Temperature Differentially Mediates Species Richness of Birds of Different Biogeographic Types

Authors: Moreno-Rueda, Gregorio, and Pizarro, Manuel

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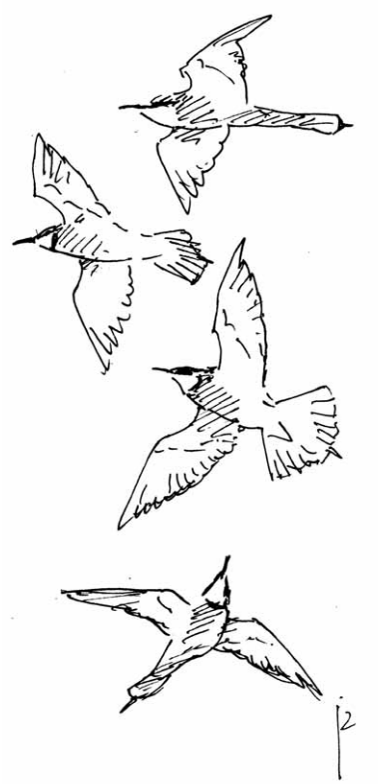
Short notes

Temperature differentially mediates species richness of birds of different biogeographic types

Gregorio Moreno-Rueda[1,2,*] & Manuel Pizarro[2]



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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

[1]Konrad Lorenz Institut für Vergleichende Verhaltensforschung, Österreischische Academie der Wissenschaften, Savoyenstraße 1a, A-1160, Wien (Austria);
[2]Departamento de Biología Animal, Facultad de Ciencias, Universidad de Granada, E-18071, Granada (Spain);
*corresponding author (gmr@ugr.es)

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).

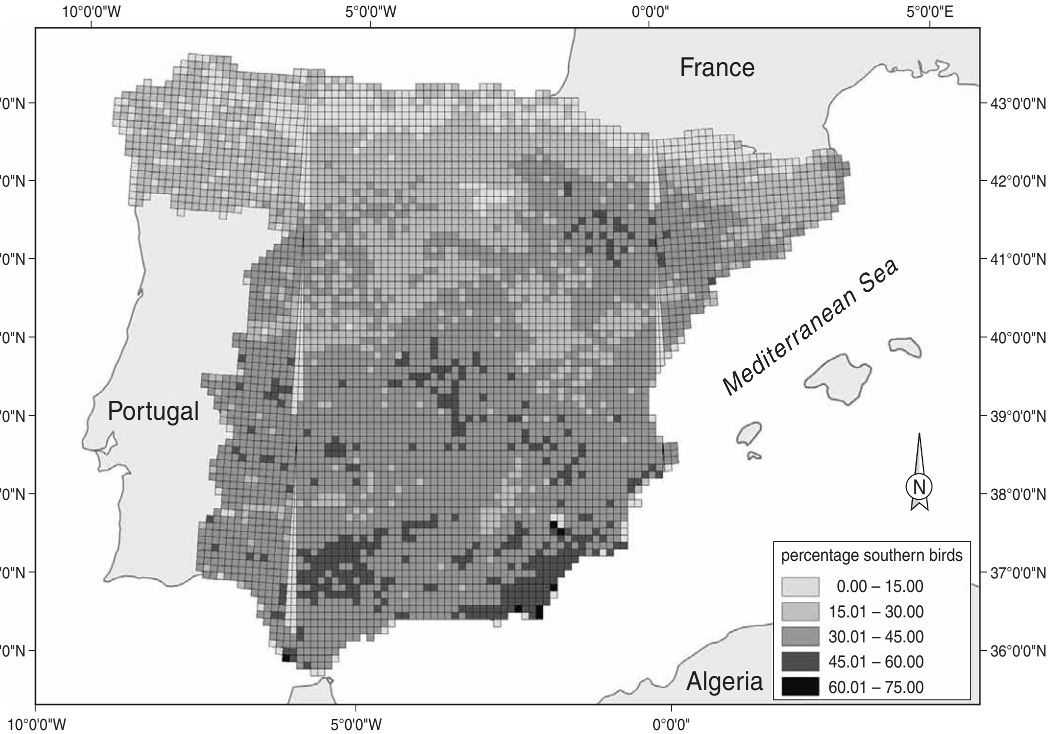

Figure 1. Distribution map for the percentage of southern species in Spain in 10 x 10 km squares.

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 km^2, 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, Lon^2xLat and LonxLat^2, according to Legendre (1993). We did not use Lon^3 and LatitudexLongitude 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 relationships, 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

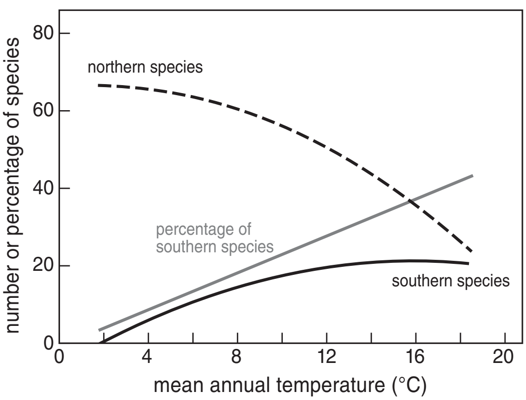

Figure 2. Relationship (without controlling for other variables) between temperature and number of southern species ($y=-7+0.24x-0.18x^2$), number of northern species ($y=66-0.66x-0.12x^2$), and percentage of southern species ($y=0.65x$). Data points are not shown for clarity.

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**
$Lon^2 x Lat$	**8.35**	**13.10**	–3.23
$Lon x Lat^2$	**–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 relationship 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 (Suáres-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 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 other 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 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)

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

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

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

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

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

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