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Source: *Ardea*, 96(1) : 115-120

Published By: Netherlands Ornithologists' Union

URL: <https://doi.org/10.5253/078.096.0113>

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Temperature differentially mediates species richness of birds of different biogeographic types

Gregorio Moreno-Rueda^{1,2,*} & Manuel Pizarro²



Moreno-Rueda G. & Pizarro M. 2008. Temperature differentially mediates species richness of birds of different biogeographic types. *Ardea* 96(1): 115–120.

This study explores the relationship between richness of bird species and climate in Spain, distinguishing groups of species according to biogeographic type. Species richness proved to be related to temperature but in a different way for each of the biogeographic groups. While controlling for other variables, species richness initially increased with temperature, but dropped when temperature increased further. As this drop was less strong in southern species than in northern species, a positive relationship between the percentage of southern species and temperature emerged. Moreover, the percentage of southern species varied with human population density, altitude range and precipitation in a quadratic way.

Key words: climatic change, habitat heterogeneity, human population, land use, Spain

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Introduction

Climate is one of the most important factors determining the distribution of avian species richness (e.g. Rahbek & Graves 2001) by its effect on primary production (van Rensburg *et al.* 2002, Chown *et al.* 2003, Hurlbert & Haskell 2003), and by its interaction with physiological requirements and tolerances of species (Turner *et al.* 1988, Woodward & Kelly 2003). Factors determining species richness are not universal, but vary among taxa (e.g. Miller *et al.* 2003). This is because the distribution of species is mediated by their ecological niche (Pulliam 2000, Wiens & Donoghue

2004), and groups of species differentiated by their taxonomy, behaviour, or physiology can have a shared or convergent evolution, responding differentially to certain factors which interact with the necessities imposed by their niche. Knowledge on the way how climate affects the distribution of avian species richness is of prime importance as the Earth is under a climatic warming (IPCC 2001). This climatic change is already affecting bird distribution (Thomas & Lennon 1999), and dramatic changes in the distribution of birds are predicted (Huntley *et al.* 2006).

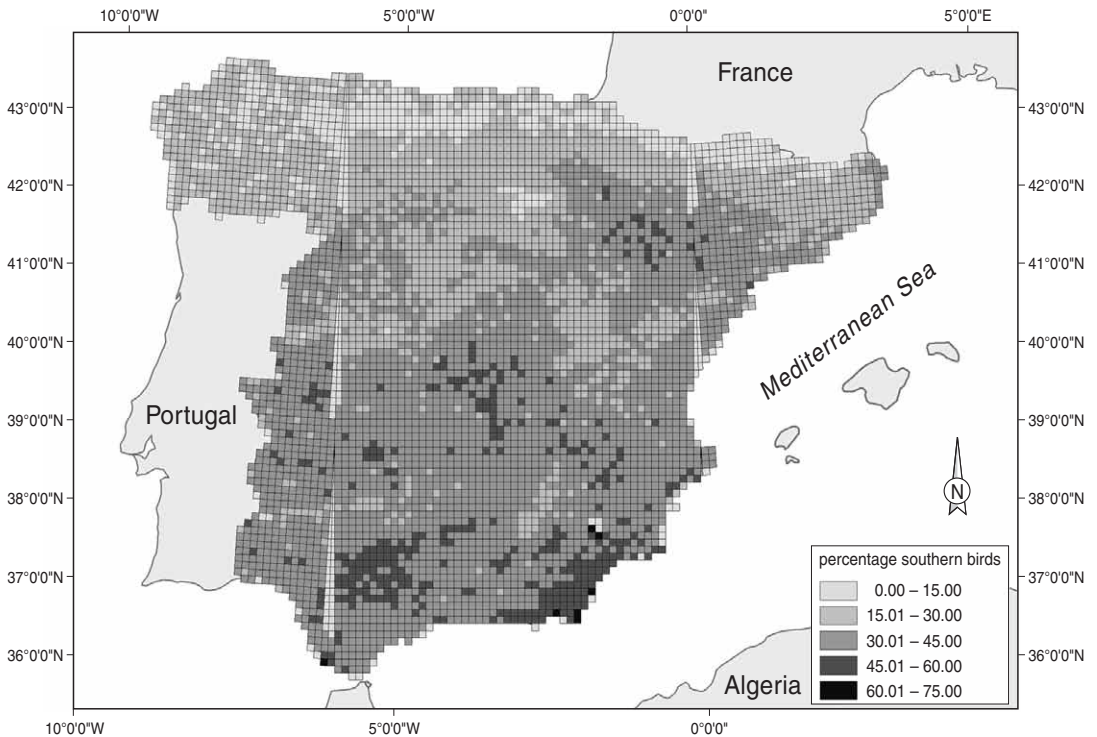


Figure 1. Distribution map for the percentage of southern species in Spain in 10 x 10 km squares.

Species in different climate zones of the Earth must be adapted to different environmental conditions, which spawned the distinction between biogeographic types (Voous 1960, Newton 2003). As species of different biogeographic types are adapted to different climates, climate might differentially affect species richness of birds of different biogeographic types. We tested this hypothesis on the basis of the distribution of birds in Spain. We predict that the richness of northern species should be negatively correlated with temperature, and positively with precipitation, while the reverse should occur in the richness of southern species (also see Santos & Tellería 1995).

Methods

The study area was peninsular Spain, which has a variety of environments ranging from Mediterranean aspects to an oceanic climate along the

Cantabrian coast. The study area was divided in 5331 UTM squares of about 10 x 10 km (Fig. 1). Cartographic distortions caused some squares to be less than 100 km², and these were removed from the analyses. Squares without environmental information were also dropped from analyses, resulting in a final sample size of 5070 squares.

Species richness was defined as the number of bird species in each cell. We used all species of breeding birds listed in the national atlas (Martí & del Moral 2003, Ministerio de Medio Ambiente 2003). We assigned each species to the category 'northern' or 'southern', according to its biogeographic type (listed in Online appendix 1). Biogeographic types for which distribution was ubiquitous (e.g. Cosmopolitan or Old World) were discarded (Online appendix 1). With these data, we calculated the percentage of southern species in each square. The percentage of southern species

was positively correlated with the richness of southern species ($r = 0.66$; $P < 0.001$; $n = 5070$ squares) and negatively with the richness of northern species ($r = -0.64$; $P < 0.001$).

Independent variables were acquired from the European Environment Agency (www.eea.europa.eu), using a geographic information system (SAGA; Conrad 2005). To test effects of climate, we considered two variables for each of the squares: (1) mean annual temperature, and (2) total annual precipitation. Mean annual temperature was strongly correlated with mean temperature in the coldest and hottest months ($r > 0.88$). Moreover, we considered (3) altitude range, (4) habitat diversity, as the sum of types of land use, taken from Corine Land Cover (www.eea.europa.eu), (5) human population density (log-transformed), (6) humanized surface area, as the percentage of area used by humans (croplands and urban zones; arcsine-transformed), which served as a negative indicator of natural land available. Lastly, in order to minimize possible effects of spatial autocorrelation, we introduced the geographic variables longitude (Lon) and latitude (Lat) of the centre of the squares, as well as the composite variables Lon^2 , Lat^2 , Lat^3 , $\text{Lon}^2 \times \text{Lat}$ and $\text{Lon} \times \text{Lat}^2$, according to Legendre (1993). We did not use Lon^3 and $\text{Latitude} \times \text{Longitude}$ because this destabilized the matrix and least squares could not be calculated. The inclusion of these terms successfully removed most of the spatial autocorrelation, indicated by Moran's I of the residual models, always lower than 0.15 (Diniz-Filho *et al.* 2003).

Variables had an almost normal distribution, otherwise they were transformed to fit a normal distribution. Variables were standardized with a mean of 0 ± 1 SD (Sokal & Rohlf 1995). To test the relationship between independent variables and species richness, we used a Generalized Linear Model (GLM) of Ordinal Least Squares (OLS). This analysis statistically controls for the effects of other independent variables. Multicollinearity was not high, as absolute values of correlations between independent variables were 0.66 or less, and tolerance was always higher than 0.3 (Quinn & Keough 2002). To test for curvilinear relation-

ships, we introduced polynomial terms of variables 1–6 into the model. Variables in the final models were selected by a stepwise backward process.

Results and discussion

Figure 1 shows the distribution of the percentage of southern species in Spain. As expected, the percentage of southern species per square correlated with temperature in a positive way ($r = 0.65$; $P < 0.001$; $n = 5070$ squares; Fig. 2). When controlling for effects of other variables, the GLM showed a significant positive relationship between percentage of southern species and temperature (Table 1). This model explained 76% of variation in percentage of the southern species. We repeated the GLMs in order to examine the relationship between temperature and species richness of southern and northern species. After controlling for the other independent variables in this study, species richness of southern and northern species were related to temperature in a quadratic way (Table 1). In both cases, species richness dropped with increasing temperature, but less so in southern species, thus explaining the results found for the percentage of southern species. Other studies have shown that the distribution or abundance of

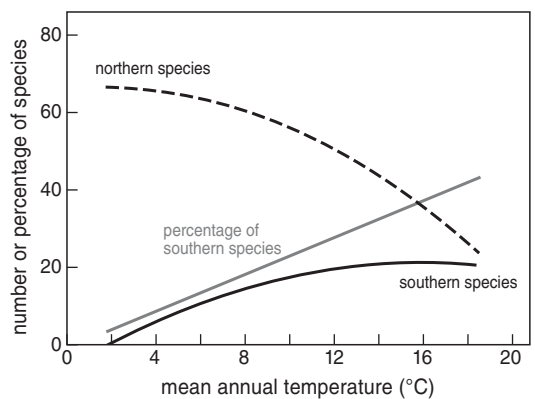


Figure 2. Relationship (without controlling for other variables) between temperature and number of southern species ($y = -7 + 0.24x - 0.18x^2$), number of northern species ($y = 66 - 0.66x - 0.12x^2$), and percentage of southern species ($y = 0.65x$). Data points are not shown for clarity.

Table 1. Results of GLM's analysing dependence of percentage of southern species, richness of southern species, and richness of northern species on various variables. The b coefficients of the multiple-regression model are given, as well as values of R^2 and F -statistic. In bold, slopes that significantly differ from zero at $P < 0.0025$ (corrected by Bonferroni). - indicates that variable was removed by backward stepwise selection.

Dependent variable	Percentage of southern species	Southern species richness	Northern species richness
R^2	0.76	0.50	0.58
F -statistic	1079.12	282.36	403.52
df	15,5054	18,5051	17,5052
Longitude (Lon)	4.980	6.29	-2.47
Lon ²	-8.73	-13.86	2.63
Latitude (Lat)	-211.80	-396.05	-133.15
Lat ²	429.34	800.81	264.82
Lat ³	-217.67	-404.67	-131.66
Lon ² xLat	8.35	13.10	-3.23
LonxLat ²	-4.33	-5.46	3.11
Human population (HP)	0.21	0.22	0.05
HP ²	-0.28	-0.30	-
Humanized area (HA)	-	0.19	0.09
HA ²	-	-0.24	-0.24
Altitude range (AR)	0.42	0.36	-0.17
AR ²	-0.49	-0.30	0.26
Habitat diversity (HD)	-0.03	0.10	0.11
HD ²	-	-	-
Temperature (T)	0.39	0.69	0.13
T ²	-	-0.37	-0.36
Precipitation (P)	0.14	0.91	0.83
P ²	-0.28	-1.09	-0.79

avian species, in general, is affected by temperature (Root 1988, Turner *et al.* 1988, Lennon *et al.* 2000), our study extending on this by showing that the effect of temperature depends on the biogeographic type considered.

While, percentage of southern species correlated negatively with precipitation ($r = -0.64$; $P < 0.001$). However, when the relationship with precipitation was controlled for other variables, a quadratic relationship emerged, with higher percentages of southern species for intermediate values of precipitation. Analysing richness of northern and southern species separately, the two biogeographic types showed a similar quadratic rela-

tionship with precipitation (Table 1). Probably, precipitation favours species richness through primary productivity (Waide *et al.* 1999, Hawkins *et al.* 2003, Whittaker *et al.* 2007), but high levels of precipitation harm species survival and breeding, affecting plumage impermeability and foraging opportunities (Lennon *et al.* 2000).

The GLM also showed a significant quadratic relationship between percentage of southern species and human population density, indicating a decline of percentage for high values of this variable (Table 1). Many southern species are associated with farmland (Suárez-Seoane *et al.* 2002), which could explain this relationship. On the other

hand, the relationship between human population density and species richness of the two southern and northern species differed, being quadratic for southern species, while linear for northern species (Table 1). Therefore, although avian species richness usually correlates with human population (e.g. Araújo 2003), this study shows differences in this relationship according to the biogeographic type considered. This may have implications for avian conservation, as southern species seem to be more sensitive to high levels of human disturbance.

The percentage of southern species showed a significant quadratic relationship with altitude range, with a decline of percentage for highest values of altitude range (Table 1). The concave-up relationship between richness of northern species and altitude range (Table 1) is probably caused by the inclusion of different faunas in the 'northern species' category, with some species inhabiting mountains, while others dwelling in plains.

In sum, this study shows that ecological factors differentially correlate with richness of species of different biogeographic types, resulting in which factors such as temperature mediate differences in the composition of avian species throughout the Iberian Peninsula. Similarly, other studies have shown that ecological factors differentially affect avian species richness according to the distribution range of species considered (Jetz & Rahbek 2002); species richness of birds of different foraging guilds is also affected by different environmental variables (Miller *et al.* 2003). The ecological determinants of avian species richness also vary geographically (Davies *et al.* 2007), which might be a consequence of different avian communities in which species richness is affected by different factors.

Lastly, temperature has increased in Spain in the last century (Hulme & Sheard 1999), and it is predicted to continue increasing in the coming years (IPCC 2001). According to the findings of this study, this will provoke a change in the composition of avian communities in the Mediterranean region by increasing the percentage of southern species. Apparently, northern species are more threatened by climatic change in the region, while in relatively cold zones southern species

would be favoured by a rise of temperatures. However, our analysis provides evidence that in relatively hot zones southern species would be harmed as well. Thus, considerable increases of temperature may cause a decline in avian species richness in Mediterranean regions.

Comments by anonymous referees, Juan Manuel Pleguezuelos, David Nesbitt and Jouke Prop improved the manuscript.

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SAMENVATTING

Rijkdom van vogels wordt voor een groot deel door het klimaat bepaald. Deze studie onderzocht het verband tussen het aantal soorten vogels en het klimaat in Spanje op grond van blokken van 10 x 10 km. Hierbij werd onderscheid gemaakt tussen 'noordelijke' en 'zuidelijke' soorten. Het aantal noordelijke soorten per blok nam af naarmate de gemiddelde jaartemperatuur hoger was, terwijl zuidelijk soorten een omgekeerde trend lieten zien. In de warmste blokken nam ook het aantal zuidelijke soorten enigszins af. Het percentage zuidelijke soorten per blok nam daardoor sterk toe naarmate de temperatuur hoger was. Het percentage zuidelijke soorten nam bovendien toe met bevolkingsdichtheid, hoogteverschillen en neerslag per blok, maar het verband was tegengesteld in het hoogste bereik van deze parameters. (JP)

Corresponding editor: Jouke Prop

Received 21 July 2006; accepted 28 January 2008

Appendix 1. Alphabetic list of bird species in Spain (scientific and common name), their biogeographic type according to Voous (1960) and that assigned by us. We assigned as 'northern' the types: Arctic, Northern Atlantic, European, Euroturquestan, Holarctic, Paleomontane, Palearctic, and Siberian-Canadian; as 'southern species' we assigned the types: Etiopic, Indoafrikan, Mediterranean, Paleoxeric, Paleoxericmontane, and Turquestan-Mediterranean. The types Old World, Cosmopolitan, 'unknown', Mongoltibetan, and Sarmatic were disregarded, as they are amply distributed or their classification was unclear to us. Distribution maps of each group are available from the authors upon request.

Scientific name	Common name	Voous' type	Assigned type
<i>Accipiter gentilis</i>	Northern Goshawk	Holarctic	Northern
<i>Accipiter nisus</i>	Eurasian Sparrowhawk	Palearctic	Northern
<i>Acrocephalus arundinaceus</i>	Great Reed Warbler	Euroturquestan	Northern
<i>Acrocephalus melanopogon</i>	Moustached Warbler	Turquestan-Mediterranean	Southern
<i>Acrocephalus schoenobaenus</i>	Sedge Warbler	Euroturquestan	Northern
<i>Acrocephalus scirpaceus</i>	Reed Warbler	Euroturquestan	Northern
<i>Actitis hypoleucos</i>	Common Sandpiper	Holarctic	Northern
<i>Aegithalos caudatus</i>	Long-tailed Tit	Palearctic	Northern
<i>Aegolius funereus</i>	Tengmalm's Owl	Siberian-Canadian	Northern
<i>Aegypius monachus</i>	Monk Vulture	Mongoltibetan	Discarded
<i>Alauda arvensis</i>	Sky Lark	Palearctic	Northern
<i>Alcedo atthis</i>	Common Kingfisher	Old World	Discarded
<i>Alectoris barbara</i>	Barbary Partridge	Mediterranean	Southern
<i>Alectoris rufa</i>	Red-legged Partridge	Mediterranean	Southern
<i>Amandava amandava</i>	Avadavat	Unknown	Discarded
<i>Anas acuta</i>	Pintail	Palearctic	Northern
<i>Anas clypeata</i>	Northern Shoveler	Holarctic	Northern
<i>Anas crecca</i>	Common Teal	Holarctic	Northern
<i>Anas platyrhynchos</i>	Mallard	Holarctic	Northern
<i>Anas querquedula</i>	Garganey	Palearctic	Northern
<i>Anas strepera</i>	Gadwall	Holarctic	Northern
<i>Anthus campestris</i>	Tawny Pipit	Palearctic	Northern
<i>Anthus pratensis</i>	Meadow Pipit	European	Northern
<i>Anthus spinoletta</i>	Water Pipit	Palearctic	Northern
<i>Anthus trivialis</i>	Tree Pipit	Euroturquestan	Northern
<i>Apus affinis</i>	Little Swift	Unknown	Discarded
<i>Apus apus</i>	Common Swift	Palearctic	Northern
<i>Apus caffer</i>	White-rumped Swift	Etiopic	Southern
<i>Apus melba</i>	Alpine Swift	Indoafrikan	Southern
<i>Apus pallidus</i>	Pallid Swift	Mediterranean	Southern
<i>Aquila adalberti</i>	Spanish Imperial Eagle	Palearctic	Northern
<i>Aquila chrysaetos</i>	Golden Eagle	Holarctic	Northern
<i>Ardea cinerea</i>	Grey Heron	Palearctic	Northern
<i>Ardea purpurea</i>	Purple Heron	Indoafrikan	Southern
<i>Ardeola ralloides</i>	Squacco Heron	Etiopic	Southern
<i>Asio flammeus</i>	Short-eared Owl	Holarctic	Northern
<i>Asio otus</i>	Long-eared Owl	Holarctic	Northern
<i>Athene noctua</i>	Little Owl	Turquestan-Mediterranean	Southern
<i>Aythya ferina</i>	Common Pochard	Palearctic	Northern

<i>Aythya fuligula</i>	Tufted Duck	Palaearctic	Northern
<i>Aythya nyroca</i>	Ferruginous Duck	Turquestan-Mediterranean	Southern
<i>Botaurus stellaris</i>	Great Bittern	Palaearctic	Northern
<i>Bubo bubo</i>	Eagle Owl	Palaearctic	Northern
<i>Bubulcus ibis</i>	Cattle Egret	Indoaffrican	Southern
<i>Bucanetes githagineus</i>	Trumpeter Finch	Palaearctic	Northern
<i>Burhinus oedicnemus</i>	Stone-curlew	Turquestan-Mediterranean	Southern
<i>Buteo buteo</i>	Common Buzzard	Palaearctic	Northern
<i>Calandrella brachydactyla</i>	Short-toed Lark	Turquestan-Mediterranean	Southern
<i>Calandrella rufescens</i>	Lesser Short-toed Lark	Turquestan-Mediterranean	Southern
<i>Calonectris diomedea</i>	Cory's Shearwater	Unknown	Discarded
<i>Caprimulgus europaeus</i>	European Nightjar	Palaearctic	Northern
<i>Caprimulgus ruficollis</i>	Red-necked Nightjar	Mediterranean	Southern
<i>Carduelis cannabina</i>	Linnet	Euroturquestan	Northern
<i>Carduelis carduelis</i>	Goldfinch	Euroturquestan	Northern
<i>Carduelis chloris</i>	Greenfinch	Euroturquestan	Northern
<i>Carduelis spinus</i>	Siskin	Palaearctic	Northern
<i>Cercotrichas galactotes</i>	Rufous-tailed Scrub-robin	Mediterranean	Southern
<i>Certhia brachydactyla</i>	Short-toed Treecreeper	European	Northern
<i>Certhia familiaris</i>	Eurasian Treecreeper	Holarctic	Northern
<i>Cettia cetti</i>	Cetti's Warbler	Turquestan-Mediterranean	Southern
<i>Charadrius alexandrinus</i>	Kentish Plover	Cosmopolitan	Discarded
<i>Charadrius dubius</i>	Little Ringed Plover	Palaearctic	Northern
<i>Charadrius morinellus</i>	Dotterel	Arctic	Northern
<i>Chersophilus duponti</i>	Dupont's Lark	Mediterranean	Southern
<i>Chlidonias hybrida</i>	Whiskered Tern	Old World	Discarded
<i>Chlidonias niger</i>	Black Tern	Holarctic	Northern
<i>Ciconia ciconia</i>	White Stork	Palaearctic	Northern
<i>Ciconia nigra</i>	Black Stork	Palaearctic	Northern
<i>Cinclus cinclus</i>	Dipper	Paleomontane	Northern
<i>Circaetus gallicus</i>	Short-toed Eagle	Indoaffrican	Southern
<i>Circus aeruginosus</i>	Marsh Harrier	Palaearctic	Northern
<i>Circus cyaneus</i>	Hen Harrier	Holarctic	Northern
<i>Circus pygargus</i>	Montagu's Harrier	Euroturquestan	Northern
<i>Cisticola juncidis</i>	Zitting Cisticola	Indoaffrican	Southern
<i>Clamator glandarius</i>	Great Spotted Cuckoo	Etiopic	Southern
<i>Coccothraustes coccothraustes</i>	Hawfinch	Palaearctic	Northern
<i>Columba livia</i>	Rock Dove	Turquestan-Mediterranean	Southern
<i>Columba oenas</i>	Stock Dove	Euroturquestan	Northern
<i>Columba palumbus</i>	Common Woodpigeon	Euroturquestan	Northern
<i>Coracias garrulus</i>	European Roller	Euroturquestan	Northern
<i>Corvus corax</i>	Common Raven	Holarctic	Northern
<i>Corvus corone</i>	Carrion Crow	Palaearctic	Northern
<i>Corvus frugilegus</i>	Rook	Palaearctic	Northern
<i>Corvus monedula</i>	Eurasian Jackdaw	Palaearctic	Northern
<i>Coturnix coturnix</i>	Common Quail	Old World	Discarded
<i>Cuculus canorus</i>	Common Cuckoo	Palaearctic	Northern

Short notes

<i>Cursorius cursor</i>	Cream-coloured Courser	Unknown	Discarded
<i>Cyanopica cyanus</i>	Azure-winged Magpie	Palaearctic	Northern
<i>Cygnus olor</i>	Mute Swan	Palaearctic	Northern
<i>Delichon urbicum</i>	House Martin	Palaearctic	Northern
<i>Dendrocopos leucotos</i>	White-backed Woodpecker	Palaearctic	Northern
<i>Dendrocopos major</i>	Great Spotted Woodpecker	Palaearctic	Northern
<i>Dendrocopos medius</i>	Middle Spotted Woodpecker	European	Northern
<i>Dendrocopos minor</i>	Lesser Spotted Woodpecker	Palaearctic	Northern
<i>Dryocopus martius</i>	Black Woodpecker	Palaearctic	Northern
<i>Egretta alba</i>	Great White Egret	Cosmopolitan	Discarded
<i>Egretta garzetta</i>	Little Egret	Old World	Discarded
<i>Elanus caeruleus</i>	Black-shouldered Kite	Indoaffrican	Southern
<i>Emberiza calandra</i>	Corn Bunting	Euroturquistan	Northern
<i>Emberiza cia</i>	Rock Bunting	Palaearctic	Northern
<i>Emberiza cirius</i>	Cirl Bunting	Mediterranean	Southern
<i>Emberiza citrinella</i>	Yellowhammer	Palaearctic	Northern
<i>Emberiza hortulana</i>	Ortolan Bunting	Euroturquistan	Northern
<i>Emberiza schoeniclus</i>	Reed Bunting	Palaearctic	Northern
<i>Erithacus rubecula</i>	Robin	European	Northern
<i>Estrilda astrild</i>	Common Waxbill	Old World	Discarded
<i>Falco naumanni</i>	Lesser Kestrel	Turquistan-Mediterranean	Southern
<i>Falco peregrinus</i>	Peregrine Falcon	Cosmopolitan	Discarded
<i>Falco subbuteo</i>	Hobby	Palaearctic	Northern
<i>Falco tinnunculus</i>	Common Kestrel	Old World	Discarded
<i>Ficedula hypoleuca</i>	Pied Flycatcher	European	Northern
<i>Fringilla coelebs</i>	Common Chaffinch	European	Northern
<i>Fulica atra</i>	Common Coot	Palaearctic	Northern
<i>Fulica cristata</i>	Red-knobbed Coot	Etiopic	Southern
<i>Galerida cristata</i>	Crested Lark	Palaearctic	Northern
<i>Galerida theklae</i>	Thekla Lark	Mediterranean	Southern
<i>Gallinago gallinago</i>	Common Snipe	Holarctic	Northern
<i>Gallinula chloropus</i>	Moorhen	Cosmopolitan	Discarded
<i>Garrulus glandarius</i>	Eurasian Jay	Palaearctic	Northern
<i>Glareola pratincola</i>	Collared Pratincole	Indoaffrican	Southern
<i>Gypaetus barbatus</i>	Lammergeier	Paleomontane	Northern
<i>Gyps fulvus</i>	Griffon Vulture	Palaearctic	Northern
<i>Haematopus ostralegus</i>	Oystercatcher	Palaearctic	Northern
<i>Hieraetus fasciatus</i>	Bonelli's Eagle	Indoaffrican	Southern
<i>Hieraetus pennatus</i>	Booted Eagle	Turquistan-Mediterranean	Southern
<i>Himantopus himantopus</i>	Black-winged Stilt	Cosmopolitan	Discarded
<i>Hippolais opaca</i>	Western Olivaceous Warbler	Mediterranean	Southern
<i>Hippolais polyglotta</i>	Melodious Warbler	Mediterranean	Southern
<i>Hirundo daurica</i>	Red-rumped Swallow	Indoaffrican	Southern
<i>Hirundo rustica</i>	Barn Swallow	Holarctic	Northern
<i>Hydrobates pelagicus</i>	European Storm-petrel	Northern Atlantic	Northern
<i>Ixobrychus minutus</i>	Little Bittern	Old World	Discarded
<i>Jynx torquilla</i>	Wryneck	Palaearctic	Northern

<i>Lagopus muta</i>	Ptarmigan	Arctic	Northern
<i>Lanius collurio</i>	Red-backed Shrike	Palaearctic	Northern
<i>Lanius meridionalis</i>	Southern Grey Shrike	Mediterranean	Southern
<i>Lanius minor</i>	Lesser Grey Shrike	Euroturquestan	Northern
<i>Lanius senator</i>	Woodchat Shrike	Mediterranean	Southern
<i>Larus argentatus</i>	Herring Gull	Holarctic	Northern
<i>Larus audouinii</i>	Audouin's Gull	Mediterranean	Southern
<i>Larus fuscus</i>	Black-backed Gull	Palaearctic	Northern
<i>Larus genei</i>	Slender-billed Gull	Sarmatic	Discarded
<i>Larus melanocephalus</i>	Mediterranean Gull	Sarmatic	Discarded
<i>Larus michahellis</i>	Yellow-legged Gull	Holarctic	Northern
<i>Larus ridibundus</i>	Black-headed Gull	Palaearctic	Northern
<i>Limosa limosa</i>	Black-tailed Godwit	Palaearctic	Northern
<i>Locustella luscinioides</i>	Savi's Warbler	Euroturquestan	Northern
<i>Locustella naevia</i>	Grasshopper Warbler	Euroturquestan	Northern
<i>Loxia curvirostra</i>	Common Crossbill	Holarctic	Northern
<i>Lullula arborea</i>	Wood Lark	European	Northern
<i>Luscinia megarhynchos</i>	Rufous Nightingale	European	Northern
<i>Luscinia svecica</i>	Bluethroat	Palaearctic	Northern
<i>Marmaronetta angustirostris</i>	Marbled Duck	Sarmatic	Discarded
<i>Melanocorypha calandra</i>	Calandra Lark	Mediterranean	Southern
<i>Merops apiaster</i>	European Bee-eater	Turquestan-Mediterranean	Southern
<i>Milvus migrans</i>	Black Kite	Old World	Discarded
<i>Milvus milvus</i>	Red Kite	European	Northern
<i>Monticola saxatilis</i>	Rock Thrush	Paleoexericmontane	Southern
<i>Monticola solitarius</i>	Blue Rock Thrush	Paleoexericmontane	Southern
<i>Montifringilla nivalis</i>	Snowfinch	Paleomontane	Northern
<i>Motacilla alba</i>	White Wagtail	Palaearctic	Northern
<i>Motacilla cinerea</i>	Grey Wagtail	Palaearctic	Northern
<i>Motacilla flava</i>	Yellow Wagtail	Palaearctic	Northern
<i>Muscicapa striata</i>	Spotted Flycatcher	Euroturquestan	Northern
<i>Myiopsitta monachus</i>	Monk Parakeet	Unknown	Discarded
<i>Neophron percnopterus</i>	Egyptian Vulture	Indoaffrican	Southern
<i>Netta rufina</i>	Red-crested Pochard	Sarmatic	Discarded
<i>Numenius arquata</i>	Eurasian Curlew	Palaearctic	Northern
<i>Nycticorax nycticorax</i>	Night Heron	Cosmopolitan	Discarded
<i>Oenanthe hispanica</i>	Black-eared Wheatear	Mediterranean	Southern
<i>Oenanthe leucura</i>	Black Wheatear	Mediterranean	Southern
<i>Oenanthe oenanthe</i>	Northern Wheatear	Palaearctic	Northern
<i>Oriolus oriolus</i>	Golden Oriole	Old World	Discarded
<i>Otis tarda</i>	Great Bustard	Palaearctic	Northern
<i>Otus scops</i>	Scops Owl	Old World	Discarded
<i>Oxyura jamaicensis</i>	Ruddy Duck	Unknown	Discarded
<i>Oxyura leucocephala</i>	White-headed Duck	Sarmatic	Discarded
<i>Pandion haliaetus</i>	Osprey	Cosmopolitan	Discarded
<i>Panurus biarmicus</i>	Bearded Tit	Palaearctic	Northern
<i>Parus ater</i>	Coal Tit	Palaearctic	Northern

Short notes

<i>Parus caeruleus</i>	Blue Tit	European	Northern
<i>Parus cristatus</i>	Crested Tit	European	Northern
<i>Parus major</i>	Great Tit	Palaearctic	Northern
<i>Parus palustris</i>	Marsh Tit	Palaearctic	Northern
<i>Passer domesticus</i>	House Sparrow	Palaearctic	Northern
<i>Passer hispaniolensis</i>	Spanish Sparrow	Turkestan-Mediterranean	Southern
<i>Passer montanus</i>	Tree Sparrow	Palaearctic	Northern
<i>Perdix perdix</i>	Grey Partridge	Euroturkestan	Northern
<i>Pernis apivorus</i>	European Honey-buzzard	European	Northern
<i>Petronia petronia</i>	Rock Sparrow	Palaearctic	Southern
<i>Phalacrocorax aristotelis</i>	Shag	Northern Atlantic	Northern
<i>Phalacrocorax carbo</i>	Great Cormorant	Old World	Discarded
<i>Phasianus colchicus</i>	Common Pheasant	Palaearctic	Southern
<i>Phoenicopterus roseus</i>	Greater Flamingo	Mediterranean	Southern
<i>Phoenicurus ochruros</i>	Black Redstart	Palaearcticmontane	Southern
<i>Phoenicurus phoenicurus</i>	Common Redstart	European	Northern
<i>Phylloscopus bonelli</i>	Bonelli's Warbler	European	Northern
<i>Phylloscopus collybita</i>	Common Chiffchaff	Palaearctic	Northern
<i>Phylloscopus sibilatrix</i>	Wood Warbler	European	Northern
<i>Phylloscopus trochilus</i>	Willow Warbler	Palaearctic	Northern
<i>Pica pica</i>	Magpie	Palaearctic	Northern
<i>Picus viridis</i>	Green Woodpecker	European	Northern
<i>Platalea leucorodia</i>	Eurasian Spoonbill	Old World	Discarded
<i>Plegadis falcinellus</i>	Glossy Ibis	Old World	Discarded
<i>Podiceps cristatus</i>	Great Crested Grebe	Old World	Discarded
<i>Podiceps nigricollis</i>	Black-necked Grebe	Old World	Discarded
<i>Porphyrio porphyrio</i>	Purple Swamp-hen	Indoafrikan	Southern
<i>Porzana parva</i>	Little Crake	Palaearctic	Northern
<i>Porzana porzana</i>	Spotted Crake	European	Northern
<i>Porzana pusilla</i>	Baillon's Crake	Old World	Discarded
<i>Prunella collaris</i>	Alpine Accentor	Palaearcticmontane	Northern
<i>Prunella modularis</i>	Dunnock	European	Northern
<i>Psittacula krameri</i>	Rose-ringed Parakeet	Unknown	Discarded
<i>Pterocles alchata</i>	Pin-tailed Sandgrouse	Palaearctic	Southern
<i>Pterocles orientalis</i>	Black-bellied Sandgrouse	Palaearctic	Southern
<i>Ptyonoprogne rupestris</i>	Crag Martin	Palaearcticmontane	Southern
<i>Pyrhcorax graculus</i>	Yellow-billed Chough	Palaearcticmontane	Northern
<i>Pyrhcorax pyrhorax</i>	Red-billed Chough	Palaearcticmontane	Northern
<i>Pyrhula pyrhula</i>	Common Bullfinch	Palaearctic	Northern
<i>Rallus aquaticus</i>	Water Rail	Palaearctic	Northern
<i>Recurvirostra avosetta</i>	Avocet	Turkestan-Mediterranean	Southern
<i>Regulus ignicapilla</i>	Firecrest	European	Northern
<i>Regulus regulus</i>	Goldcrest	European	Northern
<i>Remiz pendulinus</i>	Penduline Tit	Palaearctic	Northern
<i>Riparia riparia</i>	Sand Martin	Holarctic	Northern
<i>Rissa tridactyla</i>	Kittiwake	Arctic	Northern
<i>Saxicola rubetra</i>	Whinchat	European	Northern

<i>Saxicola torquatus</i>	Common Stonechat	Palaearctic	Northern
<i>Scolopax rusticola</i>	Woodcock	Palaearctic	Northern
<i>Serinus citrinella</i>	Citril Finch	Palaemontane	Northern
<i>Serinus serinus</i>	European Serin	Mediterranean	Southern
<i>Sitta europaea</i>	European Nuthatch	Palaearctic	Northern
<i>Sterna albifrons</i>	Little Tern	Cosmopolitan	Discarded
<i>Sterna bengalensis</i>	Lesser Crested Tern	Unknown	Discarded
<i>Sterna hirundo</i>	Common Tern	Holarctic	Northern
<i>Sterna nilotica</i>	Gull-billed Tern	Cosmopolitan	Discarded
<i>Sterna sandvicensis</i>	Sandwich Tern	Cosmopolitan	Discarded
<i>Streptopelia decaocto</i>	Eurasian Collared Dove	Indoaffrican	Southern
<i>Streptopelia turtur</i>	European Turtle Dove	Euroturquestan	Northern
<i>Strix aluco</i>	Tawny Owl	Palaearctic	Northern
<i>Sturnus unicolor</i>	Spotless Starling	Mediterranean	Southern
<i>Sturnus vulgaris</i>	Common Starling	Euroturquestan	Northern
<i>Sylvia atricapilla</i>	Blackcap	European	Northern
<i>Sylvia borin</i>	Garden Warbler	European	Northern
<i>Sylvia cantillans</i>	Subalpine Warbler	Mediterranean	Southern
<i>Sylvia communis</i>	Common Whitethroat	Euroturquestan	Northern
<i>Sylvia conspicillata</i>	Spectacled Warbler	Mediterranean	Southern
<i>Sylvia hortensis</i>	Western Orphean Warbler	Mediterranean	Southern
<i>Sylvia melanocephala</i>	Sardinian Warbler	Turquestan-Mediterranean	Southern
<i>Sylvia undata</i>	Dartford Warbler	Mediterranean	Southern
<i>Tachybaptus ruficollis</i>	Little Grebe	Old World	Discarded
<i>Tadorna tadorna</i>	Common Shelduck	Sarmatic	Discarded
<i>Tetrao urogallus</i>	Capercaillie	Palaearctic	Northern
<i>Tetrax tetrax</i>	Little Bustard	Paleoxeric	Southern
<i>Tichodroma muraria</i>	Wallcreeper	Palaemontane	Northern
<i>Tringa totanus</i>	Common Redshank	Palaearctic	Northern
<i>Troglodytes troglodytes</i>	Wren	Holarctic	Northern
<i>Turdus merula</i>	Blackbird	Palaearctic	Northern
<i>Turdus philomelos</i>	Song Thrush	European	Northern
<i>Turdus torquatus</i>	Ring Ouzel	Palaemontane	Northern
<i>Turdus viscivorus</i>	Mistle Thrush	Euroturquestan	Northern
<i>Tyto alba</i>	Barn Owl	Cosmopolitan	Discarded
<i>Upupa epops</i>	Hoopoe	Old World	Discarded
<i>Uria aalge</i>	Common Guillemot	Holarctic	Northern
<i>Vanellus vanellus</i>	Northern Lapwing	Palaearctic	Northern