BIOGEOGRAPHIA
The Journal of Integrative Biogeography

*Biogeographia – The Journal of Integrative Biogeography 2024, 39 (1): a034*
*https://doi.org/10.21426/B639162588*

# Long-term trend of Italian breeding forest birds and comparison with the other Mediterranean peninsulas

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**Keywords**: breeding forest birds; distribution limits; distribution over 150 years; fires; influence of man; islands; peninsulas; species list.

**SUMMARY**

The author has carried out a bibliographic survey of the status of breeding forest birds in Italy over 15 decades (1872-2022) in order to establish an objective long-term trend (stable, increasing, decreasing, etc.). The number of breeding forest birds in Italy amounts to 66; their distribution, with a few exceptions, indicates that they are widespread in Eurasia, but only a small percentage of Eurasian forest species have colonised Italy and the other Mediterranean peninsulas, namely 55 in Iberian, and 71 in Balkan peninsulas; a small percentage of them (between 19.7 and 22.5%) belongs to trans-Saharan migrants, and between 29.6 and 40.0% increases their populations in winter. The similarity between the forest species on the three peninsulas (Iberian, Italian, and Balkan) results between 0.44 and 0.48, indicating a certain difference in the overall avifauna in the three territories. Not all species have penetrated southwards into the three peninsulas; for example, some that stopped in the Italian Alps have instead arrived in the forests of Greece, at a latitude corresponding to southern Italy, or species that in Italy stopped in the northern Apennines in the other two peninsulas have instead arrived far south. The Iberian peninsula and the island of Corsica hold three endemic species among breeding forest birds; the Italian and Balkan peninsulas have no endemic species. A tentative reconstruction of the climatic vicissitudes of the Mediterranean has been made to explain why only broadly distributed Eurasian forest species have penetrated the Mediterranean peninsulas. Overall, the Mediterranean presently hosts mainly neo-endemic taxa among forest bird species; the only paleo-endemics can be considered the three species of nuthatches living in Corsica, Algeria, and Turkey (other than Caucasus and the islet of Lesvos) and Le Vaillant's woodpecker in the Maghreb (North Africa). Italian forests presently cover ca. 40% of the land surface, increasing since 1980', but 22% of woodland is not of natural origin (3.3% due to afforestation). However, it is difficult to know the true increase of forests, because some of them are fired every year, and this kind of statistics are lacking.

## INTRODUCTION

From the ornithological point of view, the Mediterranean area is one of the most explored regions, but for at least two millennia it has also been among the most densely populated areas by humans and most exploited by agriculture at the expense of forest areas. As for the forests that used to cover Italian territory, much of them have been taken away to make room for agriculture; this has undoubtedly caused a decline in forest bird species, however, lower than what is known for species living in other environments. Italian forest bird populations, like those in the rest of the Mediterranean area, are still substantial and undoubtedly deserve special attention from a biogeographical and conservationist point of view.

Altogether, over the last two centuries, the populations of some species of Italy's avifauna have gone into definitive extinction and others have undergone an unprecedented decline, due to direct and indirect anthropic pressure. The extinction of species in Italy is mainly due to man's increasingly intrusive activities over the millennia, but especially in the 20$^{th}$ century, when the vast majority of extinctions have been recorded in the country (Gustin et al. 2019). However, in the present century, as if to counterbalance the decline of some species, other birds are experiencing increases previously unreported in Italy, in some cases already recorded in other European countries. Recently, some forest species begun a process of colonization of environments that are covered by tree vegetation, but are generally planted by man, like urban habitats. For example, woodpigeon *Columba palumbus*, blackbird *Turdus merula*, magpie *Pica pica*, jay *Garrulus glandarius* and serin *Serinus serinus* since the 1980-1990s have started to colonise urban areas and have become an integral part of the avifauna of built-up areas (Lardelli et al. 2022).

At the same time, it is difficult to understand the reasons for the decline of some species; it is not always clear whether it has been the excessive hunting, the destruction and fragmentation of some habitats, the climate change, or in the case of forest environments the fires, generally arson, that occur more frequently and violently each year (Pepe et al. 2020). Increasing the extent of areas covered by large forest fires in Italy in the last fifteen years, in 2023 approached 69,000 ha, including more than 10,000 ha of forest ecosystems; the forests involved are largely Mediterranean scrub and oakwood (61%) and areas covered by coniferous forests and afforestation (21%). Eighty-nine percent of the areas burned in 2023 are in Sicily (72%) and Calabria (17%) (data after the ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale https://www.isprambiente.gov.it/). Thus, undoubtedly the fires could be one of the main local causes of the decline of some forest and scrubland bird species, particularly those that are more demanding and have a rather specialised ecological niche (e.g., woodpeckers, treecreepers, etc.).

Italy has a total land area of 302,073 km$^2$, while its present wooded surface is about 120,000 km$^2$, amounting to ca. 40% of the total surface (Marchetti et al. 2012, Agnoletti et al. 2022). Forests historically occupied a large part of Italy's land area, but as early as Roman times they were reduced for various reasons (use of timber for shipbuilding, modification of the soil to make it arable, etc.). At the beginning of the last century, however, substantial afforestation activity took place that increased the wooded area. According to recent statistics, the surface of forests in Italy presently is increasing, but not all forests are equal, there is a big difference between natural forests and afforestation, of course. About 65,630 km$^2$ (22% of total Italian land area) of the contemporary forests surfaces do not have a natural origin, but are the result of secondary successions occurred on abandoned farmed land since 1888; ca. 10,000 km$^2$ (3.3%) are due to afforestation carried out between 1883 and 1939, and between 1952 and 1972. About 80% of them was done with conifers, mostly black pine, sometime replacing previous broadleaved woods (Agnoletti et al. 2022).

During the course of our lives, it is rather difficult to have clear-cut answers as to the trend of species, but if we go through the past through the bibliography, we can gain a much better insight into the population dynamics of different species. The aim of this study was precisely to try to understand the old origin of Italian breeding forest birds and to investigate the evolution of their long-term trend over a fairly long period, from 1872 to 2022, i.e. 150 years, for which a conspicuous bibliography is available. Since here we are talking about the entire Italian forest surface, it will not be possible to subdivide forests by tree species and characteristics, but we will try to make some distinctions in the discussion.

## MATERIALS AND METHODS

Four periods were chosen between 1872 and 2022 in order to obtain an overall trend of breeding forest birds in Italy: a) before 1872 (Salvadori 1872); b) 1873-1929 (Martorelli 1906, Giglioli 1907, Arrigoni degli Oddi 1929); c) 1930-1993 (Schenk 1976, Meschini and Frugis 1993); d) 1994-2022 (Brichetti and Fracasso 2003-2022, Corso 2005, Gustin et al. 2016, Massa et al. 2021, Grussu 2022, Lardelli et al. 2022). The time periods were chosen on the basis of the available bibliography and therefore cover different periods of time, namely ca. 50, 56, 63, and 28 years, respectively. By consulting every bibliographical reference, and by following the trend over 15 decades, and carefully studying species by species what the different authors have written, it was possible to understand the possible long-term status of each species (stable, increasing, decreasing, strongly decreasing, fluctuating). The choice to include some species within the fluctuating category (increasing and decreasing in different times) may appear subjective, but it is the result of careful literature analysis and decades of personal experience; however, it is likely that another researcher had included some of them among different categories.

The choice of forest species was established on the basis of their main habitat according to Brichetti and Fracasso (2003-2022) and Lardelli et al. (2022); however, some species, like blackbird and European serin, although they occupy a very large part of arboreal habitats, including orchards and urban ones, were included in the list because their native habitat is the wood (Lardelli et al. 2022). Additionally, African blue tit *Cyanistes teneriffae* and long-legged buzzard *Buteo rufinus* were excluded from the Italian list, being present outside their range only in the small island of Pantelleria (Sicily), just 80 km away from Tunisia (North Africa).

The habitat of each species was obtained from the bibliography and personal experience; the ecological niche fulfilled by each species was divided into three parts (trees, soil and undergrowth), in order to define the main activities (nesting, feeding) of the species in the three portions of the forest environment considered. Additionally, on the basis of species distribution and ability to colonise forest (or urban) habitats of little naturalistic interest the species was assigned one of the following three values: 1: very generalist species in the habitat use; 2: moderately demanding species in the habitat use; 3: high demanding species in the habitat use. A higher value of species corresponds to a greater number of ecologically demanding birds.

The conservation status of species in Europe has been obtained from BirdLife International (Red List) (BirdLife International 2015). The trend of species was calculated only for the Italian peninsula; however, in order to carry out a comparison with forest birds of the Iberian and Balkan peninsulas, a list of forest birds recently breeding in those peninsulas was taken from the latest European Atlas (Keller et al. 2020) and other local references (Matveiev and Vasic 1973, 1977, Handrinos and Akriotis 1997, De Juana and Varela 2016). Sørensen's similarity index has been used, $S = 2a/(2a+b+c)$, where a is the number of species in common in the two peninsulas considered, b and c are

respectively the numbers of species found only in the first and only in the second peninsula compared. S can result between 0 (completely different) and 1 (identical) (Pielou 1977). Concerning the trend of forest birds, a comparison has been tentatively carried out with the European trend simulated in the late 21st Century in the climatic Atlas by Huntley et al. (2007). The systematics follow Baccetti, Fracasso and COI (2021).

## RESULTS

### Breeding forest species in Italy

The species regularly breeding in Italian forests number 66 (Table 1) and represent a modest percentage (22.5%) of the 293 species found breeding in Italy (Lardelli et al. 2022). They belong to 20 families, namely: Phasianidae Tetraoninae (3 species), Columbidae (2 species), Caprimulgidae (1 species), Scolopacidae (1 species), Strigidae (6 species), Accipitridae (6 species), Picidae (8 species), Falconidae (1 species), Corvidae (2 species), Paridae (6 species), Phylloscopidae (3 species), Aegithalidae (1 species), Sylviidae (4 species), Certhiidae (2 species), Sittidae (1 species), Troglodytidae (1 species), Turdidae (5 species), Muscicapidae (2 species), Regulidae (2 species), and Fringillidae (7 species) (Table 2). Except for 12 species (18.2%), i.e. the three species of Phasianidae Tetraoninae (capercaillie *Tetrao urogallus*, black grouse *Lyrurus tetrix*, hazel grouse *Bonasa bonasia*), boreal owl *Aegolius funereus*, pygmy owl *Glaucidium passerinum*, Ural owl *Strix uralensis*, grey-faced woodpecker *Picus canus*, three-toed woodpecker *Picoides tridactylus*, northern nutcracker *Nucifraga caryocatactes*, willow tit *Poecile montanus*, and fieldfare *Turdus pilaris*, absent south of the Alps, the other 54 species (81.8%) are present in different regions of the Italian peninsula. However, 4 species (6.0%) (crested tit *Lophophanes cristatus*, barred warbler *Sylvia nisoria*, garden warbler *Sylvia borin*, and ring ouzel *Turdus torquatus*) are present only in north Italy, while the other 50 cover much of the peninsula area. Only in the islands (Sicily and Sardinia) the number of breeding forest species is reduced, due to insularity species impoverishment. Out of 66 species, none became extinct through 150 years (but this occurred locally), 31 (47.0%) resulted stable, 2 (3.0%) strongly decreasing, 9 (13.6%) decreasing, 18 (27.2%) increasing, and 5 (7.5%) fluctuating (Figure 1).

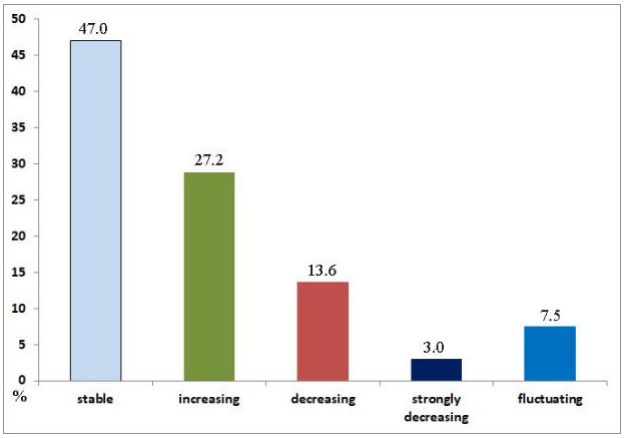


Figure 1. Percentage of different categories of abundance (stable, increasing, decreasing, strongly decreasing, fluctuating) of 66 breeding forest birds in Italy, during the 150 years considered.

Most species (53, 80.3%) are sedentary, but 21 (31.8%) of them have also wintering populations, coming from C-N Europe. In some cases, breeding populations are very small (e.g., Eurasian woodcock *Scolopax rusticola*, rare breeder in Italy), but conspicuous populations arrive during the winter; in other cases, wintering populations are added to already conspicuous breeding populations (e.g., European robin *Erithacus rubecula*). Thirteen species (19.7%) are trans-Saharan, they breed in Europe and winter in tropical Africa (Table 3, Figure 2).

Though they are species related to forest cover, do not all have similar ecology, habits and trophic requirements. If we look closely at the different families, we can see that the forest is the habitat, but the ecological niche is sometimes fulfilled in the undergrowth, in clearings, at the

edge of the forest, where the species find food, which may consist of invertebrates, berries, small mammals, etc. Table 2 summarises the essential data highlighting the importance of trees, soil (litter) and undergrowth for the different species belonging to 20 bird families. It seems clear that while there are species groups closely related to trees (e.g., woodpeckers, treecreepers and nuthatch), many other species use forest trees only to place their nests and may forage both on the ground and in the undergrowth. Overall, 59 species (89.4%) use the trees for nesting. The most specialised species resulted to be those belonging to Picidae family, which are characterised by the zygodactily, that is the presence of two fingers pointing forward and two backward, other than the hardened rectrices that allow to lean on logs. Furthermore, some species show different geographical habits, being more linked to forests in south Italy and having a wider ecological niche in north Italy, where they occur regularly also in city parks and urban outskirts.

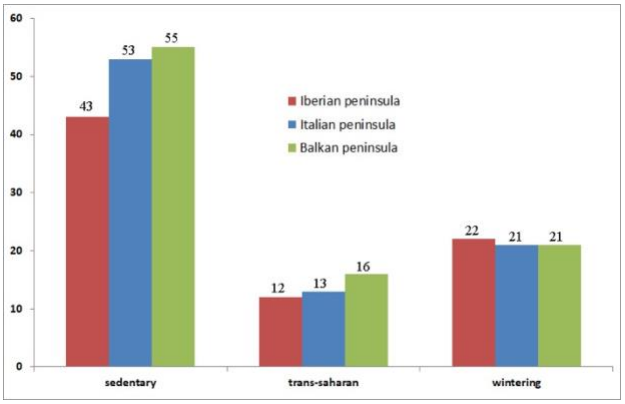


Figure 2. Number and percentage of bird forest species in the three Mediterranean peninsulas with different phenology: sedentary, trans-saharan migrants and wintering. Some sedentary species increase their populations in winter. Numbers and percentage of each category refer to each peninsula.


Figure 3. Satellite map of the Mediterranean area with the three peninsulas that characterize it; dark green areas correspond to those covered with forest (after Google Earth, modified).

Table 1. List of 66 Italian breeding forest birds since 1872 to 2022. Column 1 reports the species name and its category in the European Red List after BirdLife International (2015). Columns 2-5 report the bibliographic status in the four periods considered. Column 6 reports the reliable trend through 150 years (stable, decreasing, strongly decreasing, increasing, fluctuating). Column 7 reports the simulated trend in the late 21st Century after the Climate Atlas. Column 8 reports the main habitat of each species. Acronyms for the European red List are: LC = Least Concern. Other acronyms are: C = Central, E = East, S = South, W = West.

| **1) Species (threat)** | **2) Before 1872** | **3) 1873-1929** | **4) 1930-1993** | **5) 1994-2022** | **6) Trend 1872-2022** | **7) Simulated trend in late XXI century** | **8) Habitat** |
|---|---|---|---|---|---|---|---|
| Western capercaillie *Tetrao urogallus* (LC) | Sedentary in Alps, decreasing | Sedentary in Alps, very decreasing | Sedentary in CE Alps, decreasing | Sedentary in CE Alps, strongly decreasing | Strongly decreasing | Decreasing in C Europe | Coniferous mixed with broadleaved woods |
| Black grouse *Lyrurus tetrix* (LC) | Sedentary in Alps, fairly common | Sedentary in Alps, decreasing | Sedentary in Alps, decreasing | Sedentary in Alps, decreasing | Decreasing | Decreasing in C Europe | Coniferous woods with pastures |
| Hazel grouse *Bonasa bonasia* (LC) | Sedentary in Alps, decreasing | Sedentary in Alps, very decreasing | Sedentary in Alps, recently increasing | Sedentary in Alps, in recent westward expansion | Fluctuating | Decreasing in S Europe | Coniferous mixed with broadleaved woods and common hazel |
| Common woodpigeon *Columba palumbus* (LC) | Common sedentary breeder in all Italy | Common sedentary breeder in all Italy, also in parks of some towns | Common sedentary breeder in all Italy, also in urban parks, increasing | Sedentary and migrant breeder, increasing in all Italian regions | Increasing | Stable | Coniferous and broadleaved woods |
| Stock dove *Columba oenas* (LC) | Common passage migrant, rare as breeding | Scarce in all Italy as breeding, more common as migrant and wintering | Very scarce migrant and rare breeder in scattered sites of Italian peninsula and Sicily | Migrant breeder fluctuating, disappearing in C-S Italy, breeding only in NW Italy | Strongly decreasing | Decreasing in S Europe | Coniferous and broadleaved woods |
| European nightjar *Caprimulgus europaeus* (LC) | Migrant breeder in all Italy | Migrant breeder in all Italy | Migrant breeder in all Italy | Migrant breeder in all Italy, increasing | Increasing | Decreasing in S Europe | Wooded areas with clearings |
| Eurasian woodcock *Scolopax rusticola* (LC) | Common wintering, some pairs breed in N Italy | Common migrant wintering, rare breeder in Tuscany, Piedmont, Veneto, Lombardy, Trentino | Rare migrant breeder in N Italy, not confirmed in Tuscany, common wintering | Rare migrant breeder in Alps and N Apennines, common wintering | Stable | Decreasing in S Europe | Broadleaved and coniferous woods |
| Eurasian eagle-owl *Bubo bubo* (LC) | All Italian peninsula and Sicily | Sedentary in all Italian peninsula and Sicily, decreasing | Sedentary in Italian peninsula, decreasing, extinct in Sicily | Sedentary in Italian peninsula, probably fluctuating | Decreasing | Decreasing in S Europe | Cliffs next to woods |

| 1) Species (threat) | 2) Before 1872 | 3) 1873-1929 | 4) 1930-1993 | 5) 1994-2022 | 6) Trend 1872-2022 | 7) Simulated trend in late XXI century | 8) Habitat |
|---|---|---|---|---|---|---|---|
| Boreal owl *Aegolius funereus* (LC) | Accidental | Very rare | Sedentary breeder in Alps | Sedentary breeder in Alps | Increasing | Decreasing in C Europe | Pure and mixed coniferous woods |
| Eurasian pygmy-owl *Glaucidium passerinum* (LC) | Accidental | Rare breeding in E Alps | Rare sedentary breeder in Alps | Scarce sedentary breeder in Alps | Stable | Decreasing in C Europe | Uneven-aged coniferous woods |
| Northern long-heared owl *Asio otus* (LC) | Common in Italian peninsula | Rare breeder in N-C Italy and Sicily | Scarce migrant breeder in N Italy, rarer in C-S Italy and Sicily, wintering | Scarce migrant and sedentary breeder in N Italy, C-S Italy, Sardinia and Sicily, wintering | Increasing | Decreasing in S Europe | Coniferous and broadleaved woods |
| Tawny owl *Strix aluco* (LC) | Common in Italian peninsula and Sicily | Common sedentary in Italian peninsula and Sicily | Common sedentary breeder in all Italian peninsula and Sicily | Common sedentary breeder in all Italian peninsula and Sicily | Stable | Decreasing in S Europe | Broadleaved and coniferous woods |
| Ural owl *Strix uralensis* (LC) | Accidental | Very rare | Unrecorded as breeding | First breeding in 1994 (Udine), later increasing westwards | Increasing | Decreasing in C Europe | Beech and alpine coniferous woods |
| European honey-buzzard *Pernis apivorus* (LC) | Uncommon migrant | Uncommon migrant breeder in mounts over Po Valley, Tuscany, etc., decreasing | Uncommon migrant breeder in Italian peninsula, mainly in N Italy | Uncommon migrant breeder in Italian peninsula, mainly in N Italy | Stable | Decreasing in S Europe | Broadleaved and coniferous woods |
| Short-toed snake-eagle *Circaetus gallicus* (LC) | Common migrant breeder in Latium and Tuscany, rarely wintering | Common sedentary breeder from Alps to islands | Migrant breeder in Italian peninsula, mainly NW Italy | Migrant breeder in Italian peninsula, absent in islands | Increasing | Increasing in C Europe | Broadleaved and coniferous woods with clearings |
| Booted eagle *Hieraetus pennatus* (LC) | Migrant, very rare | Migrant, very rare | Unrecorded as breeding | Migrant and wintering, common in some regions, breeding in scattered sites | Increasing | Increasing in S Europe | Broadleaved and coniferous woods |
| Eurasian sparrowhawk *Accipiter nisus* (LC) | Breeding in N Italy | Common breeder in all Italy | Common sedentary breeder in all Italy | Sedentary breeder, increasing in all Italy since mid ‘1980 | Increasing | Decreasing in S Europe | Broadleaved and coniferous woods |

| 1) Species (threat) | 2) Before 1872 | 3) 1873-1929 | 4) 1930-1993 | 5) 1994-2022 | 6) Trend 1872-2022 | 7) Simulated trend in late XXI century | 8) Habitat |
|---|---|---|---|---|---|---|---|
| Northern goshawk *Accipiter gentilis* (LC) | Uncommon in Sardinia and Italian peninsula | Uncommon breeder in Tuscany, Abruzzo, Molise, Alps, common in Sardinia | Sedentary breeder in Italian peninsula, mainly N Italy, and Sardinia | Sedentary breeder in all Italian peninsula and Sardinia | Stable | Decreasing in S Europe | Broadleaved and coniferous woods |
| Eurasian buzzard *Buteo buteo* (LC) | Very common in all Italy | Very common breeder in all Italy | Common sedentary breeder in all Italy | Common sedentary breeder in all Italy | Stable | Decreasing in S Europe | Broadleaved and coniferous woods |
| Black woodpecker *Dryocopus martius* (LC) | Alps, central Apennines and Sicily (rare) | Sedentary in Alps, to be confirmed in Apennines and Sicily | Sedentary in Alps and scattered zones of C-S Apennines, extinct in Sicily (1900) | Sedentary in Alps and scattered zones of C-S Apennines, accidental in Sicily | Increasing | Decreasing in S Europe | Mature broadleaved and coniferous woods |
| Grey-faced woodpecker *Picus canus* (LC) | Sedentary in Alps | Sedentary in Alps | Sedentary breeder in C-E Alps | Sedentary breeder in C-E Alps | Stable | Decreasing in C Europe | Broadleaved and coniferous woods |
| Eurasian green woodpecker *Picus viridis* (LC) | Very common, rare in Sicily, never found in Sardinia | Common sedentary breeder, rare in Sicily, absent in Sardinia | Sedentary breeder in all Italy, extinct in Sicily (1930) | Sedentary breeder in the peninsula, increasing | Increasing | Decreasing in S Europe | Broadleaved and coniferous woods |
| Three-toed woodpecker *Picoides tridactylus* (LC) | Alps (rare) | Accidental | Very local sedentary breeder in E Alps | Very local sedentary breeder in C-E Alps | Stable | Decreasing in C Europe | Coniferous woods |
| Lesser spotted woodpecker *Dryobates minor* (LC) | All Italy, but no abundant | Local in all Italy, including Sicily and Sardinia | Uncommon sedentary breeder in W Alps and Apennines, extinct in Sicily (1930), no data in Sardinia from 1980 [(a)] | Sedentary breeder in all Italian peninsula, increasing | Increasing | Decreasing in S Europe | Broadleaved and coniferous woods |
| Middle spotted woodpecker *Leiopicus medius* (LC) | Central Italy (rare) | Sedentary in mounts over Po Valley, Umbria, Tuscany, Abruzzo, Latium and Sicily [(b)] | Sedentary breeder in scattered sites of C-S Apennines | Sedentary breeder in scattered sites of C-S Apennines, colonized Friuli | Stable | Decreasing in S Europe | Broadleaved woods |
| Great spotted woodpecker *Dendrocopos major* (LC) | Common in all Italy | Sedentary breeder in all Italy, | Sedentary breeder in all Italy, | Sedentary breeder in all Italy, increasing | Increasing | Decreasing in S Europe | Broadleaved and coniferous woods |

| 1) Species (threat) | 2) Before 1872 | 3) 1873-1929 | 4) 1930-1993 | 5) 1994-2022 | 6) Trend 1872-2022 | 7) Simulated trend in late XXI century | 8) Habitat |
|---|---|---|---|---|---|---|---|
| | | decreasing for deforestation | decreasing for deforestation | | | | |
| White-backed woodpecker *Dendrocopos leucotos* (LC) | East Alps | Accidental, breeder in Abruzzo | Sedentary in C Apennines and Gargano (Apulia) | Sedentary in C Apennines, unconfirmed in Apulia | Stable | Decreasing in S Europe | Broadleaved woods |
| Eurasian hobby *Falco subbuteo* (LC) | Migrant, breeding not confirmed | Migrant, breeding not confirmed | Migrant breeder in all Italy | Migrant breeder in all Italy, increasing | Increasing | Decreasing in S Europe | Edge of broadleaved and coniferous woods |
| Eurasian jay *Garrulus glandarius* (LC) | Common breeder in all Italy | Common breeder in all Italy | Sedentary breeder in all Italy | Sedentary breeder in all Italy, increasing in urban habitats | Increasing | Stable | Broadleaved and coniferous woods |
| Northern nutcracker *Nucifraga caryocatactes* (LC) | Uncommon breeder in Alps | Uncommon breeder in Alps, mainly Trentino, Veneto, Lombardy | Sedentary breeder in Alps | Sedentary breeder in Alps | Stable | Decreasing in C Europe | Alpine woods of Pinus cembra |
| Golden Oriole *Oriolus oriolus* (LC) | Migrant breeder, common in C-N Italy, less in Sicily and Sardinia | Migrant breeder, common in C-N Italy, less in S Italy, Sicily and probably in Sardinia | Migrant breeder in Italian peninsula and Sicily | Migrant breeder in Italian peninsula, Sicily, colonized Sardinia | Stable | Stable | Broadleaved woods and gardens |
| Coal tit *Periparus ater* (LC) | Uncommon breeder in all Italy | Uncommon breeder in montane areas of Italy | Sedentary breeder in all Italy | Sedentary breeder in all Italy, increasing | Increasing | Decreasing in S Europe | Coniferous and broadleaved woods |
| Crested tit *Lophophanes cristatus* (LC) | Breeding in Alps | Breeding in Alps | Sedentary breeder in Alps | Sedentary breeder in Alps and N Apennines, increasing | Increasing | Decreasing in S Europe | Coniferous woods, also mixed with broadleaved trees |
| Marsh tit *Poecile palustris* (LC) | Uncommon breeder in all Italy, unrecorded in Sardinia | Uncommon breeder in all Italy, vagrant in Sardinia | Sedentary breeder in Italian peninsula and local in Sicily | Sedentary breeder in Italian peninsula and local in Sicily | Stable | Decreasing in S Europe | Mature broadleaved and coniferous woods |
| Willow tit *Poecile montanus* (LC) | Breeding in Alps | Breeding in Alps | Sedentary breeder in Alps and C Apennines [(c)] | Sedentary breeder in Alps | Stable | Decreasing in C Europe | Montane coniferous woods |
| Great tit *Parus major* (LC) | Very common breeder in all Italy | Very common sedentary breeder in all Italy | Sedentary breeder in all Italy | Sedentary breeder in all Italy | Stable | Stable | Woods and wooded areas |

| 1) Species (threat) | 2) Before 1872 | 3) 1873-1929 | 4) 1930-1993 | 5) 1994-2022 | 6) Trend 1872-2022 | 7) Simulated trend in late XXI century | 8) Habitat |
|---|---|---|---|---|---|---|---|
| Eurasian blue tit *Cyanistes caeruleus* (LC) | Common breeder in all Italy | Common sedentary breeder in all Italy | Sedentary breeder in all Italy | Sedentary breeder in all Italy | Stable | Stable | Broadleaved and coniferous woods |
| Western Bonelli's warbler *Phylloscopus bonelli* (LC) | Breeding? | Migrant breeder, more in N Italy | Migrant breeder in Alps and Apennines, rare in S Italy | Migrant breeder in Alps, Apennines and Sardinia, rare in S Italy | Fluctuating | Increasing in C Europe | Coniferous and broadleaved woods |
| Common chiffchaff *Phylloscopus collybita* (LC) | Breeding in all Italy | Common migrant and sedentary breeding in all Italy, wintering south of Tuscany | Migrant and sedentary breeder in Italian peninsula and Sicily | Migrant and sedentary breeder in Italian peninsula and Sicily, colonized Sardinia | Increasing | Decreasing in S Europe | Broadleaved and coniferous woods |
| Wood warbler *Phylloscopus sibilatrix* (LC) | Migrant breeder in montane areas | Migrant breeder, rare in Sardinia and Apulia | Migrant breeder in Alps and Apennines | Migrant breeder in Alps, Apennines and possible breeder in Apulia | Stable | Decreasing in C Europe | Broadleaved woods |
| Long-tailed tit *Aegithalos caudatus* (LC) | Very common breeder in all Italy, unrecorded in Sardinia | Common breeder in all Italy, absent in Sardinia | Sedentary breeder in Italian peninsula and Sicily | Sedentary breeder in Italian peninsula and Sicily | Stable | Decreasing in S Europe | Broadleaved and coniferous woods |
| Garden warbler *Sylvia borin* (LC) | Rare migrant breeder in C-N Italy | Migrant breeder in montane areas, Po Valley, C Italy | Migrant breeder in N Italy, a single population in C Apennines | Migrant breeder in Alps and N Apennines, decreasing | Decreasing | Decreasing in S Europe | Woods with undergrowth |
| Eurasian blackcap *Sylvia atricapilla* (LC) | Very common sedentary breeder in all Italy | Very common sedentary breeder in all Italy | Sedentary breeder in all Italy | Sedentary breeder in all Italy | Stable | Decreasing in S Europe | Broadleaved and coniferous woods, gardens |
| Barred warbler *Sylvia nisoria* (LC) | Rare migrant breeder in N-E Italy | Local migrant breeder in the Po Valley | Local migrant breeder in N Italy | Local migrant breeder in Lombardy and Friuli, decreasing | Decreasing | Stable | Thermophilic bushy woods |
| Western orphean warbler *Sylvia hortensis* (LC) | Migrant breeder in montane areas of N Italy | Migrant breeder in hillsides of N Italy | Migrant breeder in scattered sites of all Italian peninsula | Migrant breeder in scattered sites of all Italian peninsula, decreasing | Decreasing | Stable | Edges of woods |

| 1) Species (threat) | 2) Before 1872 | 3) 1873-1929 | 4) 1930-1993 | 5) 1994-2022 | 6) Trend 1872-2022 | 7) Simulated trend in late XXI century | 8) Habitat |
|---|---|---|---|---|---|---|---|
| Short-toed treecreeper *Certhia brachydactyla* (LC) | Common sedentary breeder in all Italy, unrecorded in Sardinia | Common sedentary breeder in all Italy, absent in Sardinia | Sedentary breeder in Italian peninsula and Sicily | Sedentary breeder in Italian peninsula and Sicily | Stable | Decreasing in S Europe | Mature broadleaved and coniferous woods |
| Eurasian treecreeper *Certhia familiaris* (LC) | Breeding in Alps | Breeding in Alps and probably in Apennines | Sedentary breeder in Alps and C Apennines | Sedentary breeder in Alps and C Apennines | Stable | Decreasing in C Europe | Mature coniferous woods |
| Eurasian nuthatch *Sitta europaea* (LC) | Common in all Italy, unrecorded in Sardinia | Common in all Italy, absent in Sardinia | Sedentary breeder in Italian peninsula and Sicily | Sedentary breeder in Italian peninsula and Sicily | Stable | Decreasing in S Europe | Mature broadleaved and coniferous woods |
| Northern wren *Troglodytes troglodytes* (LC) | Common breeder in all Italy | Common breeder in all Italy, mainly in montane and hilly areas | Sedentary breeder in all Italy | Sedentary breeder in all Italy | Stable | Stable | Woods with undergrowth |
| Eurasian blackbird *Turdus merula* (LC) | Very common sedentary breeder in all Italy | Very common sedentary breeder in all Italy | Sedentary and partial migrant breeder in all Italy | Sedentary and partial migrant breeder, increasing in all Italy, locally fluctuating | Increasing | Stable | Woods with undergrowth, gardens and parks |
| Fieldfare *Turdus pilaris* (LC) | Breeding in Alps | Breeding in Alps? | Partially sedentary and migrant breeder in Alps | Partially sedentary and migrant breeder in Alps, declining | Decreasing | Decreasing in C Europe | Coniferous woods |
| Mistle thrush *Turdus viscivorus* (LC) | Common breeder in all Italy | Common breeder in all Italy | Sedentary breeder in all Italy | Sedentary breeder in all Italy | Stable | Decreasing in S Europe | Broadleaved and coniferous woods |
| Song thrush *Turdus philomelos* (LC) | Uncommon breeder in N Italy | Uncommon breeder from Alps to Apennines | Migrant breeder in Alps and Apennines | Migrant breeder in Alps and Apennines | Stable | Decreasing in S Europe | Broadleaved and coniferous woods |
| Ring ouzel *Turdus torquatus* (LC) | Rare breeder in C-N Italy | Rare breeder in Alps and Apennines | Migrant breeder in Alps and scattered sites of C Apennines | Migrant breeder in Alps and N Apennines, not confirmed in C Apennines | Decreasing | Decreasing in S Europe | Coniferous woods with bushy environments |
| European robin *Erithacus rubecula* (LC) | Very common breeder in all Italy | Very common breeder in montane | Migrant breeder in all Italy | Abundant in all Italy, locally increasing | Increasing | Decreasing in S Europe | Woods with abundant undergrowth |

| 1) Species (threat) | 2) Before 1872 | 3) 1873-1929 | 4) 1930-1993 | 5) 1994-2022 | 6) Trend 1872-2022 | 7) Simulated trend in late XXI century | 8) Habitat |
|---|---|---|---|---|---|---|---|
| | | areas of all Italy | | | | | |
| Common nightingale *Luscinia megarhynchos* (LC) | Common migrant breeder in all Italy | Fairly abundant migrant breeder in all Italy | Common migrant breeder in all Italy | Migrant breeder in all Italy, decreasing | Decreasing | Increasing in N Europe | Woods with abundant undergrowth, high maquis |
| Collared flycatcher *Ficedula albicollis* (LC) | Rare migrant breeder | Local migrant breeding in Veneto, Lombardy, Piedmont, Liguria, Tuscany, Latium, Molise and probably Calabria | Local migrant breeder in Alps, N Italy, C-S Apennines, mainly in Abruzzo, Molise and Calabria | Local migrant breeder in Alps, N Italy, C-S Apennines, fluctuating | Fluctuating | Decreasing in S Europe | Mature broadleaved woods |
| Goldcrest *Regulus regulus* (LC) | Scarce breeder in all Italy | Scarce breeder in Italian peninsula and Sardinia | Sedentary breeder in Alps and Apennines, wintering in S Italy, unrecorded in Sardinia | Sedentary breeder in Alps and Apennines, wintering in S Italy, absent in Sardinia and Sicily | Stable | Decreasing in C Europe | Coniferous woods with undergrowth |
| Common firecrest *Regulus ignicapilla* (LC) | Scarce in all Italy | Scarce in all Italy | Sedentary breeder in all Italy | Sedentary breeder in all Italy | Stable | Decreasing in S Europe | Coniferous and broadleaved woods with undergrowth |
| Common chaffinch *Fringilla coelebs* (LC) | Very common wintering and breeder in all Italy | Very common wintering and breeder in all Italy | Migrant and sedentary breeder in all Italy | Migrant and sedentary breeder in all Italy, fluctuating, locally decreasing | Decreasing | Stable | Coniferous and broadleaved woods |
| Hawfinch *Coccothraustes coccothraustes* (LC) | Uncommon breeder in C-N Italy | Uncommon breeder in montane areas, common in Sardinia | Sedentary and migrant breeder in scattered sites of Italian peninsula and Sardinia | Sedentary and migrant breeder in scattered sites of Italian peninsula and Sardinia | Fluctuating | Decreasing in S Europe | Broadleaved woods |
| Red crossbill *Loxia curvirostra* (LC) | Irregularly breeder in C-N Italy | Sedentary breeder in C-N Italy | Sedentary and migrant breeder in Alps, scattered sites of Apennines and Sicily | Sedentary and migrant breeder in Alps, Apennines, Sardinia and Sicily | Fluctuating | Decreasing in S Europe | Coniferous woods |
| Eurasian bullfinch | Uncommon breeder in | Uncommon breeder in | Sedentary breeder in | Sedentary breeder in | Stable | Decreasing in S Europe | Broadleaved and |

| 1) Species (threat) | 2) Before 1872 | 3) 1873-1929 | 4) 1930-1993 | 5) 1994-2022 | 6) Trend 1872-2022 | 7) Simulated trend in late XXI century | 8) Habitat |
|---|---|---|---|---|---|---|---|
| *Pyrrhula pyrrhula* (LC) | beech woods of C-N Italy | beech woods of C-N Italy | Alps and Apennines | Alps and Apennines | | | coniferous woods |
| Citril finch *Carduelis citrinella* (LC) | Breeder in the Alps | Breeder in the Alps [(d)] | Sedentary breeder in the Alps | Sedentary breeder in the Alps | Stable | Decreasing in C Europe | Woods adjacent to alpine meadows |
| Eurasian siskin *Spinus spinus* (LC) | Breeding in N Italy? | Migrant, some pairs breed in Alps | Sedentary and migrant breeder in Alps, S Apennines and Sardinia | Sedentary and migrant breeder in Alps, S Apennines, Sicily, Sardinia (?) | Stable | Decreasing in S Europe | Coniferous woods, also afforestation |
| European serin *Serinus serinus* (LC) | Very common breeder in all Italy | Very common breeder in all Italy | Sedentary and partially migrant breeder in all Italy | Sedentary and partially migrant breeder in all Italy, moderately declining | Stable | Increasing in N Europe | Woods, also parks and gardens |

Notes: (a) The presence in Sardinia of lesser spotted woodpecker was reported by old authors, but Massa and Schenk (1983) highlighted that there were no more recent records; Grussu (2022) considers dubitatively its presence and Lardelli et al. (2022) did not record it. (b) The presence in Sicily of middle spotted woodpecker was erroneously reported by Minà Palumbo (1857; see also Massa and Sarà 2011). (c) According to Lardelli et al. (2022) the willow tit is absent from Apennines, where evidence of its presence is lacking. (d) Arrigoni degli Oddi (1929) considered possible that *corsicana* was the taxon breeding in the Alps.

## Biogeographical peculiarities of the breeding forest avifauna in Italy and in the other peninsulas

*Jusques aujourd'huy l'on n'a point descouvert au nouveau monde aucune Méditerranée comme il y en a en Europe, Asie et Afrique* (José de Acosta 1558, Histoire Naturelle des Indes) (translated from French: No Mediterranean Sea has yet been discovered in the New World, as there are in Europe, Asia and Africa). The Mediterranean area is very special because it is an almost enclosed sea surrounded by lands, three of which jut southward in the form of peninsulas. Really, considering the Mediterranean broadly, three peninsulas project southwards into this great sea, the Iberian peninsula (which touches the Atlantic to the west), the Balkan peninsula (which touches the Black Sea to the east) and the Italian peninsula, the only one completely within the Mediterranean and proportionately narrow and long compared to the other two (Figure 3). In these regions the fauna generally has a north-south impoverishment, known as the 'peninsula effect', a form of impoverishment in 'quasi-island' territories, *sensu* Mac Arthur and Wilson (1967; cf. also Massa 1982, Battisti and Testi 2001). With regard to forest birds on the Italian peninsula, a north-south gradient of depletion has not been observed. The Apennines of peninsular Italy are home to large forests of various species with breeding bird populations in the southernmost part not substantially different from those in the north, with the exceptions above recorded.

Table 2. Main habitat and ecological niche of Italian forest bird species belonging to 20 families.

| Family | Habitat | Trees | Soil (litter) | Undergrowth |
|---|---|---|---|---|
| Phasianidae (3 species) | Coniferous mixed with broadleaved woods, coniferous woods with pastures and common hazel | Feeding | Nesting | Feeding |
| Columbidae (2 species) | Coniferous and broadleaved woods, with clearings | Feeding and nesting | Feeding | Feeding |
| Caprimulgidae (1 species) | Wooded areas with wide clearings and shrubs (aeroplanktophagous species) | Perching | Nesting | Feeding |
| Scolopacidae (1 species) | Broadleaved and coniferous woods with pastures at the edge | | Nesting and feeding | |
| Strigidae (6 species) | Cliffs next to woods, broadleaved and coniferous woods, pure and mixed coniferous woods, uneven-aged coniferous woods, beech and alpine coniferous woods, generally with big trees and holes for nesting | Nesting | Feeding | |
| Accipitridae (6 species) | Broadleaved and coniferous woods with clearings | Nesting | Feeding | |
| Picidae (8 species) | Mature broadleaved and coniferous woods with clearings | Nesting and feeding | Feeding | |
| Falconidae (1 species) | Edge of broadleaved and coniferous woods | Nesting | Feeding | |
| Corvidae (2 species) | Broadleaved and coniferous woods, alpine woods of Pinus cembra (nutcracker) | Nesting | Feeding | Feeding |
| Paridae (6 species) | Mature broadleaved and coniferous woods, also mixed with clearings | Nesting and feeding | Feeding | Feeding |
| Phylloscopidae (3 species) | Broadleaved and coniferous woods with clearings | Nesting and feeding | Feeding | |
| Aegithalidae (1 species) | Broadleaved and coniferous woods | Nesting and feeding | Feeding | |
| Sylviidae (4 species) | Woods with undergrowth, edges of woods, thermophilic bushy woods (barred warbler) | Nesting and feeding | Feeding | Nesting and feeding |

| Family | Habitat | Trees | Soil (litter) | Undergrowth |
|---|---|---|---|---|
| Certhiidae (2 species) | Mature broadleaved and coniferous woods | Nesting and feeding | | |
| Sittidae (1 species) | Mature broadleaved and coniferous woods | Nesting and feeding | | |
| Troglodytidae (1 species) | Woods with undergrowth | Nesting | Feeding | Nesting and feeding |
| Turdidae (5 species) | Broadleaved and coniferous woods, coniferous woods with bushy environments | Nesting and feeding | Feeding | Feeding |
| Muscicapidae (2 species) | Woods with abundant undergrowth, mature broadleaved woods | Nesting and feeding | Feeding | Nesting and feeding |
| Regulidae (2 species) | Coniferous and broadleaved woods with undergrowth | Nesting and feeding | | |
| Fringillidae (7 species) | Coniferous and broadleaved woods | Nesting and feeding | Feeding | Feeding |

Table 3. List of breeding forest bird species in the three Mediterranean peninsulas. * = trans-Saharan species; w = species increasing with winter populations; X = present. Ecological value of species: 1: very generalist species in the habitat use; 2: moderately demanding species in the habitat use; 3: high demanding species in the habitat use.

| species | Iberian peninsula | Italian peninsula | Balkan peninsula |
|---|---|---|---|
| *Tetrao urogallus* (3) | X | X | X |
| *Lyrurus tetrix* (3) | | X | X |
| *Bonasa bonasia* (3) | | X | X |
| *Columba palumbus* (1), w | X | X | X |
| *Columba oenas* (3), w | X | X | X |
| *Caprimulgus europaeus** (2) | X | X | X |
| *Scolopax rusticola* (3), w | X | X | X |
| *Bubo bubo* (2) | X | X | X |
| *Aegolius funereus* (3) | | X | X |
| *Glaucidium passerinum* (3) | | X | X |
| *Asio otus* (1) | X | X | X |
| *Strix aluco* (1) | X | X | X |
| *Strix uralensis* (3) | | X | X |
| *Pernis apivorus** (2) | X | X | X |
| *Circaetus gallicus** (2) | X | X | X |
| *Hieraetus pennatus* (3), w | X | X | X |
| *Accipiter nisus* (2), w | X | X | X |

| species | Iberian peninsula | Italian peninsula | Balkan peninsula |
|---|---|---|---|
| *Accipiter gentilis* (2) | X | X | X |
| *Buteo rufinus* (2) | | | X |
| *Buteo buteo* (1), w | X | X | X |
| *Dryocopus martius* (2) | X | X | X |
| *Picus sharpei* (3) | X | | |
| *Picus viridis* (2) | | X | X |
| *Picus canus* (3) | | X | X |
| *Picoides tridactylus* (3) | | X | X |
| *Dryobates minor* (2) | X | X | X |
| *Leiopicus medius* (3) | X | X | X |
| *Dendrocopos major* (1) | X | X | X |
| *Dendrocopos leucotos* (3) | X | X | X |
| *Dendrocopos syriacus* (1) | | | X |
| *Falco subbuteo** (2) | X | X | X |
| *Garrulus glandarius* (1) | X | X | X |
| *Nucifraga caryocatactes* (3) | | X | X |
| *Oriolus oriolus** (2) | X | X | X |
| *Periparus ater* (2) | X | X | X |
| *Lophophanes cristatus* (2) | X | X | X |
| *Poecile lugubris* (3) | | | X |
| *Poecile palustris* (2) | X | X | X |
| *Poecile montanus* (3) | | X | X |
| *Parus major* (1) | X | X | X |
| *Cyanistes caeruleus* (1) | X | X | X |
| *Phylloscopus bonelli** (3) | X | X | |
| *Phylloscopus collybita** (2), w | X | X | X |
| *Phylloscopus ibericus** (3), w | X | | |
| *Phylloscopus sibilatrix** (2) | | X | X |
| *Phylloscopus trochilus** (2) | | | X |
| *Aegithalos caudatus* (1) | X | X | X |
| *Sylvia borin** (2) | X | X | X |
| *Sylvia atricapilla* (1), w | X | X | X |
| *Sylvia nisoria** (3) | | X | X |
| *Sylvia hortensis** (3) | X | X | |
| *Sylvia crassirostris** (3) | | | X |
| *Certhia brachydactyla* (1) | X | X | X |
| *Certhia familiaris* (2) | X | X | X |
| *Sitta europaea* (2) | X | X | X |

| species | Iberian peninsula | Italian peninsula | Balkan peninsula |
|---|---|---|---|
| *Sitta krueperi* (2) | | | X |
| *Troglodytes troglodytes* (1) | X | X | X |
| *Turdus merula* (1), w | X | X | X |
| *Turdus pilaris* (2), w | | X | X |
| *Turdus viscivorus* (2), w | X | X | X |
| *Turdus philomelos* (2), w | X | X | X |
| *Turdus torquatus* (3), w | X | X | X |
| *Erithacus rubecula* (1), w | X | X | X |
| *Luscinia megarhynchos** (2) | X | X | X |
| *Ficedula semitorquata** (3) | | | X |
| *Ficedula hypoleuca** (3) | X | | |
| *Ficedula parva** (3) | | | X |
| *Ficedula albicollis** (3) | | X | X |
| *Regulus regulus* (2), w | X | X | X |
| *Regulus ignicapilla* (1), w | X | X | X |
| *Fringilla coelebs* (2), w | X | X | X |
| *Coccothraustes coccothraustes* (3), w | X | X | X |
| *Loxia curvirostra* (2), w | X | X | X |
| *Pyrrhula pyrrhula* (2), w | X | X | X |
| *Carduelis citrinella* (3) | X | X | |
| *Spinus spinus* (2), w | X | X | X |
| *Serinus serinus* (1), w | X | X | X |
| **Total No. of species** (n = 77) | 55 | 66 | 71 |
| **Sum, mean of ecological value of species** | 107, 1.9 | 138, 2.1 | 149, 2.1 |

Interestingly enough, it is not the same northern species that have penetrated southwards into the peninsulas; for example, in the Iberian and Balkan peninsulas, crested tit has moved southwards, but in the Italian peninsula it has stopped in the northern Apennines. Conversely, Greece (latitude of S Italy) is the southernmost limit of western capercaillie, black grouse, hazel grouse, Eurasian pygmy-owl, boreal owl, grey-faced woodpecker, three-toed woodpecker, willow tit, and northern nutcracker (Handrinos and Akriotis 1997, Keller et al. 2020), all species absent south of the Italian Alps. Some species are present in the Balkan peninsula and northern Italy, but have not reached the Iberian peninsula: hazel grouse, grey-faced woodpecker, three-toed woodpecker, willow tit, northern nutcracker, wood warbler *Phylloscopus sibilatrix*, barred warbler, collared flycatcher *Ficedula albicollis*, and fieldfare. Others are present in the Balkan and Italian peninsulas, but reach only the north of the Iberian peninsula: black woodpecker *Dryocopus martius*, middle spotted woodpecker *Leiopicus medius*, white-backed woodpecker *Dendrocopos leucotos*, ring ouzel *Turdus torquatus*, willow tit, and Eurasian treecreeper *Certhia familiaris*. Additionally, western Bonelli's warbler *Phylloscopus bonelli* and western orphean warbler *Sylvia hortensis* are west Mediterranean species, present only in the Italian and Iberian peninsulas. Balkan peninsula

has four forest birds not living in other Mediterranean areas: Syrian woodpecker *Dendrocopos syriacus*, Krüper's nuthatch *Sitta krueperi* (living on the Greek Lesvos Island, Turkey and Caucasus), sombre tit *Poecile lugubris*, and eastern orphean warbler *Sylvia crassirostris* (Keller et al. 2020). Finally, the Iberian peninsula has two endemic species, Iberian green woodpecker *Picus sharpei* (below discussed), and Iberian chiffchaff *Phylloscopus ibericus*.

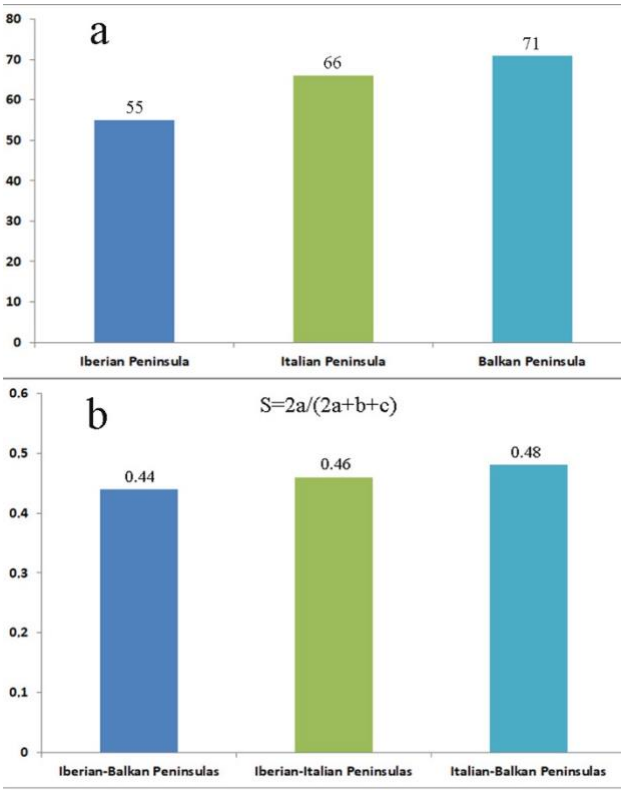


Figure 4. a) Number of breeding forest birds in the three Mediterranean peninsulas. b) Sørensen's similarity index between pairs of breeding forest birds of the three Mediterranean peninsulas.

The following numbers of breeding forest species were obtained from the Mediterranean peninsulas: Iberian peninsula 55, Italian peninsula 66, Balkan peninsula 71 (Table 3). The common component of the breeding forest avifauna of each peninsula is about 50%; altogether, 77 forest species breed in the three Mediterranean peninsulas, more or less equally distributed between them, but only part of species breeding in forests of each peninsula is in common with the other two (Sørensen's similarity index, number of species in common: Iberian-Italian = 0.46, 52, Iberian-Balkan = 0.44, 49, Italian-Balkan = 0.48, 63) (Figures 4a, 4b). Twelve species (21.8%) in the Iberian and 16 (22.5%) in the Balkan peninsula are trans-Saharan migrants, barely bigger figures than those in the Italian peninsula (19.7%); 22 species in the Iberian (40.0%) and 21 in the Balkan peninsula (29.6%) have wintering populations in addition to sedentary ones (cf. Figure 2).

Concerning the ecological value, Table 3 reports the sum of species values and their mean; while the sum of values may depend on the number of species, the mean is a more objective value. It resulted to be 1.9 for Iberian forest birds, and 2.1 for Italian and Balkan ones. The conservation status of all Italian breeding forest birds resulted to be 'Least Concern' (LC), which means that no species is considered threatened.

## DISCUSSION

### Comparison with the trend simulated in the late 21st Century

An attempt was made to compare the data collected from the Italian bibliography over 150 years and the trend simulated in the late 21st Century by Huntley et al. (2007). The two methodologies are profoundly different and this comparison may result unsatisfactory; however, it is considered useful to make a few practical considerations. According to Huntley et al. (2007) by the late 21st Century 37 (56.0%) of the 66 Italian forest species considered here will be decreasing in southern Europe, 14 (21.2%) decreasing in central Europe, only 10 (15.1%) will remain stable, 5 (7.6%) increasing in southern, central or northern Europe (Figure 5). The trend is comparable only for 13 species (19.7%), whose status matches both with the 150-year period and the simulation in the late 21st Century; namely 7 species (black grouse, capercaillie, eagle owl, stock dove, garden

warbler, fieldfare, and ring ouzel) result to be decreasing in both the 150-year considered period and the late 21st Century simulations, 2 species (short-toed snake-eagle, and booted eagle) are found to be increasing, and 4 species (golden oriole, blue tit, great tit, and wren) result stable in the two time periods. It seems obvious that the two methodologies give different results; in particular the simulation for forest species based on climatic trend seems very pessimistic, as altogether 77.2% are expected to decline in the late 21st Century, while the trend calculated through the bibliographic analysis gives a much lower figure (16.6%). Even if a predictive analysis that takes into account future climate projections should not disregard a bibliographic reference of long-term species trends, which implicitly includes information on each species' potential for possible adaptation to changes in habitat or climate, predictions for the late 21st Century may be sadly true, as it considers an entirely new factor, namely climate change.

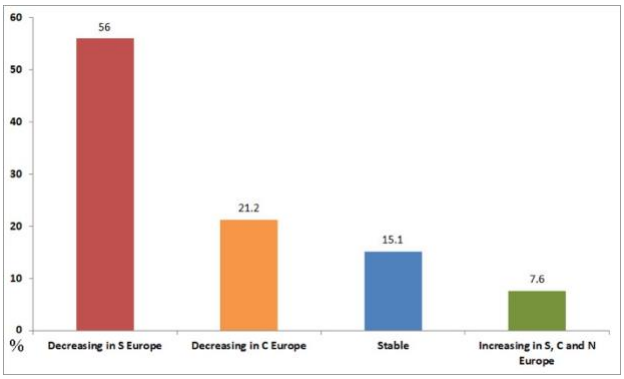


Figure 5. Simulated trend of percentage of Italian breeding forest birds in the late 21st Century according to Huntley et al. (2007).

The category of fluctuating species is generally overlooked by most ornithologists, but really there are species that have undergone positive and negative population number changes over the decades that are very difficult to understand (e.g., hazel grouse, hawfinch); other species, like the crossbill, due to the irregular cone seeds availability, fluctuate regularly in central-north Europe, however much less in the Mediterranean area, and other species may fluctuate in some countries, and not in others. In the future it will be important to consider the causes of these fluctuations, which in some cases can even lead to local extinction.

**Forest birds on peninsulas and islands**

Considering that the Iberian peninsula is the extreme western apex of Eurasia, a minimal depletion of species seems normal, which in contrast is not evident in the Balkan peninsula, an appendage of Asia. The higher number of forest birds in the Balkan peninsula can be explained by the fact that it is an area in continuity with Asia and suffers less from the peninsula effect, more evident in the other two Mediterranean peninsulas (cf. Figure 3). The isolation of the extreme south-western land of Eurasia (Iberian peninsula) allowed the evolution of two endemic species of forest birds, Iberian woodpecker (Pyrenees), and Iberian chiffchaff (westernmost French and Spanish Pyrenees and western parts of the peninsula). Concerning endemic taxa of Mediterranean Europe, another species lives in Corsica, the Corsican nuthatch *Sitta whiteheadi*, linked to black pine *Pinus nigra* forests, taxonomically related to other two forest endemic species, one living on Kabyle, the Algerian nuthatch *Sitta ledanti* linked to forest remains dominated by *Abies numidica*, and the other, Krüper nuthatch, linked to Turkish pine *Pinus brutia*, living in Turkey, Lesvos Is., and Caucasus.

The forests of peninsular Italy do not host any endemic representatives among the birds; all the species can be found in forest environments elsewhere in Europe. However, the Apennines are home to forest bird species that are most likely relicts of the last ice age, i.e. around 18,000-20,000 years old. Among these there is the trans-Adriatic subspecies of the white-backed woodpecker *Dendrocopos leucotos lilfordi*. This taxon, distributed in the Iberian and French Pyrenees to Asia Minor, Caucasus and Transcaucasia, may have arrived from the Balkans to Apennines and Pyrenees during the

last ice age; the typical subspecies (*D. l. leucotos*), widespread across Eurasia from north, central and eastern Europe to northeast Asia, may instead have arrived in central Europe from the north. A similar case is reported also for a mammal, the chamois, present with *Rupicapra rupicapra* in the Alps and with another species, *Rupicapra pyrenaica*, subdivided into two subspecies, *R. p. pyrenaica* and *R. p. ornata*, in Pyrenees and Apennines, respectively (Nascetti et al. 1985). Another interesting case is that of the Eurasian green woodpecker; the species-complex consists of *Picus viridis*, distributed from western Europe to the Caucasus and Iran, the Iberian green woodpecker *P. sharpei*, distributed in the Iberian and French Pyrenees, and the related Le Vaillant's woodpecker *P. vaillantii*, distributed in north-western Africa from central Morocco to Tunisia (Maghreb). The divergence event between the Iberian and the European lineages took place during the mid-Pleistocene (0.7–1.2 Mya), and a post-glacial range expansion of two lineages from distinct refugia located in the Iberian peninsula and in eastern Europe occurred. During the Pleistocene much of the forests suitable for green woodpeckers in central and northern Europe were covered by ice, tundra, steppe or other unsuitable habitat; thus, the woodpeckers might have occupied the current range during the past 20,000 years (Perktas et al. 2011, Pons et al. 2011).

The Pleistocene occurred just 2.5 Mya and the last post glacial warming began only 15,000 years BP. Most organisms presently distributed across Europe remained in refugia in the south 18,000 years BP in the Iberian, Italian and Balkan peninsulas, and possibly near the Caucasus and Caspian Sea. As the climate warmed rapidly, populations at the northern limits of the refugia would expand into the areas of suitable territory. Very likely E-W mountain ranges of Europe (Pyrenees, Alps, Dinaric Alps, Balkan Mountains, and Caucasus) could act as physical barriers to dispersal, and consequently populations in the peninsulas remained isolated. European species might have undergone range contractions and expansions in and out of southern refugia, and possibly in adverse periods they may go extinct in some or all the three peninsulas. Europe would then be recolonised from more distant refugia such as Turkey, the Middle East, and possibly the Caspian region or Africa (Frenzel 1973, Hewitt 1996, 1999, Tzedakis et al. 2002, Brito 2005). The Balkan peninsula appears to have served as a primary colonization source, followed by the Iberian peninsula, while the Italian peninsula provided very few colonists moving North (Hewitt 2004). In assessing the role of refugia in the recolonization of post-glacial central and northern Europe, Hewitt (2000, 2004) concluded that the Balkans were the most important refugium for that recolonization, also thanks to the low altitude of mountains (Balkan Mountains and Dinaric Alps) separating it from rest of the Europe. The Pyrenees acted as barrier to northern recolonization from the Iberian peninsula in some cases, probably not in others. Finally, the Alps likely were an insurmountable barrier for most species, and consequently the Italian peninsula provided few colonists moving North (Hewitt 2000).

Other possible relicts of the last ice age in the Apennines are black woodpecker, middle spotted woodpecker (Figures 6a, 6b), goldcrest, Eurasian treecreeper, collared flycatcher (Figure 6c; it is an ecologically demanding bird of secondary cavities, produced by branch breakage or excavated by woodpeckers, found in mature trees, which then play a really important role in sustaining populations of this bird), the western European subspecies of the bullfinch *Pyrrhula pyrrhula europoea*, hawfinch *Coccothraustes coccothraustes* (with a sedentary population also in Sardinia), Eurasian siskin *Spinus spinus* (with a small breeding population also in Sicily, on Etna) (Figure 6d) and red crossbill *Loxia curvirostra 'sensu lato'*. The latter, unlike the northern populations (linked to cone seeds of larch and spruce pines), is associated with the black pine (with bigger cones than spruces and larches) and characterised by a more massive beak


Figure 6. Two species of woodpeckers found as far south as southern Italy: black woodpecker (increasing) (6a) and middle spotted woodpecker (uncommon, but stable over a long period) (6b); Collared flycatcher, trans-Saharan species breeding in the Apennines to Calabria, where Europe's southernmost nesting sites are found (6c); Eurasian siskin (6d), generally linked to coniferous trees (black pine in the photo), recently benefited of afforestation with exotic species; Crossbill male (6e): it is evident the massive bill and the discolored plumage compared to north European individuals; Sicilian subspecies of long-tailed tit *Aegithalos caudatus siculus* (6f), clearly differentiated from the Italian peninsular populations (Photos 6a-6e: Calabria, Park of Sila, by G. Congi; photo 6f: Sicily, Ficuzza, by M. Coco).

(Figure 6e), smaller size, evident discoloration in both males and females, and marked sedentariness. Similar populations of sedentary crossbills evolved not only in the Italian peninsula, but also in the Iberian and Balkan peninsulas, Corsica, Sicily (Etna), Cyprus, and North Africa. Some of them live at the expense of the cones of the Aleppo pine *Pinus halepensis*, also characterised by big size. Species status has recently been proposed for the three main sedentary populations on Mediterranean peninsulas, islands and North Africa (*L. balearica* in the Balearics and Iberian peninsula, *L. poliogyna* in North Africa, Italian peninsula, Sicily (Etna) and Corsica, *L. guillemardi* in Cyprus and Balkan peninsula), as was previously the case for *Loxia scotica* (Massa et al. 2022).

One aspect that is certainly interesting concerns the behaviour of some typical forest species, which in recent years have had a significant increase in populations. The black woodpecker in the south Italy is a species typically associated with mature forests, but in the north has begun to colonise reforestation of poplar groves. According to Casale (2015) it first bred in Ticino Park (Lombardy) in 2006, and in subsequent years it rapidly colonised other parts of the protected area. In 2012-2015 it was first reported in the Pavia sector. The situation changed over the next eight years, as the black woodpecker moved further south and away from the riverine belt (a continuous forest); it presently breeds on the outskirts of Pavia and within the urban area of Milan in large parks with forest cover (wood in the southwest town, and in the Park North of Milan in the northeast) (G. Bogliani, University of Pavia, pers. comm.). It has also colonised the hills south of Turin and reached the southern outskirts of the city; it also occurs in cultivated poplar groves but so far there is no evidence that it nests there. However, along the Ticino River, a large 100-km ecological corridor between the Alps and the northern Apennines, it has no shortage of stretches of natural or semi-natural forest in which to nest, sometimes alternating with cultivated poplar groves. Generally, it uses mostly larger white poplars for digging nest cavities, trees that are alive and apparently in good condition (Beraudo et al. 2023). Other examples are mistle thrush, nuthatch, and long-tailed tit, which in southern Italy are associated only with forests, but in the north colonise city parks.

The situation is different on the large Italian islands, which are poorer in species than peninsular Italy. Sicily has been definitively an island for only 20 thousand years (Antonioli et al. 2012), so it is assumed that numerous species reached it earlier and then remained isolated for around twenty thousand generations. However, this was enough to give rise to local endemic forms; indeed, some isolated populations not yet taxonomically recognised, but certainly differentiated from continental ones live in Sicily. For example, Sicilian great and blue tits are smaller in size compared to continental individuals; the smaller size of these birds can be explained by Bergmann's rule according to which there is an inverse correlation between body size and average temperature in the geographical area of origin. The relict populations of the above-mentioned sedentary species may have remained isolated for several millennia, although for some of them probably there may have been mixing with more recent northern immigrant populations. It would be interesting to establish whether the isolation caused adaptations and differentiations or whether the gene flow was maintained, a fact that would deserve to be studied in depth with genomic investigations. A particular case is represented by the Sicilian population of the long-tailed tit *Aegithalos caudatus siculus* (Figure 6f), a taxon found mainly in broadleaved woods; its isolation in Sicily for at least 20,000 years has led to a clear differentiation, not only in the grey back, but also in the colouring of the head, which generally lacks the characteristic dark lateral bands, in the grey (not reddish) scapulars and in the size of the wing and tail, which are on average shorter than those of continental individuals (Ientile 2010, Lo Valvo

2020). It seems that interbreeding with peninsular populations does not occur, thanks to the 3 km long sea arm of the Strait of Messina between Sicily and southern Italy. A similar case of isolation, but that occurred in a non-forest insular species, is that of the Sicilian rock partridge *Alectoris graeca whitakeri*, clearly differentiated from the peninsular taxon (Lucchini and Randi 1998).

Probably due to the loss of mature woodland areas in Sicily, the eagle owl and three woodpecker species became extinct in the 20th Century, namely black woodpecker, Eurasian green woodpecker, and lesser spotted woodpecker *Dryobates minor* (La Mantia et al. 2015); the latter seems to be disappeared also from Sardinia (Grussu 2022, Lardelli et al. 2022). The extinction in Sicily and perhaps Sardinia of the lesser spotted woodpecker is difficult to understand, considering that in northern Italy it is an expanding species and recently has colonised young poplars (Porro et al. 2021). The insularity and/or marginality of distribution could be eventually considered, being the island population of this woodpecker at the southern edge of the distribution.

Far more isolated is Sardinia, which, in accordance with the reconstructions of Alvarez et al. (1974), together with Corsica and other microplates (among which those that formed the Kabyle in Algeria) would have broken away from the Iberian peninsula and migrated towards the center of the Tyrrhenian Sea. This would have happened over 20 Mya; this ancient isolation undoubtedly allowed numerous invertebrate species to differentiate, but as far as forest birds are concerned, there must have been some gene flow with other Mediterranean populations in fairly recent times. However, the isolation allowed the subspecific differentiation of some forest birds: jay *Garrulus glandarius ichnusae*, coal tit *Periparus ater sardus*, blue tit *Cyanistes caeruleus ogliastrae*, great tit *Parus major corsus*, wren *Troglodytes troglodytes koenigi*, sparrowhawk *Accipiter nisus wolterstorffi*, goshawk *Accipiter gentilis arrigonii*, and great spotted woodpecker *Dendrocopos major harterti*. The last three of them are non-Passeriformes, which generally require longer isolation times than Passeriformes to differentiate themselves from continental populations. Most of them are subspecies in the Sardinian-Corsican system, recognised by taxonomists (Vaurie 1959, 1965).

## Palaeogeographical vicissitudes of the Mediterranean

The Mediterranean Sea is subject to very complex tectonic activities, due primarily to the strong collision between the large Eurasian Plate to the north and the African Plate to the south. Between them there are other microplates; the Hellenic Arc is an arc-shaped tectonic structure about 1,000 km long that stretches from the Ionian Islands, located north-west of Greece, to the island of Rhodes from which the Cyprus Arc originates. Generating this complex structure was the subduction (still ongoing) of the African plate, moving S-N at a rate of about 10 mm/year, under the Aegean microplate, which in turn moves in a NE-SW direction by about 45 mm/year (Chamot-Rooke et al. 2005).

In the second half of the Messinian (between 5 and 6 Mya), the exceptional event of the salinity crisis, which is the drying up of the Mediterranean Sea, occurred. The connection between the Atlantic Ocean and the Mediterranean Sea was interrupted; only a few large brackish lagoons remained, water was scarce for at least half a million year, and lions, buffalos, monkeys and elephants moved to the only areas where water still existed (Axelrod 1975). During the Messinian it was possible for many animal species to reach geographical areas that they would hardly have reached had the Mediterranean continued to exist. The pollen research carried out by Fauquette et al. (2006) established that the Mediterranean area was then characterised by two types of vegetation: in the southernmost part conditions were dry and warm and the vegetation was relatively open, while in the northernmost part the warm-humid conditions allowed the growth of forest-type

vegetation. The researchers were also able to establish that the salinity crisis was not directly caused by the climate and that the climate did not change substantially during this period, particularly in the southernmost part of the area, where it remained very dry and warm before, during and after the salinity crisis (Fauquette et al. 2006).

The Quaternary was a period of exceptional climatic instability. During the cold-dry episodes, forests were replaced by steppes and tundra in the north and by savannah-like formations from the tropics to southern Europe; the continental vertebrate faunas of peninsular Italy and Sicily included elephants, lions and hippos, indicating a savannah environment even at our latitudes. In the Pliocene (between 5.3 and 2.6 Mya), the climate must still have been relatively warm; the Mediterranean climate stabilised more or less 3 Mya, but considerable climatic changes also occurred in the Pleistocene (between 2.6 Mya and 11,700 years BP), particularly during glaciations and interglacial periods.

The effects of each glaciation on the fauna were cancelled out by the next one, so that the last glaciation explains the distribution and diversification patterns of today's avifauna. Although the deciduous forests of Europe were reduced and compressed in the Mediterranean peninsulas during the Pleistocene, areas covered by forests remained in North Africa and the Middle East. During glacial periods there was a drop in sea level of the order of 60 meters in the first glaciation and as much as 130 meters in the last (Würm, around 18,000 years BP); the maximum temperatures would have allowed the coexistence of European vegetation and associated fauna (Keast 1990). It is from the period before the first glaciation that pollen shows the presence of a Mediterranean-type vegetation, i.e. scrubland characterised by *Quercus ilex* (or *Q. coccifera/calliprinos*), *Pistacia* and Ericaceae (mainly represented by *Arbutus unedo*) (Pons 1981). Pollens dating back to the Würmian glaciation (12,000-110,000 years BP) show that much of southern Europe was composed of *Artemisia* steppes with scattered patches of forest (the average temperature was ca. 8 °C lower than today) and only later, after the retreat of the glaciers, 12,000 years BP, there was an expansion of *Juniperus* and *Pinus*, and a re-growth of *Quercus* forests was observed (Blondel 1990, Grove 1996). This kind of vegetation favoured the spread of bird species associated to coniferous (e.g., crossbills, siskin) and to evergreen broadleaved forests (many species of passerines, woodpeckers, etc.) (cf. also Pavia 2022).

In Mediterranean habitats today evergreen sclerophylls are found, which have adapted to the abundant winter rains that alternate with very dry summers; they have small, thick, evergreen leaves, usually with a villous covering and frequently with a robust cuticle, which allow them to retain moisture during long dry periods (Shugart 1990). Their deep root systems allow them to capture water at depth; in addition, many species are well adapted to withstand fire disturbance, promoting rapid re-growth of vegetation after fire. This type of structure seems to have originated in relatively warm and moderately mesic conditions and has pre-adapted different species to climates with shorter periods of rainfall and greater temperature variability. Such modifications are ancient, as can be judged from the presence of essentially modern scrub and woodland evergreen sclerophyll taxa in the Miocene and Oligocene floras, which experienced very wet summers. These characters are therefore not an evolutionary response to an ancient and persistent Mediterranean-type climate; from a functional point of view, adaptation to the Mediterranean climate is a fine-tuning when considering the ability to reproduce in a short period of wet weather during the coldest part of the year (Shugart 1990). Aridity in summer is the major limiting factor for plant activity, not the cold of winter; flowering and growth take place mainly in winter and spring and only a few species and rare individuals vegetate in summer (Axelrod 1955, Blondel 1990, 2018). The Mediterranean climate is therefore much

younger than the sclerophylls, as it only appeared after the first glacial events.

## The climatic phases

The climatic phases have been studied both by sampling and identifying fossil pollen, and by analysing the ratio of oxygen $^{18}O$ to $^{16}O$, which changes with temperatures. When temperatures are very low due to ice caps, i.e. during glaciations, water and marine organisms are enriched in $^{18}O$ and thus the ratio between $^{18}O$ and $^{16}O$ is in favour of the former; the opposite occurs when temperatures rise, i.e. during interglacial stages (Fauquette et al. 2006). Thanks to the study of the ratio between $^{18}O$ and $^{16}O$, it was discovered that glacial and interglacial stages amount to about sixty and glaciations to about thirty. These periodic climatic changes make us understand how shifts in the range of fauna and flora could have taken place southwards and then northwards, and also how so many endemic invertebrate species could have formed in mountainous areas of the Mediterranean peninsulas, where populations could remain imprisoned and isolated for long periods of time and thus undergo differentiation, thanks to small adaptive changes. Examples are the Iberian mountains, the Apennines in Italy and the Balkans in the east, areas rich in taxa of endemic invertebrates but with only single cases of endemic forest bird species (Blondel 1990, 2018, Keller et al. 2020, Massa 1993, 2022). According to Hewitt (2004) the Balkan peninsula appears to have served as a primary colonization source to north Europe, followed by the Iberian peninsula, whereas Italy provided very few colonists moving North, due to Alps barrier; this possibly may explain why certain species did not reach the central and southern Apennines (e.g., crested tit), while they were able to colonise the other two Mediterranean peninsulas; however, the recent expansion in north Apennines of crested tit (Lardelli et al. 2022) shows its present ability to live at lower Apennine latitudes.

It is very interesting to highlight that when comparing the entire breeding avifauna with the forest birds breeding in the three peninsulas the same Sørensen's similarity index values were found (Massa 2022); in a sense, the forest species represent a significant sample of the entire avifauna of the three peninsulas and show that a similar biogeographical story occurred.

As stated above, corroborated by paleobotanical and paleontological data, at least during the last two million years the expansion and contraction phases of glacial and Arctic conditions and the consequent expansion of ecological zones forced the entire European avifauna to take refuge in the Mediterranean (Le Houérou 1980). Thirteen thousand years ago deciduous oak forests were located at the southern tip of the Balkan, Italian and Iberian peninsulas; they reached Scandinavia only 6,000 years later. Mediterranean vegetation never completely disappeared during the Pleistocene, even under the most severe climatic conditions. During the interglacial period, Mediterranean forests at low to medium altitudes were widespread, mainly dominated by deciduous and non-evergreen broadleaf trees. The expansion of vegetation took place between 12,000 and 9,500 years BP (Blondel 1990, 2018). This has allowed the majority of species to continue living in these Mediterranean-type habitats.

Following Blondel (1990, 2018) Mediterranean forest birds originated in the large forest blocks of Eurasia; every species living in the Italian forests, as well as in the other Mediterranean peninsulas, are almost certainly also found in central European forest environments. For the reasons stated above, species of true Mediterranean origin are hardly found in mature evergreen oak forests today. The nearly absence of endemic taxa among Mediterranean forest birds is unexpected, especially when one considers how many endemic plants there are and how many opportunities species have had to become

isolated (Blondel 1990, 2018, Covas & Blondel 2008). Overall, the Mediterranean avifauna is no different from that of Europe today, but barely impoverished, probably due to the fact that the Mediterranean region falls on the south-western edge of Eurasia (Blondel 1990, 2018).

## Man's influence on present-day forest avifauna

The great naturalist Gaius Plinius Secundus (Pliny the Elder) wrote '*Summum munus homini datum arbores silvaeque intelligebantur*' (translated from Latin: Trees and forests must be understood as the supreme gift given to mankind). It seems clear that already at the beginning of the first millennium, men of science were aware of the importance of forests and individual trees. The Mediterranean, and in particular the three peninsulas, were then covered with important forests, which, due to overexploitation and the need to obtain cultivable land, were considerably reduced over the following hundreds of years. It is obvious that the animal populations that were associated with those forests also declined; however, to the best of our knowledge, no forest birds have become extinct in historical times, except for in single insular regions.

At the beginning of the Holocene, 11,700 years BP, the warming of the climate became more pronounced, the incident solar radiation at Mediterranean latitudes was about 7% higher than today, and precipitation more numerous. It should be noted that in the Fezzan (Matkandush, Sahara, Libya) there are rock carvings of species such as giraffes, elephants, dating back some seven thousand years, indicating the existence of a savannah where today there is a rocky desert (Figure 7). This is evidence of the natural relatively rapid climate change a few thousand years ago, and the youth of the Sahara desert. This was the most important period for the pedogenesis of the Mediterranean where there was a climatic optimum; it was during this period that the first Neolithic cultures and the very first agricultural activities were born (Le Houérou 1980). The pastoralism and agricultural practices marked the first changes to the environment that would later become increasingly accentuated. The present extension of the maquis is associated with deforestation by man, which has not stopped since the beginning of the Neolithic period, 8,000 years BP. The most favourable time for the natural expansion of the maquis was probably in the Xerothermal period, when the climate was drier and warmer than today (Axelrod 1975). According to Le Houérou (1980), between 8,000 and 3,500 years BP, during the Neolithic and Protohistoric revolutions, man exerted a very important transformative action on vegetation, initially in the eastern and then in the western Mediterranean. The definition of 'revolution' is due to the fact that in the 2,500 years of that period there was a large increase in the world's human population, which grew from 10 to 100 million (Le Houérou 1980).

Figure 7. Rock carvings of giraffes and elephants, dating back some seven thousand years, at Matkandush, in the Libyan Sahara (Fezzan), showing that what today is desert was a savannah only a few thousands of years ago.

Between 5,000 and 4,000 years BP there was also a climatic deterioration towards aridity throughout the Mediterranean, and for at least 2,500-4,000 years shepherds and farmers have been burning down forests to obtain better pastures and new land for cultivation. This has had a particular significance on Mediterranean vegetation, which can undoubtedly be considered fragile and vulnerable, due to the climatic conditions in which it lives (relatively mild winter, long aridity in summer), especially susceptible to fire and overgrazing. In much of the Mediterranean region historically logging and fire have degraded the original oak forests to the maquis stage and altered the relative abundance of other smaller tree species. Overgrazing and inappropriate cultivation practices subsequently caused the disappearance of shrub species, changing maquis into garrigue, a type of woody Mediterranean vegetation consisting of very low evergreen shrubs (e.g., rosemary, thyme, broom, dwarf palm, etc.) and allowing soil erosion. Thus, little by little the ancient forest landscape was converted into heaths covered with grasses and other wind-resistant and undemanding herbaceous species. Human activity has produced vast expanses of garrigue; bare spaces and small rocky areas are often interspersed among the plants. Due to regular fires or overgrazing, garrigue can cover large expanses and is perhaps one of the most widespread environments in the Mediterranean area because of these negative factors.

In 1888 the extent of Italian forests was 42,150 km$^2$, the present extent amounts to 117,000 km$^2$, accounting for 37.8% of the country's surface, with an increase of 75,630 km$^2$ and an annual growth rate of 595.5 km$^2$ (Agnoletti et al. 2022). Most forests are found in the Alps and Apennines, but a fair amount of forest cover also exists in coastal (e.g., pine forests), lowland areas, and islands. Over nearly a century, humans have also reforested, mostly with conifers, and in many cases terraced hillsides and mountainsides in order to plant trees. Thus, a fair percentage of Italy's forest cover is made by tree planting.

Figure 8. Terracing in the islands of Cyprus (above) and Crete (below) carried out in the steep slopes of mountains to obtain arable soil and plant olive trees.

Throughout the Mediterranean area, and particularly in islands characterised by rugged hills and mountains, man has sought to obtain arable land by terracing with great difficulty and powerful manpower the slopes, even steep hills and mountains, in order to obtain soils where to cultivate. Cyprus, Crete, Sicily have mountain terraces that have served both for the planting of coniferous forests and for the cultivation of olive groves (Figure 8). Eventually, although tree cover of limited ecological value, these have served for the establishment of some of the most widespread species of forest birds. These events have contributed in no small measure to the recent distribution of bird species, especially those associated with tree vegetation.

According to available statistics, tree cover in Italy is increasing, mainly since 1980' (Agnoletti et al. 2022; Figure 9); recently the extent of the forest has increased remarkably,

rising from 91,414 km$^2$ in 1990, to 94,704 km$^2$ in 2000, and reaching 96,532 km$^2$ in 2008 (for all three dates, the error standard of the estimate is very small, amounting to 0.1%; Marchetti et al. 2012). Thus, during the period 1990-2008, there was an increase in forest area of 5,118 km$^2$. It was certainly the same phenomenon of progressive abandonment of rural land that sees the triggering of processes of natural recolonization by shrub and tree species in marginal areas (Marchetti et al. 2012). However, it should be noted that while it is true that due to the abandonment of agriculture, mainly in central and northern Italy, forests are expanding naturally, some recent forest increase (3.3%; Agnoletti et al. 2022) is due to afforestation, mainly with conifers.

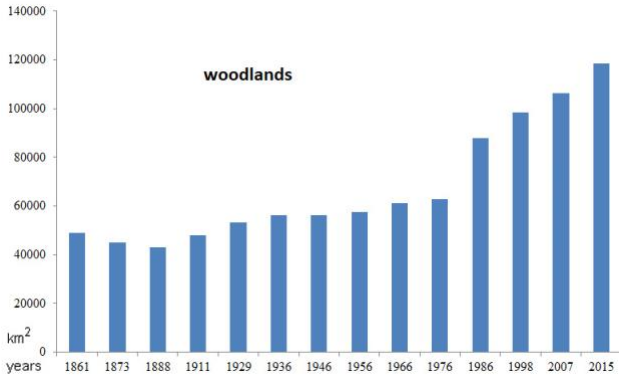


Figure 9. Annual increase of wooded area in Italy from 1861 to 2015; 3.3% of the recent increase (since 1980') is due to afforestation (after Agnoletti et al. 2022, reprocessed).

However, although fairly accurate data are available on the increase in forested areas (mostly afforestation), the statistics do not take into account the area burned year after year; statistics on the area of forest destroyed by fire are very poor and in some cases absent. The Italian regions more affected by fire generally are Sicily, Calabria, and Sardinia. In terms of percentage, the habitats more affected by fires from 2000 to 2023 are Mediterranean pine forests, and Italy resulted to be the 3$^{rd}$ most affected country by forest fires in Europe (after Spain and Portugal) (Pepe et al. 2020); ca. 1,784,000 hectares of Italian land have been fired, mainly arson, between 2000 and 2023, which is 5.9% of the total Italian land area (Figure 10). Of course, not all of the fire passed through forests, some of it affected pastures, shrubs, garrigue, and even cultivated land; the majority of the forests traversed by fire, however, were coniferous afforestation, which once burned are obliterated forever.

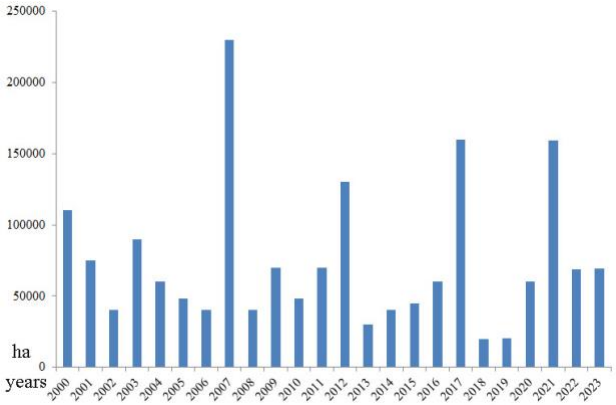


Figure 10. Hectares of land interested by Italian fires between 2000 and 2023; the total surface of fires, mainly arson, which affected Italian land amounts to ca. 1,784,000 hectares, much covered by forests (after Pepe et al. 2020, updated).

There is an obvious difference between natural forests and afforestation; many species of invertebrates or even herbaceous or shrubby plants established within natural forests are lacking in afforestation, and thus some bird species select only certain forest environments and not others. Data collected in the Iberian peninsula (Telleria and Santos 1994) allowed finding out the relationships between a series of environmental variables and the abundance of individual species of forest birds. The variable most highly correlated with the abundance of species was floristic composition and the diameter of trees; bird density was also correlated with mean annual rainfall (positive correlation: e.g., chiffchaff, goldcrest, robin, bullfinch; negative correlation: e.g., Bonelli's warbler) (Telleria and Santos 1994). This shows that obviously each forest has its own characteristics, and these in turn allow the presence of certain species and not others.

Although, in general, from 1980 to 2003 populations of many common forest birds in some parts of Europe appeared to be declining by 13-18% (Gregory et al. 2007), in particular in Great Britain (Fuller et al. 2005); Gil-Tena et al. (2009) found a certain degree of variation across the Iberian peninsula. Interestingly, the percentage of diminution is very similar both for species and populations. Overall, in Italy a similar percentage (16.6%) of forest bird species resulted to be decreasing, both over a long time (150 years) and in present times (Lardelli et al. 2022), also similar to that found (20%) by Gil-Tena et al. (2009) in Spanish forest bird populations. The latter authors highlighted that forest maturation is most influencing dynamic of forest birds, which are more related with advanced forest development stages than with initial succession stages as those of young forests. Reif et al. (2023) found that the long-term population trends of ground-nesting birds are more negative than the trends of species nesting above the ground, with an increase from eastern to western European countries; this probably is due to the effect of nest predation, probably higher in the western countries. In addition, they highlighted that the effect of longitude interacted with the habitat association, being strong in woodland species and weak in open-habitat species; they concluded that the pattern suggests that the increased nest predation pressure in the woodland of the western countries may be due to higher abundances of herbivorous mammals that destroy forest ground and shrub layer, leaving nests exposed to predators. Very likely, some of these mammals are introduced or re-introduced artiodactyls.

Overall, species that inhabit a forest do not remain in that forest forever; the greatest species diversity can be found in forests where different stages of succession are represented at all times (Avery and Leslie 1990). In conclusion, presently this may depend on the forest management by man, as well as on the age of the trees, the presence of permanent open spaces (important to birds), and other characteristics at the edge of woodland. The forest consists of numerous microhabitats that depend on forest species (conifers, broadleaf trees of different species, etc.), age, trunk diameter, exposure, altitude, amount of litter, and the presence of undergrowth and clearings. These ecological factors enable the establishment of different species of birds. An afforestation of allochthonous *Eucalyptus* is certainly unattractive to most Mediterranean forest species, not only birds; it can be easily understood that the most ecologically demanding species are found only in certain types of forest, if a species is uncommon then it will occur only in wide woods with singular ecological characteristics.

More recently, in the last few decades, perhaps due to climate change or the increased trophic availability within cities, some forest species have begun to colonise the tree cover of towns and have become heavily urbanised. Some species (e.g., woodpigeon, blackbird, serin) had already carried out this urban colonisation process many years earlier in central Europe, others (e.g., jay) have begun to do so in Italian towns. The reasons for this recent immigration may be many: better winter temperatures inside cities compared to forests, lower likelihood of predation for some species, greater availability of trophic resources, which allow a greater number of reproductions per year (e.g., woodpigeon, three times a year and sometimes from January to November; La Mantia 1994), and finally lower mortality of fledglings. In addition, other species, like siskin and crossbill, benefited from recent conifer afforestation, mainly in south Italy (Congi 2021, G. Congi pers. comm.).

Only in the Iberian peninsula two endemic forest birds live; however, the fact that all forest species present in Italy are Least Concern (BirdLife International 2015) also means that generally researchers who dealt with the red lists did not consider them to be at risk because these birds are widespread in Europe and do not face any kind of present threat. However, according to the Italian red list (Gustin et al. 2019) six forest bird species are considered

at local risk: barred warbler (Critically Endangered), black grouse (Endangered), western capercaillie, middle spotted woodpecker, white-backed woodpecker, and garden warbler (Vulnerable); in addition, the Sardinian subspecies of goshawk is considered Endangered, while the other forest species are listed as Least Concern. The long-term study calculated over 150 years, however, shows a less risky trend for the two woodpecker species above cited ('stable' in Table 1), while for the other four species the status in Italy is not at all positive. Also, the mean ecological value (1.9-2.1; Table 3) denotes a good presence of ecologically demanding species in all the three peninsulas.

Among the causes of the expansion of bird species there are creation of new habitats, increase in trophic availability, and climatic fluctuations. It is not always easy to understand the cause of the expansion of certain species, but certainly new trophic factors and probably, at least as far as urban environments are concerned, significantly higher average temperatures in association with the anthropic activities from which the birds sometimes benefit, contribute. This takes place because in nature, animal populations undergo colonisation events, declines, increases or simple fluctuations over time (Isenmann 1990, Massa and La Mantia 2007, La Mantia et al. 2014).

## CONCLUSIONS

Overall, today the Mediterranean forest avifauna is no different from that of Europe, but hardly impoverished, very likely due to the fact that the Mediterranean region falls on the south-western edge of Eurasia. The nearly absence of endemic species among Mediterranean forest birds is unexpected, especially when one considers how many endemic plants there are and how many opportunities species have had to become isolated. However, from the reconstruction made in the preceding pages, it can be understood that the avifauna of the forests of Mediterranean Europe is of fairly recent origin and, above all, the result of the isolation of Eurasian populations during the ice ages, when the Italian peninsula (together with the Iberian and Balkan ones) remained isolated refugia for the fauna and flora. The effects of each glaciation on the fauna were cancelled out by the next one, so that the last glaciation explains the distribution and diversification patterns of presently forest avifauna. Most species became definitively established during the last ice age and can be considered in this sense as glacial relicts. A portion of species that colonised the Balkan peninsula in turn colonised the Italian peninsula via the trans-Adriatic route and are therefore absent from the Alps. However, those which have differentiated from north-eastern populations should be considered neo-endemic taxa, dating back some 18-20,000 years. Thus, this time frame was sufficient for differentiation of isolated populations of some species, at the subspecific or specific level. This took place in the Iberian peninsula, Sicily and probably the Apennines. Only the Iberian peninsula has two endemic species, which have become isolated due to the Pyrenean barrier and the fact that the Iberian peninsula is the extreme south-western apex of Eurasia, separated from North Africa by the Strait of Gibraltar. It remains quite unknown what has happened in the Sardinian-Corsican system, which, although very old, presently hosts only a few differentiated populations of some forest species of birds, except for Corsican nuthatch, a species endemic to Corsica, and absent elsewhere, related to Algerian nuthatch (Kabyle) and Krüper nuthatch (Turkey, Caucasus and Lesvos islet). Here briefly another Mediterranean forest species deserves to be mentioned, Le Vaillant woodpecker in North-West Africa, belonging to green woodpecker group and isolated in the Maghreb, probably when the Strait of Gibraltar reopened around 5 Mya. This woodpecker, and the three species of nuthatches mentioned above are undoubtedly among the oldest forest species in the Mediterranean area and may be considered paleo-endemic taxa.

"Account of the past will be useful in understanding present and future events" [Thucydides (460-404 BCE), Peloponnesian War between Athens and Sparta, translated from Latin]. As we have seen above Huntley et al. (2007) have attempted to simulate the future of European avifauna in the late 21st Century; the very pessimistic vision they present, much more than the trend currently calculated on the basis of the bibliography consulted, may be grimly realistic, but this will depend only on humans making important decisions for environmental conservation. Italian forest species, like those in the rest of the Mediterranean, will face some challenges in the coming decades because of the problems faced by their elective habitat, the forest. Wishing to reduce to a few but important threats to forests, they could be climate change, global warming, reduction of old-growth forests, increased fires and $CO_2$ emissions (Figure 11).

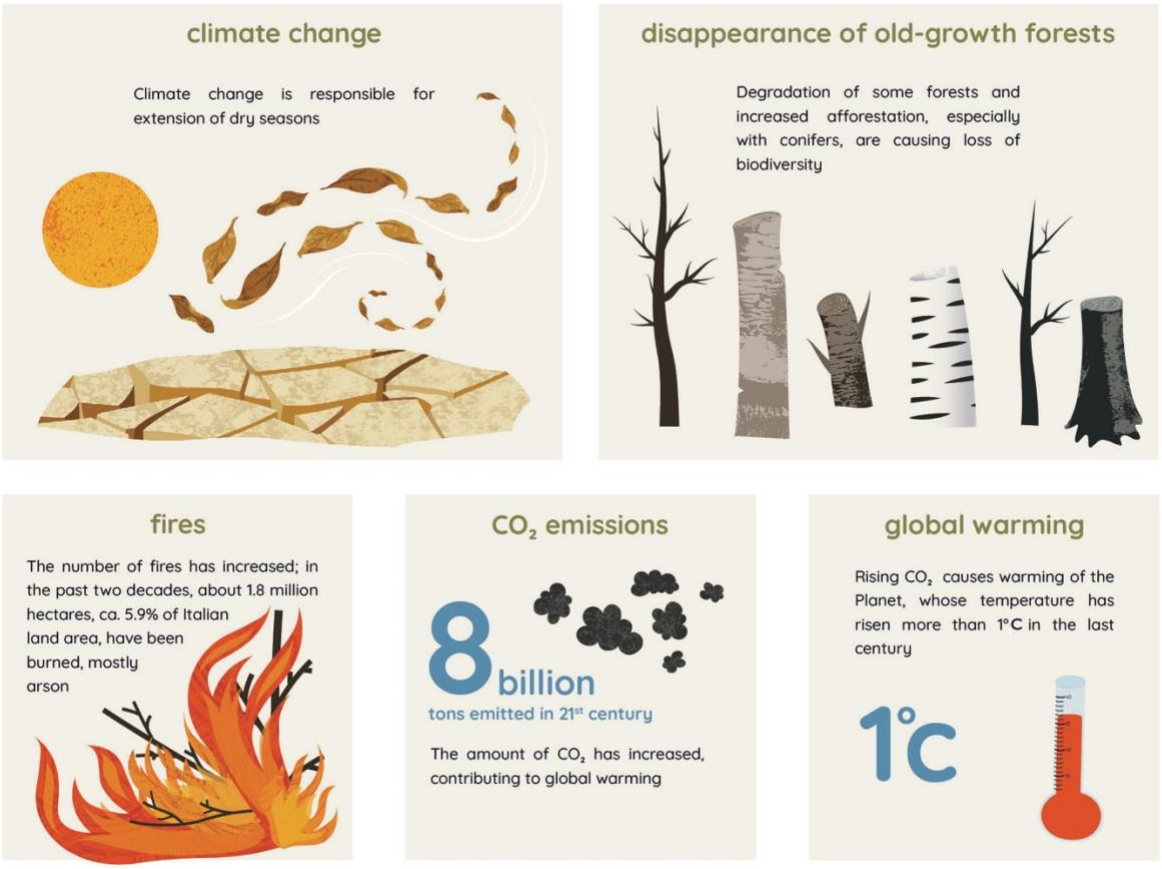


Figure 11. Main threats forest birds will face in the coming decades: climate change, global warming, reduction of old-growth forests, increased fire, and CO2 emissions (drawing by V. Massa).

## ACKNOWLEDGMENTS

First of all, I would like to remember the biogeographer, naturalist and evolutionist Valerio Sbordoni (1942-2024), animator for many years of the Società Italiana di Biogeografia and the journal Biogeographia; he had amicably asked me to write a contribution for this journal and regrettably left us without having had the chance to read the latest issue of the journal.

Further, due credit should be given to Jacques Blondel, who was the first to outline the possible origin of Mediterranean forest birds; without his work this article would not have seen the light of day. Many thanks are due to many friends, specialists on Mediterranean birds, for

their advice, suggestions, and fruitful discussions on biogeographical, taxonomic and habitat issues. In particular, I would like to thank Giuseppe Bogliani for some information on the black woodpecker expansion in north Italy, Fulvio Fraticelli for the discussion on Italian ornithological topics, Tommaso La Mantia for bibliographical references and stimulating suggestions on forestry issues, Rafael da Silveira Bueno for his support in the processing of Italian forest area, Gianluca Congi who kindly provided advice and nice photos of forest bird species from south Italy, Mathia Coco, who has kindly made available the photo of the Sicilian long-tailed tit, and Violetta Massa, who depicted the Figure 11. Finally, I am indebted with two anonymous referees for their useful and constructive suggestions, and bibliographic references.

**Dedication**. This article is dedicated to the writer Italo Calvino (1923-1985) on the centenary of his birth. Calvino, the only humanist in a family of scientists, father agronomist, mother botanist, two uncles chemist, and a brother geologist, undoubtedly felt the need to recompose the rift with his family, writing in an ecological vein 'Il Barone rampante' (1957) an indictment against the building speculation of the 1950s, when no one was yet talking about ecology. Calvino testified to the ancient continuity between Italian forests and those in France and Spain, which is discussed in this article regarding forest birds, some of which due to habitat fragmentation are declining. One sentence within this short story is interesting: "I do not know if it is true what one reads in books, that in ancient times a monkey that had set out from Rome jumping from tree to tree could reach Spain without ever touching the ground. In my time of places so dense with trees there was only the gulf of Ombrosa from end to end and its valley to the crests of the mountains". Furthermore, in the short story "La nuvola di smog" (1958) he was talking about a cloud of smog that gravitated over the city in which the protagonist lived causing dust and dirt to pervade everything, soiling rooms, clothes, walls and streets; in the same book he included another short story, "La formica Argentina", already published in 1952, where he discussed among the first in Italy of an alien species: the unpleasant invasion in the 1920s of the Argentine ant in San Remo and the Riviera di Ponente (Liguria, Italy).

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*Submitted: 17 November 2023*

*First decision: 19 February 2024*

*Accepted: 1 March 2024*

*Edited by Francesco Paolo Faraone*