thick (30-60 stalks/m<sup>2</sup>), flooded or very damp. Nests are usually at about 50-70 cm above water level, and their distance from water increases over time, as if they followed the growth of vegetation. Reed warbler generally forms lax colonies, in young reed stalks, the diameter of which is 5-6 mm, with a maximum density of 30-40 nests/hectare. Great reed warbler, instead, nests among more mature reed stalks, with a diameter of more than 6-7 mm, and prefers the margins of reed-beds with large ponds or channels. Its maximum nest density is 18 nests/hectare.

Another species well adapted to reed-beds is bearded tit (*Panurus biarmicus*), a small timaliid with peculiar breeding behaviour. After fledging, the young join

in large flocks and search for food in surrounding reed-beds. Gregariousness, however, does not last long, and is followed by the formation of the first young pairs.

The formation of pairs in young that are not yet sexually mature is a very rare phenomenon in birds. It is also worth noting that bearded tit is one of the few species in which sex is phenotypically distinguishable from the very beginning by different colours of the bill. In autumn and winter, their insectivorous diet becomes granivorous, and gives rise to changes in their gastric walls. In winter, seeds are a safer resource and this makes Italian communities resident or only partially migrant.

Reed-beds are also important habitats for the nesting of bittern (*Botaurus stellaris*) and little bittern (*Ixobrychus minutus*), two ardeids which are endangered in Europe, due to the reduction of their breeding grounds.

Other, more colonial ardeids nesting in reed-beds and joining in heterospecific colonies are purple heron (*Ardea purpurea*), squacco heron (*Ardeola ralloides*), little egret (*Egretta garzetta*) and night heron (*Nycticorax nycticorax*). Except for little egret, these species are also endangered, and are therefore very important from the conservation and management viewpoints.



Little bittern (*Ixobrychus minutus*) hunting

Heron communities are usually found in areas inaccessible to terrestrial predators, as their nests are built just above the water, and their juveniles are vulnerable and incapable of escaping or defending themselves against predators for several weeks after birth. Loss and deterioration of habitats are the main threats for ardeids.

A list of threatened reed-bed species is hard to draw up, because the reduction of these environments has made all these species extremely vulnerable. However, worthy of mention are purple gallinule (*Porphyrio porphyrio*), which may still be found in Sardinian ponds, and which has recently been re-introduced in Sicily; white-headed duck (*Oxyura leucocephala*), which was extinct in Italy in the 1960s, and is now being re-introduced in Apulia, although it is endangered by hybridisation with an allochthonous species - ruddy duck (*Oxyura jamaicensis*), ferruginous duck (*Aythya nyroca*) and red-crested pochard (*Netta rufina*), two anatids which, in the past, used to be widespread in Italy, but presently number only a few hundred and dozen species, respectively.

In Italy, the main cause of extinction or dramatic reduction of these four species is certainly due to extensive poaching and shooting, which the local



Purple heron (*Ardea purpurea*)

populations cannot tolerate. In autumn, the hunting season begins before these communities can migrate, and this causes mass extermination of local communities. Instead, when the season sets in, hunting may affect larger numbers of more diversified animals.

Mallard (*Anas platyrhynchos*) is one of the most widespread and easily found species in Italian wetlands, but has recently become of conservational interest because its natural populations are constantly and freely mixed with farmed specimens for hunting purposes. Domesticated individuals are phenotypically variable, and the colour of their plumage, size of bodies, and breeding periods are very different from those of the wild populations. The present laws regulating the management of Italian fauna (e.g., law 157/92) and particularly faunal introduction are too general to be controlled by local administration.

Other typical reed-bed birds are rails, a very elusive species. Among the nesting families is water rail (*Rallus aquaticus*) and moorhen (*Gallinula chloropus*), which are common, but there are also the rarer spotted crake (*Porzana porzana*), little crake (*Porzana parva*) and the already-mentioned purple gallinule.



A flock of ferruginous duck (*Aythya nyroca*); males have typical white irises

Coot (*Fulica atra*)

The only predator whose breeding period is closely associated with these marshlands is marsh harrier (*Circus aeruginosus*). It chooses its breeding grounds very carefully, settling in inaccessible reed, or sometimes in cattail or rush meadows, using any open area for hunting. Italy is this bird's southernmost breeding ground, its centre being in central Europe, and therefore the nesting community is not very large (about 40 pairs), and its density is always quite low.

The situation changes completely during the winter season, when groups from the north converge in Italy, and marsh harrier becomes a common sight in all medium-sized wetlands.

Coot (*Fulica atra*) may be found in large bodies of water, together with two other podicipeds, great crested grebe (*Podiceps cristatus*) and little grebe (*Tachybaptus ruficollis*). The nests of these species are built on heaps of drifting reed and other plant debris anchored to emerging or floating plant tufts.

In halophytic areas, there is shelduck (*Tadorna tadorna*), a medium-sized anatid which nests in underground galleries, such as those abandoned by rabbits (*Oryctolagus cuniculus*), old pipes or tunnels in vegetation. When pairs are numerous, the juveniles are gathered in large nurseries and adults take turns guarding them. Typical nesting species in coastal marshlands are black-winged stilt (*Himantopus himantopus*), avocet (*Recurvirostra*

Shelduck (*Tadorna tadorna*) with chicksMale of Kentish plover (*Charadrius alexandrinus*) sitting on its nest: in this species both sexes take turns brooding, but only one of the parents takes care of the young after the eggs hatchRedshank (*Tringa totanus*)



Fan-tailed warbler (*Cisticola juncidis*)

*avosetta*), Kentish plover (*Charadrius alexandrinus*) and red shank (*Tringa totanus*). Oystercatcher (*Haemantopus ostralegus*), which usually nests on beaches, and collared pratincole (*Glareola pratincola*) are rarer and only found in small areas. This vegetation belt also hosts several species of perching birds, some of which are typical of arid areas, such as crested lark (*Galerida cristata*), calandra lark (*Melanocorypha calandra*), short-toed lark (*Calandrella brachydactyla*), and others associated with grass- and pastureland, like skylark (*Alauda arvensis*) and yellow wagtail (*Motacilla flava*).

In central and southern Italy, *Salicornia* and *Suaeda* meadows are typical environments for the small sylviid spectacled warbler (*Sylvia conspicillata*). Other perching birds, which are less selective in their choice of habitat, but are generally found in shrubby vegetation in wetlands, are fan-tailed warbler (*Cisticola juncidis*) and stonechat (*Saxicola torquata*).

Extremely important habitats for the nesting of birds in wetlands are small islands and low ridges. Here live most of the Italian colonies of terns and gulls, particularly common tern (*Sterna hirundo*), little tern (*Sterna albifrons*), gull-billed tern (*Gelochelidon nilotica*), sandwich tern (*Sterna sandvicensis*), black-headed gull (*Larus ridibundus*), Mediterranean gull (*Larus melanocephalus*) and slender-billed gull (*Larus genei*). Two other very important species from the conservational viewpoint nesting on these islands are spoonbill (*Platalea leucorodia*) and flamingo (*Phoenicopterus ruber*, see pp. 120-121).

The presence of these species is limited by lack of available space on the islands. Birds compete for the best breeding grounds and larger species are obviously favoured, but the time of settlement is also important, because the first species to arrive are privileged. It has been demonstrated that the creation of artificial islands and their management for breeding purposes may increase the number of nesting species. In this respect, essential intervention regards the management of water levels in basins containing the islands, periodical remodelling of banks, and monitoring of vegetation.



Spoonbill (*Platalea leucorodia*)

**Moulting.** At the end of the breeding season, most species moult, i.e., once a year they replace their plumage completely. Moulting is a significant event in the lives of birds, due to the metabolic expense associated with the formation of new feathers, the reduced capacity for movement and thermoregulation, and especially because new, good-quality plumage contributes to future survival. This is why moulting does not occur together with other activities which require loss of energy, such as breeding and migration.

Some birds even migrate to reach their most appropriate moulting grounds, i.e., environments protecting them from predators and containing a large quantity of food.

Ducks provide a good example of moult migration. At the end of their breeding season, they migrate to areas that may even be hundreds of kilometres from their breeding grounds. These are not necessarily in the same direction or along the same route as their post-breeding migration, but may be opposite or along different migration flyways. This movement is not an initial migration to wintering grounds, but a phenomenon in itself. Information on how to reach moulting areas is not genetically determined, but learnt. The first anatids to moult-migrate are the young following their parents or other adults, and their flyway remains the same throughout their lives. Moulting migration flyways



Moulting migration of shelducks in northern Europe. It is not known whether the Italian nesting population flies to moult to the Waddensee or to the lagoons of Sivash in the Ukraine

provide useful indications about the historical reproductive distribution of populations and changes in the various areas. Migrations are so extraordinary because they join populations living at opposite ends of breeding grounds. Identification and conservation of moulting grounds are therefore crucial for the management of these species.

Almost all anatids shed all their remiges, and moulting individuals become apterous (wingless) and unable to fly for a couple of weeks. Ducks - unlike swans and geese, for which the beginning of moulting coincides with the end of the breeding season - keep the two events separate. Moulting anatids migrate to protected, quiet areas, where they can feed and escape predators and man without flying. They usually occupy flooded areas covered with thick marshland vegetation.

Protection, rather than food, seems to determine the choice of moulting grounds, also because in that period almost all environments at Italian latitudes are rich in food. In order to cope with the energy requirements of this stage, ducks select various habitats, diets, behaviours and physiological characteristics. According to local conditions, these adaptations may also vary at intra-specific level. Metabolic adaptations are particularly interesting, and regard the development of organs carrying out protein synthesis and reduction



Anatids also moult in sheltered areas, such as those flooded and covered with thick marsh vegetation (Lake of Burano, Tuscany)



Flock of mallard (*Anas platyrhynchos*) displaying their eclipse plumage

of muscular tissues, especially those involved with flight.

Phenologically speaking, moulting grounds are first occupied by adult males, followed by adult females and the young. At this stage, the plumage of anatids is called "eclipse", the colours and patterns of which are suitable for mimicry, but which also eliminates or strongly reduces these animals' chromatic sexual dimorphism.

In Italian marshlands, moulting groups form in June and do not break up until early September. The females with late

clutches may moult until late September. Very little is known about the whereabouts and timing of moulting grounds.

However, these special places are certainly visited by Italian nesting communities, and therefore, in addition to mallard and garganey (*Anas querquedula*), they may also host teal (*Anas crecca*), shoveler (*Anas clypeata*),



Pochard (*Aythya ferina*)

gadwall (*Anas strepera*), pochard (*Aythya ferina*) and ferruginous duck (*Aythya nyroca*). The arrival of specimens from the nearby Balkans and central Europe cannot be ruled out, although their moulting grounds are usually in other regions.

Some species of perching birds may also visit marshland after their breeding season. The most common are Italian sparrow (*Passer italiae*), tree sparrow (*Passer montanus*) and yellow wagtail.

The first two species are resident and moult very slowly, in about 70-80 days, because their only deadline is the arrival of winter. Instead, yellow wagtails must prepare for a 4000-kilometres journey that takes them to sub-Saharan regions in western Africa, and they therefore moult quickly, in about 40 days, to prevent overlap with the pre-migrating stage, in which energy must be stored.



Garganey (*Anas querquedula*)



Male of yellow wagtail (*Motacilla flava*), a widespread nesting subspecies in Italy, *M. f. cinerocapilla*

**Migration rests.** In most species, migration consists of alternating periods of flight and rest. The latter is therefore an essential part of the phenomenon and contributes to the successful migration and survival of individuals. It is during rests, more than during flight, that birds risk predation. The length of rest is one of the main parameters in determining migration velocity, and largely depends on the climatic and trophic conditions of the grounds. Coastal marshlands are the first resting grounds for migrants crossing long stretches of sea, but are also favourite spots for species which are closely associated with these environments. These areas host large numbers of densely thronged migrants that may be seen from a considerable distance. They are also useful in navigation, as many species are oriented towards typical landscape features. The sky above deltas, in particular, is often blackened by enormous flocks of migrating birds.

Coastal marshlands may represent temporary shelters or passageways for some species, and indispensable food sources for others. Typically aquatic species, such as waders and anatids, are closely associated with them. In brackish ponds and coastal lakes, waders are spotted redshank (*Tringa erythropus*), whimbrel (*Numenius phaeopus*), ruff (*Philomachus pugnax*), curlew sandpiper (*Calidris ferruginea*) and little stint (*Calidris minuta*).



Spotted redshank (*Tringa erythropus*) in Cesine (Salento)

Ruff displays interesting behaviour during migration and rest. Communities of this species, which winter in western Africa and cross the Mediterranean to breed in northern Europe and Siberia, find their first feeding grounds along the Italian coastline after an uninterrupted flight of about 4000 kilometres. In late February, the first to arrive are the males, followed by the females a few weeks later. In Italian resting areas, they accumulate enough energy to enable them to fly for another 2000-3000 kilometres non-stop, and this "fattening" stage lasts about 20 days.

In March and April, almost all retrodunal ponds host feeding ruffs and, until 20-30 years ago, a few of these ponds housed single-species roosts of several thousands of individuals.

These birds generally roost on small islands with shrubby, sparse or totally absent vegetation, low on the water, or even partially submerged. Today, the numbers of this species have fallen so dramatically, that many roosts no longer exist, or are so small that they can only accommodate a few dozens or hundreds of individuals. In May, migration continues, but roosts disappear because resting periods are shorter. Autumnal migration follows flyways further west, along the Atlantic coastline, and only small numbers of spring migrants fly over Italy again.



Teal (*Anas crecca*) flying over wetlands, San Rossore (Tuscany)



Penduline tit (*Remiz pendulinus*)

Anatids (wildfowl) are present both as diving species, such as tufted duck (*Aythya fuligula*) and pochard, and as surface species, like teal, widgeon (*Anas penelope*), pintail (*Anas acuta*), garganey and shoveler. The most common goose is greylag goose (*Anser anser*), whereas bean goose (*Anser fabalis*) and white-fronted goose (*Anser albifrons*) are rarer and only found in small areas.

Among these species of ducks and geese, only garganey does not winter in Italy, and its migration is very similar to that of ruff, with large numbers of migrants in spring and few in summer. The post-breeding passage occurs very early, with large numbers in late August. Both migrating flows have highly synchronised passage times, with only a 1-2-day difference between northern and southern Italy, which is typical of far-flying migrants.

As regards perching birds, reed-beds host the largest numbers of these species, especially during post-breeding migration. In late summer, a great number of warblers, especially reed warbler and great reed warbler, are added to the nesting populations, together with sedge warbler (*Acrocephalus schoenobaenus*), the rarer grasshopper warbler (*Locustella naevia*) and Savi's warbler (*Locustella luscinioides*). The presence of aquatic warbler (*Acrocephalus paludicola*) is very unusual, as this is one of the most endangered Palearctic species (an estimated 5000-8000 pairs in Europe).

Resident species nest in areas extending between 50° and 60° N, from eastern Germany to western Siberia, and winter in the western Sahel. The typical breeding and winter quarters for these species are sedge fields, alone or associated with a few shrubs of *Salix* spp. or tufts of *Phragmites*.

The main cause of their falling numbers is the gradual destruction of their habitats. In autumn, typical species are medium- or short-distance flyers, i.e., those that do not winter south of the Sahara, but remain in the Mediterranean basin.

In autumn, typical species are reed bunting (*Emberiza schoeniclus*) and penduline tit (*Remiz pendulinus*). Reed buntings arriving in autumn belong to northern and eastern groups of the subspecies *E. s. schoeniclus*, the bills of which are different from those of the subspecies living in Italy, called *E. s. intermedia*. Apparently, the two subspecies evolved only recently, by adopting different food during their winter season. In winter, *E. s. schoeniclus* feeds on small grass seeds, and therefore it strays from damp marshlands, and is often associated with other perching bird species, such as finches and sparrows. Instead, *E. s. intermedia* maintains its insectivorous diet even in winter, feeding on insect larvae it finds by pecking reed stalks, and thus remaining closely associated with marshlands.

**Wintering.** In winter, aquatic birds are the most commonly found species along Italian coastal marshlands, which regularly house more than 100 species and almost one million individuals. The list of wintering aquatic birds does not vary geographically within Italy, the only differences being associated with population numbers. Important factors in determining the structure of the community are the salinity and eutrophy of water, its depth, its area, and the presence of nearby wetlands. Generally speaking, the greater the environmental diversity, the larger the numbers of species, because diversity satisfies the ecological needs of many species, but also compensates for the temporary unavailability of some areas, due to changing environmental or climatic conditions - such as frost - or to human activities. As wetlands are not functionally disjointed areas, the identification of wintering populations in a specific area has little ecological and conservational meaning. The basic geographical units used to study aquatic bird populations are therefore groups of nearby areas sharing similar ecology and function. Knowledge of the ecological requirements of the various species and the use made of these areas are needed to identify these groups.

In Italy, groups of wetlands which may largely be considered as coastal lakes and brackish ponds, and which are internationally important as wintering areas because they regularly host aquatic bird populations of more than 20,000 individuals, are the ponds near Oristano, Sinis and Cagliari (Sardinia),



Flamingo nursery in the Valli di Comacchio (Emilia Romagna)

the Valli di Comacchio (Po Delta), the lagoon of Orbetello and the lake of Burano (Tuscany), and the lakes of Lesina and Varano (Gargano promontory). Selection of grounds according to the quantitative criterion of 20,000 individuals identifies the most important areas and the locally dominating bird species. However, their relative distribution - especially of the rarer species - in the various areas, with regard to the total size of the populations, is also important. Otherwise, key grounds for the survival of less numerous species, i.e., the most threatened, would not be identified. Conventionally, areas hosting at least 1% of a biogeographic population are considered internationally important. Here, the species the numbers of which are internationally important are five: flamingo (Stagno di Cagliari, Palmas-Sant'Antioco, Oristano-Sinis, Orbetello-Burano), black-necked grebe (*Podiceps nigricollis*: Comacchio), great white egret (*Egretta alba*: Comacchio, Orbetello-Burano, Oristano-Sinis), greylag goose (Comacchio, Maremma near Grosseto), and cormorant (*Phalacrocorax carbo*: Oristano-Sinis). Other species found in these areas are listed in the table on pages 136-137.

**Circadian use of the habitat.** Some species visit coastal wetlands by day or by night, alternatively. Their periodical movements are sometimes very conspicuous and evocative, and determine the ecological role of the area. Study of these movements is therefore important to evaluate bird populations correctly.

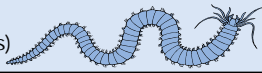



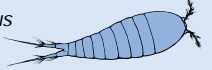
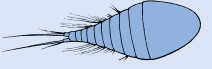



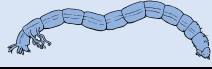
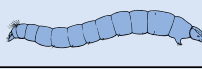
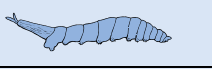
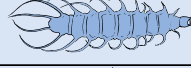

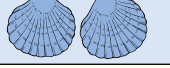
Among waders are various species that wander in search of food by day, and concentrate in particular places in brackish ponds by night. The most easily found winter roosting grounds are those of curlew (*Numenius arquata*) and golden plover (*Pluvialis apricaria*), because of the calls of these birds before building their nests. Harder to find and limited to southern Italy are the roosting grounds of stone curlew (*Burhinus oedicephalus*), an extremely elusive species even when gregarious, outside the breeding season. These species gather in *Salicornia* meadows and other shrubby vegetation, and choose places protected from terrestrial predators, generally isolated by water. In addition to their calls, other typical manifestations in roosting grounds are synchronised flights of flocks over the chosen area. The reason for these flights is still unknown, although they may be meant to attract birds of the same species or protect against raptors. In this period, several species of diurnal raptors, such as peregrine (*Falco peregrinus*), hobby (*Falco subbuteo*) and sparrowhawk (*Accipiter nisus*) fly to these areas to hunt. In Italy, rather than on waders, they prey on starling (*Sturnus vulgaris*), Italian sparrow, tree sparrow, reed bunting and swallow (*Hirundo rustica*) which, in different periods of the year, form large

Flamingos (*Phoenicopterus ruber*) are among the most typical animals of shallow, salty or brackish ponds. In the Mediterranean, these environments are found in coastal lagoons, retrodunal ponds, salt-pans, and in the few areas where tides reveal silty banks. Flamingos are a filtering species, although they also feed on molluscs and small fish. With their feet, they turn over the surface layers of the bottom to bring out annelids, crustaceans and larvae of dipterans and coleopterans. Feeding in large flocks optimises filtering. Flamingos nest in large colonies on silty or sandy islands and, in most natural grounds, breeding does not occur every year, but only when the water level is favourable, generally after heavy spring rainfall.

The demographic characteristics of this species are very peculiar among birds, as they are very long-lived – they may reach the age of 60 – they achieve sexual maturity only at 4 years, and lay only one egg at a time.

The Mediterranean community belongs to the subspecies *P. r. roseus*, recently proposed as a separate species, and lives between the Mediterranean and the western African coasts; exchanges have been registered with the Caspian community.

The number of nesting pairs in the Mediterranean may depend on cold currents which, in spring, flow from the Canary Islands along the coast of Mauritania, where a large wintering community may be found. These currents are rich in nutrients and considerably increase the productivity of these wetlands, so that many individuals nest locally instead of migrating to the Mediterranean.

1	<i>Nereis</i> (annelids)	
2	<i>Tubifex</i> (annelids)	
3	<i>Hydrobia</i> (gastropods)	
4	<i>Cerastoderma</i> (bivalves)	
5	<i>Cletocamptus</i> (copepods)	
6	<i>Metis</i> (copepods)	
7	<i>Gammarus</i> (amphipods)	
8	<i>Cyprideis</i> (ostracods)	
9	<i>Artemia</i> (anostracans)	
10	<i>Chironomus</i> (dipterans)	
11	<i>Halocladus</i> (dipterans)	
12	<i>Ephydra</i> (dipterans)	
13	<i>Berosus</i> (beetles)	
14	<i>Potamonectes</i> (beetles)	
15	<i>Acanthocardia</i> (bivalves)	

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
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Feeding chart of flamingos (data taken from the Italian magazine *Airone*)

Over 25,000 pairs nest in the Mediterranean, probably the highest number ever reached since Roman times. This is due to conservation and management policies adopted for this species in the basin of Fangassier, in the Camargue, where the regular nesting of one colony has been protected since the 1960s. It totals now 22,000 pairs. The rising numbers of this colony are due to improved protection of the species and habitats in which it breeds throughout the Mediterranean. In Italy, flamingos have bred regularly since 1993. The first nesting ground was the pond of Molentargius (Sardinia), followed by the lagoon of Orbetello (1994, but unsuccessfully used in the following seasons), the salt-pans of Margherita di Savoia (1996) and the Valli di Comacchio (2000). Settling of breeding pairs came after a slow increase in the wintering community. Today, the Italian nesting community is estimated around 3500 pairs, and about 14,000 individuals spend the winter here. When not in their breeding season, flamingos may be seen in various places, and at least 44 sites

have hosted wintering flocks in the last decade, although wintering distribution is rather concentrated: 90% of the community is found in nine sites and 50% in two (Ponds of Cagliari and wetlands near Oristano). Although flamingos are symbols of the conservation of nature, their rising numbers in Italian and Mediterranean wetlands have raised the issue of their sustenance with regard to their impact on habitats and other aquatic bird communities. Flamingos impoverish food sources used by other endangered species, such as shelduck and avocet, jeopardise available feeding grounds - such as *Ruppia* grassland - which is very important for many anatids (e.g., marbled teal *Marmoreta angustirostris* in Spain) - and compete with many species of gulls and teals for nesting grounds. It is therefore necessary to evaluate carefully their impact on a wide geographical scale, and perhaps control the size of the nesting community in the Mediterranean by managing its breeding grounds, i.e., allowing only a certain number of pairs, calculated on the basis of demographical parameters.

roosting areas in reed-beds in coastal wetlands. Starling roosts may be huge, with sometimes hundreds of thousands of individuals.

The roosting grounds of greylag goose are particularly impressive, and sometimes include a few cranes (*Grus grus*), a species which seldom winters in Italy today. The lives of these species, like those of all ducks, are deeply affected by hunting and other kinds of human activities in these birds' feeding grounds. During the day, many anatids gather in areas of little environmental value and/or extremely limited, but protected from disturbance, such as irrigation basins or sea stretches near wetlands, and only fly to their feeding grounds by night, when these areas are finally available. This gives rise to a diurnal distribution that does not mirror the actual value of the grounds, and hinders faunal conservation and management strategies.

Other species occupying these areas as roosts, but not only, are cormorant and pygmy cormorant (*Phalacrocorax pygmaeus*). Cormorants roost on trees, pylons and any other high constructions. Over the years, their presence is made visible by the large quantity of excrement that dries the vegetation underneath. Flights from feeding grounds to the roost, which may be as far as 40 km apart, begin 2-3 hours before sunset, and become intense in the last hour before sunset. Roosts are left with greater synchronism within 30 minutes after sunrise. Some wetlands, such as those near the lake of Varano, may be



Swallow (*Hirundo rustica*) near roost

both roosts and feeding grounds, although birds feeding there are fewer than those roosting. Pygmy cormorants, instead, avoid man-made constructions and gather on trees and shrubs near reed-beds.

Common and little tern hunt in small retrodunal ponds, but seldom nest there. Many of these ponds are either too ephemeral to guarantee safe breeding grounds, or are not sufficiently protected from human activities, whether tourism or vandalism.

During their breeding season, the cruising range of common tern is of about 20 km and of little tern 10 km, so they can wander over extensive grounds. In winter, they are replaced by sandwich tern, which wanders from coastal lakes to beaches. During migrations, these areas are visited by large numbers of little gull (*Larus minutus*) and black tern (*Chlidonias niger*), which capture insects at sunset.

During the day, gulls rest along calm, protected basins, where they preen their feathers and drink from lakes and freshwater springs. After storms, areas previously deserted may suddenly be occupied by thousands of common gulls, Caspian gulls (*Larus cachinnans*) and slender-billed gulls, which generally live along beaches and nearby sea stretches. Other typical seabirds, such as red-breasted merganser, great crested grebe and black-necked grebe, visit these areas during the winter, either to feed or shelter during storms.



Breeding colony of Mediterranean gull (*Larus melanocephalus*) and slender-billed gull (*Larus genei*)



Coypu (*Myocastor coypus*) in lake of Burano (Tuscany)

## ■ Mammals

Mammals, like birds, do not feature species that are exclusive to coastal lakes or brackish ponds, and few of them are associated with wetland ecosystems.

Generally, the zoocenoses of these environments contain mammal species that visit extensive and varied ecological units and wander to wetlands only occasionally. However, these very generalist species are the most widespread, and it may be misleading not to mention them.

Among insectivores are medium- to small-sized species (mole, shrew mouse, musk shrew), which generally feed on invertebrates, with only a few omnivorous species, one of which is often hedgehog (*Erinaceus europaeus*). Hedgehogs commonly visit these areas, but the small mounds of soil dug by common mole (*Talpa europaea*) and Roman mole (*Talpa romana*), two complementary burrowing species, are also a common sight. Common mole is typical in northern Tuscany, Umbria and Marches, and Roman in southern Italy, although they are not found in Sicily or Sardinia.

Among the shrews, Miller's water shrew (*Neomys anomalus*) is perhaps the only species associated with aquatic environments, although these sunny habitats are visited by thermophilous shrews such as Savi's pygmy shrew (*Suncus etruscus*), white-bellied shrew (*Crocidura leucodon*) and white-toothed shrew (*Crocidura suaveolens*).

Some species of bat generally hunt along stretches of water or canals, such as long-fingered bat (*Myotis capaccinii*), Daubenton's bat (*Myotis daubentonii*), noctule (*Nyctalus noctula*) and Kuhl's pipistrelle (*Pipistrellus kuhlii*).

The geographical distribution and ecological preferences of insectivores and bats are still largely unknown, especially in brackish ecosystems.

All Italian lagomorph species - mountain hare obviously excepted - visit the driest wetlands. European rabbit (*Oryctolagus cuniculus*), a species native to the Mediterranean maquis, which colonises several other environments, is found on well-drained sand, where it can burrow its lairs.



Common mole (*Talpa europaea*)

Hare is rarer, although the three Italian species may all be found in their favourite places. They are common hare (*Lepus europaeus*), Apennine hare (*Lepus corsicanus*) and Sardinian hare (*Lepus capensis*).

Among rodents, harvest mouse (*Micromys minutus*) is only found in the wetlands of the Po Delta and at Padule di Fucecchio in Tuscany, but it may also live in Latium and Campania. This species is not exclusive to coasts, and is in fact generally found in rice-paddies and inland marshes among reeds. However, it also lives in brackish wetlands along the Po Delta, in high grassland, mounds and riverbanks.

Another rodent that prefers freshwater, but also brackish habitats covered with vegetation, is Eurasian water vole (*Arvicola terrestris*). Both harvest mouse and Eurasian water vole populations are declining in Italy, probably due to mechanical cleaning of canals and water pollution. Eurasian water vole may also compete with coypu (*Myocastor coypus*), an American species now naturalised and widespread in Italy.

Like most of the species treated so far, coypu also loves freshwater or mildly brackish environments, as it feeds and shelters in lush vegetation. Coastal wetlands are often severely degraded and large populations of Norwegian rat (*Rattus norvegicus*) and black rat (*Rattus rattus*) are very common. The latter is



A litter of Norwegian rat (*Rattus norvegicus*)

generally found near pine woodland. Both species have a severe environmental impact, as they prey on nests and chicks of birds nesting on the ground, such as waders, gulls and terns.

In areas surrounded by Mediterranean maquis or woodland, footprints and quills indicate the presence of European porcupine (*Hystrix cristata*). This species is moving northwards, and has recently reached southern Liguria and the Po Delta.

The only carnivorous species that may be considered aquatic is otter (*Lutra lutra*). Unfortunately, it has been extinct in all coastal wetlands for many years, and its small communities are only found along a few streams in southern Italy. Until the 1980s, the species lived in the lake of Burano, but its typical pungent-smelling marks have not been recorded since 1987-1988. Degradation and poor conservation of coastal wetlands make re-introduction of this species in the near future highly unlikely.

The most common, probably ubiquitous carnivorous species are fox (*Vulpes vulpes*) and weasel (*Mustela nivalis*). Polecat (*Mustela putorius*) is perhaps the mustelid that most frequently lives in aquatic environments. It is generally found along freshwater channels, but may wander as far as coastal dunes and other habitats near salty, brackish areas.



The banks of coastal lakes and ponds are ideal habitats for Norwegian rat

## Conservation and management

SERGIO PARADISI · FABIO PERCO · LORENZO SERRA

By the mid-20th century, reclamation of wetlands had been completed. Since then, the conservation and management of coastal wetlands have become essential issues for the conservation policy of Italian natural resources.

The great number of species included in the EU Birds Directive (79/409/EEC), the presence of rare and endemic species listed in the Habitat Directive (92/43/EEC), the importance of the landscape, and growing awareness of proper ecological use, all make coastal lakes and brackish ponds extremely interesting from the conservational viewpoint. However, at present, natural management presents striking contrasts between the economic interests involved in the exploitation of resources (fishing, fish-farming and hunting), on one hand, and, on the other, the overwhelming pressure of expansion exerted by new urban building, together with tourist and industrial facilities.

Unfortunately, anthropic pressure in these areas has not been relaxed since reclamation works were carried out. On the contrary, it has continued on a large scale, especially with the development of tourist complexes, which have slowly and inexorably destroyed the few remaining sanctuaries along Italian coastlines.

This chapter analyses the causes of degradation, but particularly focuses on conservation issues and the effectiveness of preservation, and suggests successful restoration modes for these habitats, which have now been adopted in many protected areas.



A wildlife sanctuary equipped for walkers and naturalists in the Valli di Comacchio (Emilia-Romagna)



## ■ Fish-farms

The survival of brackish coastal environments and the fish that inhabit them is often associated with various types of fish-farming. On one hand, preservation of this economic activity is carried out through conservation practices, involving the protection of bars from erosion and maintenance to prevent silting-up. On the other, fish-farming itself may be a problem, both when it is carried out by traditional extensive methods, and when it exploits modern techniques.

In recent years, fish-farming in brackish water has often had to face progressive environmental degradation and other limiting factors, such as marked decreases in the natural birth of fry, an event which lies at the base of production. Farmers have thus had to buy fry caught elsewhere or produced with the modern techniques of artificial insemination, which are quite expensive.

Inexperienced amateurs capture large numbers of coastal fish, the populations of which are already falling, and thus contribute to a further reduction in their numbers, giving rise to a true vicious circle.



Fishing-boats on lake of Varano (Gargano, Apulia)

Traditional fish-farming has been implemented with farms applying intensive methods that yield a few kilos of fish per square metre of basin, enabling the introduction of large-sized fish which can guarantee higher survival rates. These farms have economic but also psychological advantages, as they renew interest in this activity.

The need to invest in the possibility of creating new jobs leads to the restoration and maintenance of accessory conservational activities which, in the past, were carried out systematically and carefully, and which aim at preserving these fragile biotopes over time.

The other side of the coin is the spoiling of the landscape. New farms must therefore tend to be as inconspicuous as possible and to limit the discharge of nutrient-rich water in the basins. The fertilizing effects of these waters may also increase the production of fish in intensive fish-farms, but the risk of eutrophication is such that there must be a correct balance between the two methods of fish-farming.

In these delicate environments between land and sea, the search for new forms of co-existence between man and nature has continued for centuries, but the problem cannot be said to have been solved yet.



Severely degraded wetlands near Golfo di Augusta (Sicily)

## ■ Conservation of birds and mammals

Loss and alteration of habitats are the main threats to bird and mammal communities in coastal ponds. Although reclamation of land was complete by the early 1960s and many coastal wetlands are now protected in some way, slow, inexorable destruction still continues.

The construction of new industry and extensive urbanization of coastlines have hindered the preservation of coastal wetlands. They have remained ecologically isolated, besieged by towns and subjected to various forms of pollution. These changes have caused the disappearance of extensive agriculture and lagoon fish-farming, which guaranteed the survival of almost natural ecosystems where animals could shelter and feed. In addition to this, subsidence and erosion of coastlines have further thwarted conservation.

Small wetlands are either almost entirely protected or totally abandoned. This makes their management easier, although they are seldom large enough to host vital or numerous animal populations. Bird and mammal communities are therefore small, and some species may only be found during particular stages in their lives. Large wetlands, which are potentially more important and deserve protection, are subjected to mixed conservation policies, which are seldom, if ever, compatible.

Fishing, for instance, inevitably clashes with the protection of the original fish or fish-eating birds and mammals. For instance, fish-farms pollute water extensively and destabilise the entire ecosystem by destroying food chains. Aquatic sports and equipment (water skiing, water scooters, etc.) greatly disturb animals, especially during their breeding period. Hunting, in addition to killing animals directly, also disturbs and pollutes.

The lead in cartridges is deposited on the bottom of basins and reaches very high concentrations in areas where hunting is permitted, and is one of the main causes of poisoning in various anatid and mud-dwelling species. Lead pellets are deliberately swallowed by birds, which mistake them for the small 2-3-cm pebbles they usually swallow and keep in their gizzards to help their digestion.

As of today, all attempts at introducing non-toxic pellets in the lead alloy used to manufacture bullets for hunting purposes have failed, due to the strenuous opposition of Italian hunting associations, although non-toxic pellets have been used for over 30 years in the United States and have recently become compulsory in various European countries.

Measures for the preservation of fauna are part of a larger biodiversity preservation project of the Rio Agreement. EU members have provided

guidelines for the protection of this common heritage by means of various laws and agreements.

The EU Birds Directive (79/409/EU) aims at protecting the species listed in Annex 1 by identifying the most important sites for bird protection - called Special Protection Areas - safeguarding them against any form of pollution, deterioration or disturbance.

The EU members are required to provide a list of their Special Protection Areas, the number and extent of which meet the requirements of the Law. Its application is funded by the EU, by means of ACE (Actions by the Community for the Environment), ACNAT (Actions by the Community relating to Nature Conservation), and also LIFE - Nature.

This last, specific law is completed by the Habitat Directive (92/43/EU), which aims at protecting the natural habitats listed in Annex 1, associated with the plant and animal species listed in Annex 2. The final goal is to create a network of protected areas called Nature 2000. This network will be composed of Special Protected Areas identified by the EU Birds Directive, together with other areas called Community Important Sites, identified by the Habitat Directive.



Sediments are also excavated to keep the bottom level constant



Vegetation is often composed of a mixture of spontaneous plants (*Phragmites australis*) and cultivated species (*Arundo donax* of central Asian origin)

In addition to this, EU members must identify and regularly monitor the conservation conditions of habitats and species listed in Annexes 1 and 2. The European funds needed for the application of this law are called LIFE.

Among the international agreements affecting coastal wetlands directly are the Ramsar Agreement on internationally important coastal wetlands, the Bern Agreement on wildlife conservation, and the Bonn Agreement on conservation of migrants. This last agreement aims at preserving and rationally managing migrating populations worldwide.

The most important agreement, however, is the African-Eurasian Migratory Waterbird Agreement, which focuses on those aquatic birds migrating between the African and Eurasian continents. As these species are associated with fragmented environments, they are particularly affected by human activities. Unfortunately, Italy has not yet ratified this agreement, despite the fundamental role it plays for migrants crossing its territory and resting on it. This further weakens the conservation strategies of the agreement.

#### ■ Environmental restoration of wetlands

EU Directives 409/79 and 43/92 include several species of European interest, the habitats of which must be preserved by the EU members. Most of these species typically live in wetland ecosystems, i.e., peat bogs, marshes, swamps, streams, and lakes up to 6 m in depth, as specified in the Ramsar Agreement. All these areas are unstable over time, and their conservation clashes with man's tendency to limit, or even totally preclude freedom to these ecosystems.

For instance, in civilised Western Europe, lagoons, deltas and retrodunal ponds (if they still exist) are no longer free to transform themselves gradually and naturally, because banks, dams, piers to consolidate beaches, etc. are built all around them to protect the nearby towns and crops.

Basically, when preserving wetland ecosystems in populated areas, authorities end up safeguarding peculiar habitats by managing small, surviving natural areas, because human presence hinders modification of large portions of territory. Although it is essential for these ecosystems to be free, in the end the areas actually protected are very small and practically besieged and jeopardised.

In these conditions, an important starting point is the analysis of ecological factors which most affect these ecosystems, such as water availability and the various stages of vegetational succession. Degradation and extinction of habitats often depends on lack of surface water, either due to watertable

Taxonomically, aquatic birds belong to the following families: loons, grebes, pelicans, cormorants, herons and bitterns, storks, spoonbills, flamingos, ducks, geese and swans, cranes, rails, coots, crakes and gallinules, oystercatchers, avocets and stilts, thickknees, courses and pratincoles, plovers, sandpipers and curlews, gulls and terns.

Most of them are ecologically associated with wetlands. This identification provides objective parameters to identify important sites that must be protected according to the Ramsar Agreement, after they have been added to a special list provided by each member country.

Since this list was drawn up, the group

of aquatic birds has also been used regularly for scientific, geographical, administrative and political purposes. The Ramsar Agreement marked a turning point in the history of the conservation of nature, as it is the first international agreement that identifies and recognises the need unanimously to address policies for environmental conservation worldwide.

The chart below lists the species constituting at least 5% of aquatic birds wintering in one of the five main wetlands included in "coastal lakes and brackish ponds".

Figures exceeding this threshold within the same site are in bold type (figures show average number of individuals in January between 1991 and 2000).



	VALLI DI COMACCHIO	LESINA AND VARANO	BURANO AND ORBETELLO	PONDS OF CAGLIARI	ORISTANO AND SINIS
<b>Cormorant</b>	782	<b>1848</b>	706	<b>1201</b>	<b>5324</b>
<b>Flamingo</b>	13	0	1092	<b>3663</b>	<b>3246</b>
<b>Widgeon</b>	<b>1989</b>	170	<b>1705</b>	<b>1630</b>	<b>2390</b>
<b>Teal</b>	1129	515	<b>1266</b>	<b>1318</b>	<b>3139</b>
<b>Mallard</b>	<b>4283</b>	9	<b>1399</b>	906	1584
<b>Pochard</b>	946	<b>4318</b>	<b>2795</b>	148	<b>8589</b>
<b>Coot</b>	<b>14749</b>	<b>14670</b>	<b>8278</b>	<b>4302</b>	<b>9541</b>
<b>Lapwing</b>	697	20	<b>1179</b>	<b>1570</b>	<b>2329</b>
<b>Red-backed sandpiper</b>	330	72	550	<b>2675</b>	626
<b>Herring gull</b>	<b>2950</b>	365	835	<b>1573</b>	2104
<b>Black-headed gull</b>	1249	<b>3054</b>	<b>1320</b>	<b>2133</b>	<b>2835</b>
<b>NUMBER OF SPECIES</b>	70	48	72	70	75
<b>NUMBER OF INDIVIDUALS</b>	34396	28847	24963	26127	49565



Antagonistic behaviour between two blackwinged stilts (*Himantopus himantopus*)

lowering following agricultural interventions by man, or lack of direct supply and excessive permeability of the soil. Once this problem is solved, perhaps by relying on rainfall and restoring the typical habitats of various species in limited areas, only a restricted number of species can be included in the preservation programme. If wetland areas are larger, this becomes a less pressing issue, and various biodiversity levels may be taken into account, each of which has specific relevance.

A brief analysis of environmental types of natural importance still existing in Italian coastal wetlands shows that some of them have been negatively affected by man - in Italy far more than in other countries - and the areas considered are freshwater and brackish marshlands, and especially flooded grassland, wetlands, swamps and, generally, temporary marshlands.

The seasonal quantity of water in these biotopes is so variable that they may completely dry up for lengthy periods. This favours rare and migrant species like collared pratincole (*Glareola pratincola*). Many important species in Europe are adapted to these variable environmental conditions, such as most amphibians, which breed in ponds or ponds without fish. Newts and frogs (and fish, if any) are important links in the food chain, at the top of which are large predators (such as ardeids, some raptors, and otter), and their large numbers depend not only on the area covered by a certain habitat but also its vegetation.

Shallow freshwater marshlands, when free to develop, are colonised by very dynamic and invasive plant species. The ecological development of a new swamp may be thus divided into: a first stage with free water and lush, submerged vegetation (stonewort and/or various species of aquatic phanerophytes).

At this stage, the main species are those feeding on these plants, such as many anatids, among which, in clear water, are the rare ferruginous duck (*Aythya nyroca*) and various charadriiform waders, like green sandpiper (*Tringa ochropus*), which feed on large numbers of aquatic invertebrates. When the prey is not too small (as when predators colonise areas which have been flooded some time previously), the habitat may be colonised by rare species such as spoonbill (*Platalea leucorodia*) and glossy ibis (*Plegadis falcinellus*).

The second stage regards fully developed reed-beds, which occur after the invasion of emerging macrophytes (generally sedges and grasses), spreading beyond the margins of marshlands. Shade by the thick plant cover means that the development of both submerged vegetation and aquatic invertebrates is hindered.

This has a negative effect on many mud-dwelling birds (among which a typical species is blackwinged stilt - *Himantopus himantopus* - which loves open, eutrophic bodies of water), but may nevertheless be interesting for the inconspicuous presence of important species like bittern (*Botaurus stellaris*), little bittern (*Ixobrychus minutus*), purple heron (*Ardea purpurea*), squacco heron (*Ardeola ralloides*), marsh harrier (*Circus aeruginosus*) and many others.

The sub-stage called *thick and mature reed-bed*, in which free water further diminishes, may favour the presence of some rails and perching birds, typical of these environments, but is generally characterised by shrubs and the first trees. These anticipate scrub and true hygrophilous woodland, both of which grow later.

Normally, scrub is not a particularly interesting stage if it covers a large area, as it does not host very important species. The only exception is when these areas are chosen as breeding grounds by colonial species, such as ardeids like *Egretta garzetta* and *Nycticorax nycticorax*, and sometimes *Ardeola ralloides*.



The banks of coastal lakes sometimes have small landing-stages (Lake of Lesina, Apulia)

Tamarisks, so beautifully described by the Italian poet Gabriele D'Annunzio, are a particular feature of vegetation near coastlines and brackish marshland. No other tree suited to the Italian climate can better withstand soil and aerosol salinity near the sea. The exceptional vigour of tamarisks in harsh environments, which is due to particular adaptations - tiny, scale-like leaves that prevent water loss, highly effective metabolism in eliminating excessive salt - has long been known. This is why, although tamarisks are spontaneous in the Mediterranean, man has favoured their growth not only as ornamental plants, but also to consolidate coastlines.

Tamarisks, which are probably native to sub-desert areas of central Asia, are now a typical feature of the Italian coastal landscape. The tree-like African tamarisk (*Tamarix africana*) and the shrubby French tamarisk (*Tamarix gallica*) are coastal species. Other tamarisk, with their pretty pink flowers, were introduced as ornamentals in both seaside towns and parks and gardens. Although tamarisks are primary food sources for a few species of beetles and bugs, most of the insects living on them are occasional, as these plants - often used to create windbreaks - are natural interceptors of flying insects. Beetles associated with tamarisks feed on their buds, leaves and flowers. Among the most frequently found are shining beetle (*Mimela junii*), leaf beetle (*Stylosomus tamaricis*, *Altica tamaricis*) and weevil (*Coniatus tamarisc*), the specific names of which indicate their association with the plants they feed on. However, the most typical are the numerous, small apionids feeding on



the floral capsules of tamarisks, such as *Corimalia* (*C. pallida*, *C. tamarisc*, and others), with their extremely mimetic yellowish colouring with tiny dark spots. Xylophagous beetles, i.e., those feeding on trunks and branches (branch and twig borers and jewel beetles) are also frequent, together with their predators (ladybugs and soft-winged flower beetles). Bugs also feature a few phytophagous species almost exclusive to tamarisks. Among them are plant bug (*Tuponia tamaricis*) and chinch bug (*Artheneis foveolata*). Among homopterans are leafhoppers, some soft, wax and tortoise scales (*Trabutina leonardii*, *Chionaspis etrusca*) and jumping plant lice (*Crastina loginovae*).

The larvae of several butterfly species live in close trophic relationship with tamarisks. Examples are the small gelechids *Ornativava tamiriciella* and *O. plutelliformis*, the elegant pterophorids *Agdistis tamaricis* and *A. meridionalis*, and the pyralid *Lepidogma tamaricalis*, whose larvae live in typical silky nests built on the tops of branches. Geometrids are represented by *Eupithecia ultimaria* and *Semiothisa aestimaria*, whose caterpillars mimic plant colours. There is also one representative of the noctuids, *Clytie illunaris*.



Alimini Grande lake near Otranto (Apulia)

It is worth noting that the transition from reed-bed to woodland is often marked by the growth of allochthonous infesting plant species like *Amorpha fruticosa* or false indigo, which is extremely difficult to eradicate. When the area is completely covered by woodland, it becomes of interest again, because it now contains woodland species, which differ from those of protected wetlands.

This, together with the very lengthy period needed for full-fledged woodland to develop, leads to priority restoration (as these wetlands evolve at different times in different areas), towards open marshland and reed-beds.

Extensive, temporarily flooded areas have limited fish populations, which enable the mineralisation of organic matter, and this enhances the biological productivity of the site, reducing hazardous situations, such as botulism. It is worth remembering that, in Italy, the summer mortality of small- and medium-sized aquatic birds is very high, due to poisoning by *Clostridium botulinum*, a devastating bacterium.

As an overall, lasting balance over extensive areas is highly unlikely, the only solution must be specific management which, given certain conditions, yields various advantages.

Many interesting solutions have been tested in the experimental area of the Island of Cona (Natural Reserve of the Isonzo delta, province of Gorizia, Friuli Venezia Giulia).

For instance, emerging macrophytes are controlled by at least three highly effective herbivorous species like horses, oxen and greylag geese (*Anser anser*). A group of about 20 horses roams over a total area (divided into fenced sub-areas) of 100 hectares, and 20-30 oxen graze between spring and autumn, i.e., when the vegetation cover is lush.

The introduced gaggle of geese now amounts to over 100 specimens (and growing), which joins another, larger group previously introduced in other regional natural reserves of Friuli Venezia Giulia (Valle Cavanata, Valle Canalnovo, delta of the Stella).

The results of this management are now being studied, but partial data clearly show that experiments are so far promising, because the action of herbivorous species, particularly of pre-existing individuals (and their spatial distribution, in the case of mammals) may keep wetlands in a permanently initial ecological stage, preventing or greatly reducing the feared scrub stage in undesired areas.

The results of this peculiar, seemingly complex management, which only re-creates a pristine ecological condition, appear to be very interesting, as they preserve ecosystems, habitats and species, the spatial distribution of which is naturally unpredictable, over small areas and lengthy periods.

## Suggestions for teaching

MARGHERITA SOLARI

### ■ Osmosis and fish

- Objectives: to understand the relationship between physiological adaptations of organisms and their environment; to study the osmotic processes regulating saltiness; to identify fish species.
- Level: elementary school pupils (8-10 years) and junior high students.
- Collaboration: possible collaboration with a fish-farming expert.
- Tools: laboratory equipment (scales beakers, funnels, semi-permeable film or greaseproof or parchment paper), sugar or salt, rubber bands, literature.



#### PRELIMINARY STAGE

1. To show the osmotic process through a simple laboratory experiment. The funnel tube is wrapped in parchment paper and secured with a rubber band. A concentrated solution of salt and water or sugar and water is poured into the funnel, and the level is marked with a felt pen. The funnel is then inserted into a beaker filled with distilled water so as to cover the tube completely. This allows the passage of water from the beaker to the funnel, and the level of the solution rises. The experiment is repeated by inverting the starting conditions (concentrated solution in the beaker and distilled water in the funnel). In this case, the level of the liquid in the beaker rises. This shows that, through semi-permeable films, water passes from less to more concentrated solutions. These experimental conditions also demonstrate their similarity with the physiological ones in fish in freshwater and in the sea, whereby cell fluids are more and less concentrated in comparison with those of the surrounding environment.
2. To analyse the physiological processes regulating the concentration of physiological fluids with regard to the environment (production of water through urine, production of salt through glands, absorption of large amounts

Area equipped for birdwatching (Pialasse di Ravenna, Emilia Romagna)



of water through the intestine, muciferous glands which hinder absorption of water through the skin).

3. To be aware of the great subtlety of these processes, which make fish poorly adaptable to salinity variations in the environment. To learn about euryhaline and stenohaline conditions.

#### CONTINUATION OF WORK

4. Discuss the characteristics of water in coastal lakes, particularly changes in salinity due to various factors and easily identifiable (periods of severe evaporation, rainfall, introduction of freshwater from tributaries, permeability of the soil, infiltration of seawater, tides, etc.).

5. Divide the class into groups to identify, through several sources, the fish species caught in coastal lakes and to compare them with those fished in freshwater and in the sea in the same area; research may use various references, but work on the spot is necessary, such as interviewing fishermen, fish-farmers, or visiting fish markets and interviewing vendors.

6. Compare the results of the various groups and identify the most common species found in the coastal lake environment.



Old mill in the lagoon of Orbetello

7. Study the characteristics of the species found: euryhaline conditions, food, life-cycle, migration for breeding or trophic reasons, breeding, farming and fishing possibilities (with regard to their lifestyle: e.g., fishing by day or by night, in a particular season, etc.).

8. Discuss the economic importance of fishing in coastal areas. Examine fish-farming as an activity which may preserve the environment by managing coastal areas and their resources properly.

#### ■ Long journeys between water and sky

- Objectives: to understand the most important stages in the lives of birds; to develop the ability for observation, analysis and comparison.

- Level: pupils aged 9-14.

- Possible collaboration: a nature expert or ornithologist.

- Tools: suitable clothes for excursions, a sufficient number of binoculars (at least one every two pupils), cameras for the excursion, literature, stationery for final work, documentaries showing migrating birds.



Oystercatcher (*Haematopus ostralegus*) are rare and localised



Flamingos (*Phoenicopterus ruber*)

#### PRELIMINARY STAGE

1. Identify a suitable coastal lake for the group excursion. Discuss the excursion with a guide and identify four or five species likely to be found in the season planned for the excursion. Prepare bibliography on these species (e.g., ducks, greylag geese, herons, etc.).

#### CLASSWORK

2. Watch a documentary on migrants - a few minutes may suffice to arouse interest and elicit discussion.
3. Describe in a simple way, and with photos, the various stages of a bird's life, from egg hatching to parental care, juvenile stages, breeding and moulting.
4. Discuss the bird species of the area which are known to the pupils, and distinguish between stationary and migrating ones.
5. Analyse the reasons of migration in various species (food, breeding, wintering, moulting), and the processes determining it (orientation, socialization, resting periods, etc.).
6. Analyse the lives and migrating flyways of the identified species; draw up short descriptions of the birds and mark their flyways on a map (presumably Northern Europe and North Africa).
7. Discuss the coastal lake environment as a resting, breeding or moulting ground. Mark the main Italian coastal lakes on a map.

#### EXCURSION

8. Excursion with a guide; pupils learn how to use binoculars and then take notes.

#### CONCLUSIONS

9. Pupils are asked to write a report on the excursion, including their personal comments and opinions on the importance of preserving coastal lake habitats for the species of passage which shelter there.
10. Prepare panels sketching the work done, in order to prompt other students to respect the environment.

#### POSSIBLE FURTHER RESEARCH

11. If the examined area contains particularly interesting bird species, such as kingfishers, penduline titmice, herons and flamingos, further research may follow the general study. This may include the relationship between the morphology, functions and lives of these animals, e.g., shape of legs and toes, type of flight, colour of feathers, type of nests, shape of bills and food (see the flamingo section, pages 120-121).

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Basic text, although dated in some parts, of the ecology of brackish waters. It is recommended reading for all those who wish to learn more about the ecology of these environments.

SACCHI C. (ed.), 1980-1983 - Guide per il riconoscimento delle specie animali delle acque lagunari e costiere Italiane (*"Field guides to animals in Italian lagoons and coastal waters"*). Consiglio Nazionale delle Ricerche, collana del progetto "Promozione della Qualità dell'Ambiente".

This series, unfortunately still incomplete and now somewhat out of date, on how to identify marine and brackish-water species, is nevertheless a useful aid.

SPAGNESI M. & DE MARINIS A.M. (eds.), 2002 - Mammiferi d'Italia (*"Italian mammals"*). Quaderni di Conservazione della Natura. Ministero per l'Ambiente e Istituto Nazionale per la Fauna Selvatica. A brief volume on Italian mammals, taken from the *"Iconografia dei Mammiferi d'Italia"*, by the same publishers.

TONOLLI V. 1964 - Introduzione alla limnologia (*"Introduction to limnology"*). Ist. Italiano Idrobiologia, Verbania-Pallanza.

Although forty years old, this work is still of great value for its general description of brackish-water

## Glossary

- > Anoxia: lack of oxygen.
- > Association: basic phytosociological unit; in syntaxonomy, it corresponds to the concept of "species", referring however to vegetation.
- > Astatic: subject to variations in level.
- > Brachypterous: (insect) with abnormally small wings, flightless.
- > Brackish: salt content between 1.5‰ and 35‰.
- > Class: the apical unit in phytosociology, which includes orders, alliances and associations.
- > Climatic climax: referring to vegetation which has reached maximum evolution (climax) in given environmental conditions.
- > Colony: group of nests of one or more species of birds (monospecific vs heterospecific colony); when nests are scattered over a large area but breeders show social behaviour, colonies are called "lax".
- > Ecotone: transitional environment between well-defined habitats.
- > Endemic: organism with distribution restricted to a well-defined geographical area.
- > Exopercolative: referring to soils in which water tends to move upwards by evaporation.
- > Euryhaline: organism which can live in environments with a wide range of salinity.
- > Fossorial: organism adapted for digging the soil, where it usually lives.
- > Garrigue: short, degraded maquis of the Mediterranean area formed by scrubland.
- > Haline: salty.
- > Halophile: organism living in brackish waters or salt-impregnated soils.
- > Halophyte: plant specialising in living in a salty environment.
- > Hygrophile: organism which seeks moisture.
- > Macropterous: insect with fully-developed wings and generally capable of flight.
- > Migrations: periodic movements during which animals migrate from their breeding grounds to winter quarters or vice versa; movements which do not include an obligatory return to the point of departure and have no preferential direction are known as phenomena of dispersal or nomadism.
- > Moulting: in birds, the periodical shedding of feathers.
- > Parenchyma: plant tissue with cells specialising in different functions.
- > Phanerogam: vascular plant which develops flowers.
- > Phytophage: organism which feeds on plants.
- > Plumage: feathers, characteristic of birds.
- > Psammophile: organism which lives exclusively or prevalently in sandy environments.
- > Remiges: the flight feathers of birds' wings: they are subdivided into primary remiges, which grow near the carpometacarpals and phalanges, and secondary remiges, which grow near the ulna.
- > Seasonal phenology: the study of seasonal phenomena; in ornithology, these include migration periods and dates of egg-laying.
- > Sexual dimorphism: existence of differences in appearance between the males and females of a species.
- > Succulent: plant with abundant water parenchyma.
- > Xylem: synonymous of vascular tissue in wood, the principal function of which is upward translocation of water and solutes.

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