SUPPLEMENTARY ELECTRONIC MATERIAL

ARDEOLA 67(2)

WINTER BIRD RICHNESS DISTRIBUTION IN THE SOUTH-WESTERN PALEARCTIC: CURRENT PATTERNS AND POTENTIAL CHANGES

DISTRIBUCIÓN DE LA RIQUEZA INVERNAL DE AVES EN EL PALEÁRTICO OCCIDENTAL: PATRONES ACTUALES Y POSIBLES CAMBIOS

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Appendix 1.

Alphabetic list of passerine species considered in this study. Large crows (*Corvus* sp.) have been excluded.
*[Lista de las especies de paseriformes consideradas en este estudio. Los grandes córvidos (*Corvus *sp.) han sido excluidos.]*

Aegithalos caudatus, Alauda arvensis, Ammomanes cinctura, Ammomanes deserti, Anthus pratensis, Bucanetes githagineus, Carduelis carduelis, Carduelis citrinella,Certhia brachydactyla, Certhia familiaris, Cettia cetti, Chersophilus duponti, Chloris chloris, Cisticola juncidis, Coccothraustes coccothraustes, Cyanistes caeruleus,Cyanistes teneriffae, Cyanopica cooki, Emberiza calandra, Emberiza cia, Emberiza cirlus, Emberiza striolata, Erithacus rubecula, Fringilla coelebs, Fringilla montifringilla, Galerida cristata, Galerida theklae, Garrulus glandarius, Lanius excubitor, Lanius meridionalis, Linaria cannabina, Lophophanes cristatus, Loxia curvirostra, Lullula arborea, Melanocorypha calandra, Monticola solitarius, Motacilla alba, Motacilla cinerea, Oenanthe deserti, Oenanthe leucorhoa, Oenanthe moesta, Parus major, Passer domesticus, Passer hispanoliensis, Passer montanus, Periparus ater,Petronia petronia, Phoenicurus moussieri, Phoenicurus ochruros, Phylloscopus collybita, Pica pica, Poecile palustris, Prunella collaris, Prunella modularis, Pycnonotus barbatus, Pyrrhula pyrrhula, Regulus ignicapillus, Regulus regulus, Saxicola torquatus, Serinus serinus, Sitta europaea, Spinus spinus, Sturnus unicolor, Sturnus vulgaris, Sylvia atricapilla, Sylvia deserti, Sylvia deserticola, Sylvia undata, Troglodytes troglodytes, Turdoides fulvus, Turdus iliacus, Turdus merula, Turdus philomelos, Turdus pilaris, Turdus torquatus,Turdus viscivorus.

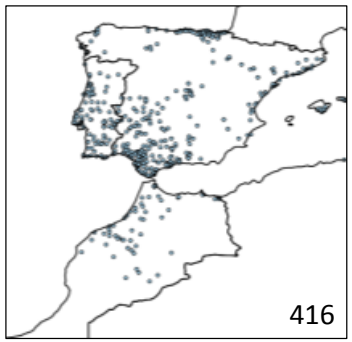
Appendix 2.

Distribution of localities reported by ring recoveries**.**
[Distribución de las localidades donde se han controlado las aves anilladas.]

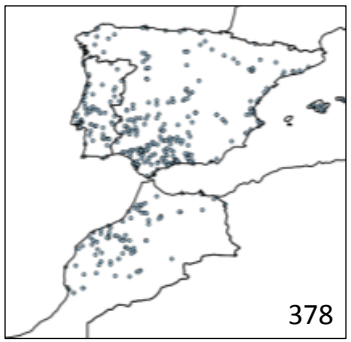
Figure 2-1. Geographical distribution of localities used to model the winter distribution of the six species. Figures in each map refer to the number of localities where one or more ringed individuals were recorded. The data were provided by the Euring Data Bank (http://www.euring.org/).

[Distribución geográfica de las localidades utilizadas para modelizar la distribución invernal de las seis especies. Los valores en cada mapa se refieren al número de localidades donde se registraron uno o más individuos. Los datos fueron facilitados por Euring Data Bank (http://www.euring.org).]

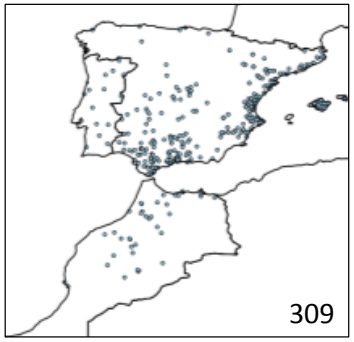
Anthus pratensis



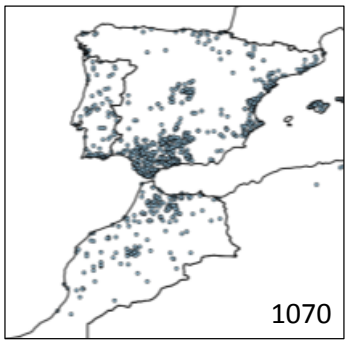
Motacilla alba



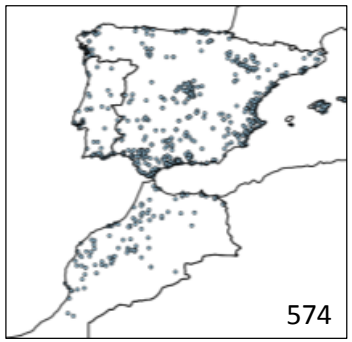
Phoenicurus ochruros



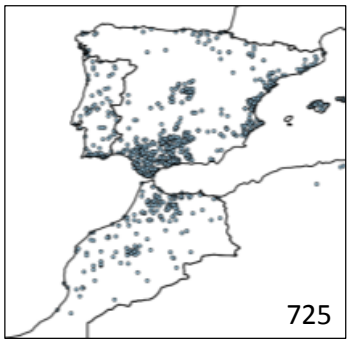
Erithacus rubecula



Phylloscopus collybita



Sylvia atricapilla



Appendix 3.

Further details on Maxent analyses and validation.
[Detalles adicionales sobre los análisis con Maxent y su validación.]

The species distribution models were constructed with Maxent 3.4.1, a popular machine-learning technique designed to predict the occurrence probabilities of species by combining species presences (latitude and longitude, Appendix S2) with the geographical distribution of environmental variables (Phillips *et al*., 2006, 2017; Elith *et al*., 2011). The ability of these maps to identify sectors of different environmental suitability has been tested with the occurrence of species in the sites sampled with line transects (Fig. 1B, 2). Where the actual distribution of species agrees with the occurrence probability provided by Maxent, we used the models to forecast the changes in the extent and suitability of wintering areas according to predictions of climate change.

Data for birds were prepared for modelling by cleaning duplicate locations and places of ringing and/or recovery that have not been recorded accurately. Since ring recovery distribution can be affected by human activity (Busse, 2001), we used the layer of human footprint (Sanderson *et al*., 2002) as a bias grid to distribute 10,000 background points with a likelihood of presence proportional to the human footprint index (Fandos & Tellería, 2017).

We ran Maxent (cloglog output; regularisation multiplier b = 1; auto-features; convergence threshold = 0.00001) in 10 replicates with 70% of the presences as training data and the rest as test data for internal verification. The Area Under the Curve (AUC) provided by the receiver operating characteristic curves was used to assess the congruence between observed and detected records in the test data reserved for verification in Maxent (Fielding & Bell, 1997; Phillips *et al*., 2006; but see Lobo *et al.,* 2008). However, this internal validation only shows if models predict the distribution of samples (e.g. the ring recoveries) but not the actual distribution of species. To cope with this problem, we tested the average models with the data provided by field work in sampling sites (see Tellería *et al*., 2016). The results indicated that, despite the fact that AUC scores were lower than in internal validations (Table 3-1), the models were able to predict the actual presence of species. As a result, we used models to predict the actual and future occurrence probabilities of species over the study area (Fig. 3-1). We averaged SDM prediction rasters from multiple species, as a surrogate of the species richness that, after validation in sampling sites (Table 3-1), was used to predict the spatial-temporal patterns of passerine richness in the study region (Fig. 4).

Busse, P. (2001). European passerine migration system–what is known and what is lacking. *Ring*, 23: 3-36.
Elith J., Phillips S.J., Hastie T., Dudík M., Chee Y.E., & Yates C.J. (2011). A statistical explanation of MaxEnt for ecologists. *Diver Distrib*., 17: 43-57.
Fandos, G. & Tellería, J.L. (2017). Range compression of migratory passerines in wintering grounds of the Western Mediterranean: conservation prospects. *Bird Conservation International*, 28: 462-474
Fielding, A.H., & Bell, J.F. (1997). A review of methods for the assessment of prediction errors in conservation presence/absence models. *Environmental conservation*, 24: 38-49.
Lobo J.M., Jiménez-Valverde A. & Real R. (2008). AUC: a misleading measure of the performance of predictive distribution models. *Global Ecol. Biogeogr*.,17: 145-151.
Phillips, S.J., Anderson, R.P. & Schapire, R.P. (2006). Maximum entropy modelling of species geographic distributions. *Ecol Mode*., 190: 231-259.
Phillips, S. J., Anderson, R. P., DudÍk, M., Schapire, R. E., & Blair, M. E. (2017). Opening the black box: an open-source release of Maxent. *Ecography*., 40: 887-893. DOI: 10.1111/ecog.03049.
Sanderson, E.W., Jaiteh, M., Levy, M.A., Redford, K.H., Wannebo, A.V. & Woolmer, G. (2002) The human footprints and the last of the wild. BioScience, 52: 891-904.
Tellería, J.L., Fernández-López, J. & Fandos, G. (2016) Effect of Climate Change on Mediterranean Winter Ranges of Two Migratory Passerines. *PLoS ONE*, 11: e0146958

Table 3-1. Contribution of the environmental variables in Maxent models (percent contribution/permutation importance). Percentage contribution indicates the change in regularised gain by adding the corresponding variable. Permutation importance represents, for each environmental variable in turn, the resulting drop in training AUC when the values of that variable on training presence and background data are randomly permuted. They are normalised to show percentages. Symbols in parentheses show the trend of the response curves for the study variables: +, increase; -, Ω : hump-shaped, -: decrease; = no trend).
[Contribución de las variables ambientales en los modelos de Maxent (contribución porcentual/importancia de la permutación). La contribución porcentual indica la ganancia del modelo al incluirse cada variable. La importancia en la permutación representa la pérdida cuando se elimina. Los símbolos en parénesis presentan las tendencias en las curvas de respuesta dentro del rango de cada variable: +, aumento; -:disminución, Ω : mínimos en los extremos, = sin tendencia.]

	TEMPERATURE	PRECIPITATION	WOOD COVER	AUC[1]±sd	AUC[2]
Anthus pratensis	10.5 /9.7 (Ω)	55.5/74 (Ω)	34 /16.3 (=)	0.869 ± 0.007	0.740
Motacilla alba	39.9/27.1 (+)	19.5 /55.7 (Ω)	40.6 /17.2 (-)	0.854 ± 0.011	0.735
Phoenicurus ochruros	41.6 /31.3 (+)	15.4 /36 (-)	43 /32.7 (-)	0.851 ± 0.014	0.693
Erithacus rubecula	33.3 /27.4 (+)	7.9 /39.2 (=)	58.8 /33.4 (=)	0.808 ± 0.006	0.696
Phylloscopus collybita	49/30.7 (+)	11.9 /44.6 (-)	39.1/24.7 (=)	0.840 ± 0.009	0.763
Sylvia atricapilla	46.6 /31.2(+)	25.6 /57.7 (Ω)	27.9/12.1 (-)	0.835± 0.006	0.747

1: Internal verification (mean and sd of ten rounds; see text). 2: external verification of the average model by means the species distribution in sampling points.*