SUPPLEMENTARY ELECTRONIC MATERIAL

ARDEOLA 65(2)

DISTRIBUTION OF THE RED-BACKED SHRIKE *LANIUS COLLURIO* AT ITS WESTERN RANGE BOUNDARY: PATTERNS AND CONSERVATION PROSPECTS

DISTRIBUCIÓN DEL ALCAUDÓN DORSIRROJO *LANIUS COLLURIO* EN EL BORDE DE SU ÁREA DE DISTRIBUCIÓN: PATRONES Y PERSPECTIVAS DE CONSERVACIÓN

José Luis TELLERÍA[1] *

Orcid: 0000-0001-6170-8860

[1] Department of Biodiversity, Ecology and Evolution, Faculty of Biological Sciences, Universidad Complutense, 28040 Madrid, Spain.

* Corresponding author: telleria@ucm.es

SUMMARY._This note examines the effects of habitat, landscape, climate and geographical situation on the occurrence probability of the Red-backed Shrike at its westernmost range boundary. The results from 127 sampling localities distributed east–to–west along 600 km in northern Spain reflect local and regional effects on species distribution. Habitat patch size (the species prefers large patches) and summer temperatures (the species avoids warmer sites) are the two main environmental correlates of species distribution. In addition, the occurrence of the Red-backed Shrike decreased in the westernmost sectors of the study area. This result could be related to a peninsula effect potentially reinforced by the atypical migratory circuit of this summer passerine (birds arrive from the east). The conservation prospects of this peripheral population suggest a retreat to cold highlands as global warming increases, a reduction in suitable habitat patches due to forest encroachment resulting from rural abandonment and the reduced availability of individuals to offset local extinctions in the westernmost border of its European range.

Key words: habitat availability, migratory circuit, peninsula effect, peripheral population.

RESUMEN._Esta nota examina los efectos del hábitat, el paisaje, el clima y la situación geográfica sobre la probabilidad de aparición del alcaudón dorsirrojo en el límite occidental de su área de distribución. Los resultados de 127 localidades de muestreo distribuidas de este a oeste a lo largo de 600 km en el norte de España reflejan efectos locales y regionales sobre la distribución de la especie. El tamaño de los parches de hábitat disponibles (selecciona grandes parches) y las temperaturas estivales (evita los sitios más cálidos) fueron los dos principales correlatos ambientales de su distribución. Además, la probabilidad de aparición de este alcaudón disminuyó en los sectores más occidentales de la zona de estudio. Esto pudiera estar relacionado con un efecto península reforzado por el atípico circuito migratorio de este migrante transahariano (las aves llegan desde el este). La conservación de esta población periférica de alcaudones debiera contemplar su probable retracción hacia las zonas más altas y frías en un contexto de calentamiento global, la reducción de su hábitat por la expansión del bosque con el abandono rural y las dificultades de las poblaciones periféricas para compensar las extinciones locales con nuevos individuos en esta frontera occidental de su área de distribución.

Palabras clave: circuito migratorio, disponibilidad de hábitat, efecto península, población periférica.

APPENDIX 1._Generalized linear models (binomial distribution and logit link) were used to test the effects of LONGITUDE, PRECIPITATION, TEMPERATURE, PATCH AREA ($\log_{10}$ transformed), VEGETATION and VEGETATION^2 on the presence/absence of the Red-backed Shrike in the study areas.

ID	Localities	Transects	NS	Lcollurio	VEG	PATCH	LONG	PREC	TEMP
1	Ajo1	1	N	1	1,49325982	1,462398	-3,6608	202	21
2	Ajo2	2	N	0	0,60218671	1,74818803	-3,6555	211	20,9
3	Bakaiku	1	S	0	0,68196267	1,99563519	-2,115017	187	19,4
4	Bakaiku-b	1	S	0	3,25703701	1,31597035	-2,091317	163	19,6
5	Bakio1	3	N	0	3,16958982	2,00432137	-2,791793	227	20,7
6	Bakio2	1	N	0	5,12E-07	1	-2,85402	218	21
7	Bakio3	3	N	1	2,05215947	2,05307844	-2,77083	237	19,2
8	Barcina	1	S	1	0,91526947	2,25042	-3,32787	122	18,1
9	Barana-2	1	S	1	2,55747137	1,60205999	-3,31898	126	17,6
10	Buelna1	2	N	0	1,13616679	1,63346846	-4,62496	188	20,3
11	Burón-1	2	S	1	5,12E-07	1,70586371	-5,048683	101	15,8
12	Buxan	2	S	0	2,77539709	1,78532984	-8,7167	113	19,1
13	Cantabraña	1	S	0	2,80304323	0,68033551	-3,4789	83	19,2
14	Cármenes-1	1	S	1	2,80171826	1,5797836	-5,551317	80	16
15	Cofiñal	1	S	0	2,50986394	1,17609126	-5,27833	103	15,1
16	Colombres1	4	N	1	1,56158228	2,19589965	-4,53507	178	20,8
17	Comillas	1	N	0	1,77156061	0,95424251	-4,27129	171	21,1
18	Cubelas	1	S	1	1,7817509	1,85125835	-7,318283	89	18,6
19	Cudillero1	4	N	0	2,56693309	2,06445799	-6,28064	176	20,6
20	Cudillero2	2	N	0	0,82872896	1,67209786	-6,29753	169	20,8
21	Cudillero3	2	N	0	1,96922002	1,67209786	-6,34922	171	20,4
22	Cudillero4	2	N	0	1,96692408	1,47712125	-6,36187	168	20,6
23	Degaña	1	S	0	2,85912295	1,07918125	-6,55317	87	17,1
24	Dodro 1	1	S	0	3,88468777	1,61278386	-8,7167	107	20
25	Dodro 2	1	S	1	3,2329677	2,17897695	-8,7166	96	20,1
26	Ea1	2	N	1	3,35251698	1,74818803	-2,65267	248	20,4
27	Ea2	2	N	0	1,43153985	1,79934055	-2,59647	236	21,1
28	Ea3	1	N	0	1,55075806	0,84509804	-2,56596	241	21
29	Ea4	2	N	0	2,51803497	1,61278386	-2,67624	213	21,5
30	Ea5	1	N	1	2,91568624	1,04139269	-2,64088	243	20,4
31	Ea6	1	N	0	1,74199649	1,44715803	-2,63174	240	20,3
32	Elguea-1	1	S	1	2,51171915	1,161368	-2,49843	126	19
33	Elguea-2	1	S	0	3,55553937	0,81291336	-2,50938	128	18,9
34	Embalse de Ruesga	1	S	1	2,16339265	1,18469143	-4,5434	90	16,5
35	Escobados de Abajo	1	S	1	2,52673247	1,161368	-3,585067	97	17,3
36	Fervenza	3	S	0	2,64899019	2,60314437	-8,9167	101	17,6
37	Fisterra	2	S	0	1,49385575	2,10380372	-9,2667	101	18,9
38	Fondodevilla	1	S	0	3,34828005	0,8260748	-6,760867	78	18,1
39	Fonsagrada	1	S	0	2,07346985	1,32221929	-7,069317	129	16,5
40	Genicera	1	S	0	2,80350693	1,04139269	-5,50028	97	15,3

41	Güemes	3	N	1	1,29880587	2,57403127	-3,627901	169	21,3
42	Hondarribia1	1	N	1	3,48247391	1,00432137	-1,82697	331	21,5
43	Hondarribia2	1	N	1	0,36503163	1,4345689	-1,81638	333	21,2
44	Hortas	1	S	1	1,50370625	2,30535137	-8,2105	109	18,9
45	Iturmendi	1	S	0	1,08309693	1,78532984	-2,131867	188	19,3
46	Lamella	1	S	1	2,96612611	1,81954394	-7,682567	97	18,3
47	Lario	1	S	1	2,62809851	1,60959441	-5,08928	104	15,9
48	Lavandera	1	S	1	2,8841919	1,11394335	-5,5048	97	15,3
49	Laxe1	7	N	0	1,8543083	1,95904139	-9,01195	116	18,7
50	Laxe2	2	N	1	2,40065405	1,12385164	-9,017925	112	19,1
51	Laxe3	2	N	0	0,93006223	1,36172784	-9,00017	121	17,9
52	Laxe4	1	N	0	2,56677954	1,1172713	-8,98877	114	18,1
53	Laxe5	2	N	1	1,71640526	1,7084209	-8,9011	113	18,4
54	Laxe6	1	N	1	2,60747704	1,21484385	-8,88115	107	18,6
55	Llanes1	1	N	0	0,36503163	0,74818803	-4,71919	186	21,1
56	Llanes2	1	N	0	5,12E-07	0,94448267	-4,72769	187	21,1
57	Llanes3	2	N	0	3,21583606	1,41497335	-4,80772	190	21,1
58	Luiña	1	S	1	3,20343547	1,462398	-6,773	84	17,8
59	Marentes	1	S	0	3,6301946	0,69897	-6,896533	89	19,8
60	Marieta	1	S	0	1,03895079	1,57403127	-2,54335	128	19,2
61	Marieta-2	1	S	1	2,94427789	1,75891189	-2,524483	126	19,2
62	Miño1	5	N	0	2,76647396	2,26078667	-8,15888	125	19
63	Miño2	1	N	0	3,21697691	0,84509804	-8,15904	119	19
64	Miño3	1	N	0	2,2393067	1,51851394	-8,090117	119	18,4
65	Miño4	1	N	0	1,88913905	0,69897	-8,088364	119	18,4
66	Mosteiro	1	S	0	3,06421292	0,60205999	-7,7898167	89	18,3
67	Mudá	1	S	1	3,28180662	0,81954394	-4,40633	77	16,9
68	Navia1	1	N	0	1,30033351	0,84509804	-6,66635	166	19,8
69	Navia2	1	N	0	1,71429812	1,14612804	-6,68508	155	20,3
70	Navia3	3	N	1	2,45767525	1,81291336	-6,67212	158	20,3
71	Novales1	1	N	0	0,7107878	1,17609126	-4,16393	195	20,9
72	Novales2	2	N	0	1,15301864	1,49136169	-4,171689	191	20,9
73	O Cadavo	1	S	0	2,53573895	2,06069784	-7,242067	96	17,6
74	Ofaro	1	S	0	2,23482796	1,23044892	-8,7333	120	18,2
75	Ofito	1	S	0	2,35282204	0,63346846	-7,055133	90	18
76	Orio1	2	N	0	2,27648199	1,74818803	-2,09719	336	20,1
77	Orio2	1	N	1	1,2641177	1,34242268	-2,1072	299	21,3
78	Orio3	1	N	0	5,12E-07	1,14612804	-2,10151	320	20,8
79	Oyambre1	1	N	0	2,64525548	1,04139269	-4,3227	163	21,2
80	Oyambre2	1	N	0	1,62690182	0,47712126	-4,32194	163	21,2
81	Oyambre3	1	N	0	3,05269489	1,462398	-4,32617	167	21,1

82	Ozaeta	1	S	1	2,80921709	2,01703334	-2,50975	126	19,1
83	Parapertú	1	S	1	3,06794955	1,78532984	-4,36803	82	15,9
84	Penches	1	S	0	2,75821783	1,73239376	-3,3667	113	18,5
85	Pobladura de la Terc	1	S	0	1,18478512	1,3283796	-5,7233	86	15,6
86	Rabanal	1	S	0	1,62412089	0,84509804	-5,9781	85	15,7
87	Rebenal	1	S	1	1,54546422	0,98227123	-4,60638	93	15,8
88	Rebollar	1	S	0	2,33467983	1,46982202	-6,5952	83	17,4
89	Redipollos	1	S	1	2,05948153	1,62324929	-5,26037	89	16
90	Rendil	1	S	0	1,95864437	1,44715803	-8,13055	100	19
91	Retorta	1	S	1	3,14095813	1,71600334	-7,745183	102	18,2
92	Ribadeo1	3	N	0	1,48794582	2,1172713	-7,15487	157	19,3
93	Ribadeo2	1	N	0	1,6422264	0,84509804	-7,16206	156	20
94	Ribadeo3	3	N	0	3,21723532	1,95904139	-7,09481	130	20
95	Ribadeo4	1	N	0	1,79000424	1,25527251	-7,05461	126	20,7
96	Ribadeo5	2	N	0	1,8993613	1,51851394	-7,057642	121	20,8
97	Ribadeo6	1	N	0	0,7765742	1,2787536	-7,076552	117	20,6
98	Rodiezmo	1	S	1	2,77080914	1,51851394	-5,68603	84	16
99	Rois	1	S	0	0,97725811	1,85125835	-8,7	96	19,7
100	San Emiliano	1	S	0	1,90414703	0,9956352	-6,0021	84	15,7
101	San Felices	1	S	0	2,93323138	0,60205999	-3,77915	77	18,6
102	San Martín	1	S	1	1,60259138	1,14612804	-4,586633	89	16,3
103	San Martin de Tercia	1	S	0	1,06590753	1,20951501	-5,714817	83	15,7
104	Santoña1	1	N	0	2,43074986	1,2787536	-3,4452	204	20,7
105	Santoña2	1	N	0	4,14858531	1,462398	-3,48567	186	21,5
106	Sena	1	S	1	3,67472859	1,04139269	-5,96305	82	16,2
107	Sena de Luna-1	1	S	0	1,51237704	2,04139269	-5,95665	79	16
108	Solle	1	S	1	3,57545546	1,23044892	-5,2433	98	15,7
109	Valverdín	1	S	0	1,74545235	0,60205999	-5,5393	87	15,4
110	Velila del Carrion	1	S	1	1,17922305	1,34242268	-4,85883	84	16,1
111	Vilarrube1	4	N	0	4,26604767	1,72098574	-8,04232	117	19,4
112	Vilarrube2	2	N	0	2,18767768	1,30749604	-8,02791	120	18,7
113	Vilarrube3	2	N	0	3,52730345	1,29666519	-8,02821	148	18
114	Vilarrube4	1	N	0	2,03099252	1,17609126	-8,01751	115	19,2
115	Vilarrube5	1	N	0	1,97883905	1,39794001	-8,00853	113	19,1
116	Villabellaco	1	S	1	1,96714279	1,36172784	-4,3069	80	16,6
117	Villaviciosa1	1	N	0	0,53310798	1,12057393	-5,32456	190	20,8
118	Villaviciosa2	1	N	0	0,8924158	1,43933269	-5,31992	190	20,8
119	Villaviciosa3	1	N	0	1,59221953	0,8573325	-5,35723	186	21,1
120	Villaviciosa4	2	N	0	2,46875035	1,462398	-5,35434	190	20,6

121	Viveiro1	2	N	0	2,59606588	1,88649073	-7,527386	151	19,8
122	Viveiro2	1	N	0	2,69257143	0,91907809	-7,53381	154	19,3
123	Viveiro3	1	N	0	1,75845971	1,51851394	-7,65209	151	18,7
124	Viveiro5	1	N	0	2,12362115	1,08635983	-7,65039	163	18,5
125	Viveiro6	1	N	0	1,92821127	1,12385164	-7,64195	148	19,1
126	Zarautz1	2	N	1	2,79969491	1,55990663	-2,18331	273	21,5
127	Zumaia1	5	N	1	1,66247949	2,195069	-2,22301	302	21,2

APPENDIX 2_ R CODE.

DISTRIBUTION OF A MIGRATORY PASSERINE (LANIUS COLLURIO L.) AT THE RANGE BOUNDARY: #PATTERNS AND CONSERVATION PROSPECTS.

```
# JLTellería.   Ardeola 2018
# Logistic regression analysis (0/1)
# Import the data file
dater<-read.csv("C:/.../LcollurioNS.csv")
# I see the variables
names(dater)
# I see the data
summary(dater)
# I upload  MUMIn and other...
require(MuMIn)
require(car)
# I represent each missing data by the symbol NA
options(na.action = "na.fail")
# Logistic regression with all the variables
modelo <-glm(Lcollurio ~ VEG + I(VEG^2)+ PATCH + LONG+
TEMP+PREC+NS,data = dater, family = binomial)
summary(modelo)
# deviances
d2 <- round(100*(modelo$null.deviance-modelo$deviance)/modelo$null.deviance,2)
d2
# VIF (multicollinearity...)
vif(modelo)
# models with delta <2 (see below model selection with dredge ; repeat the previous
analyzes...)
model1 <-glm(Lcollurio ~ VEG + PATCH + LONG+ TEMP,data = dater, family =
binomial)
model2 <-glm(Lcollurio ~ I(VEG^2)+ PATCH + LONG+ TEMP, data = dater, family =
binomial)
```

```
model3 <-glm(Lcollurio ~ TEMP + PATCH+ LONG,data = dater, family = binomial)
model4 <-glm(Lcollurio ~ VEG +PATCH+ LONG+ TEMP + PREC,data = dater,
family = binomial)
# Selection with  AICc
my.models<-model.sel(model1, model2,model3,model4,rank=AICc)
my.models
# Weights
importance(my.models)

#### Selection with dredge
dredge(modelo, beta="sd", rank="AICc")
sel.table<-as.data.frame(my.models)
sel.table
importance(my.models)

# End
```