

Title	Habitat segregation by breeding origin in the declining populations of European Robins wintering in southern Iberia
Authors	de la Hera, Iván;Fandos, Guillermo;Fernández-López, Javier;Onrubia, Alejandro;Pérez-Rodríguez, Antón;Pérez-Tris, Javier;Tellería, José Luis
Publication date	2017-10-21
Original Citation	de la Hera, I., Fandos, G., Fernández-López, J., Onrubia, A.' Pérez- Rodríguez, A., Pérez-Tris, J. and Tellería, J. L. (2017) 'Habitat segregation by breeding origin in the declining populations of European Robins wintering in southern Iberia', Ibis, 160(2), pp. 355-364. doi:10.1111/ibi.12549
Type of publication	Article (peer-reviewed)
Link to publisher's version	10.1111/ibi.12549
Rights	© 2017, British Ornithologists' Union. This is the peer reviewed version of the following article: de la Hera, I., Fandos, G., Fernández-López, J., Onrubia, A.' Pérez-Rodríguez, A., Pérez- Tris, J. and Tellería, J. L. (2017) 'Habitat segregation by breeding origin in the declining populations of European Robins wintering in southern Iberia', Ibis, 160(2), pp. 355-364. doi:10.1111/ibi.12549, which has been published in final form at https://doi.org/10.1111/ ibi.12549. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Use of Self- Archived Versions.
Download date	2025-04-17 08:40:09
ltem downloaded from	https://hdl.handle.net/10468/7018



University College Cork, Ireland Coláiste na hOllscoile Corcaigh

## SUPPLEMENTARY MATERIAL

De la Hera *et al*. Habitat distribution by breeding origin in the declining populations of European Robins wintering in southern Iberia.

#### 1) Habitat distribution according to the individual morphology of Robins

**Table S1.** Distribution between habitats, sites, populations (according to their morphology) and age (adult and juvenile) of the 149 Robins captured during winter in Campo de Gibraltar region. The assignation of the migratory behaviour of Robins is based here on the morphological classification functions (MCF) described in Pérez-Tris et al. (2000). These MCF consider the overall P8 length and the primary distances of the 9 longest primaries (excluding the vestigial outermost primary: P10), the so-called wing formula, for the estimation of the migratory behaviour of Robins. Primary distance was defined as the distance from the tip of each primary to the tip of the longest primary with the wing folded, with a value of zero for the primary (or primaries) constituting the wingtip. To facilitate the comparison between the morphological and isotopic methods of population differentiation, we also provided in brackets the distribution of Robins based on the  $\delta D_f$  values (see Table 1 in the manuscript).

	Migratory Robins		Sedentary Rol		
Sites	Adults	Juveniles	Adults	Juveniles	Total
Woodlands					
San Carlos Carretera	6 (11)	5 (13)	17 (12)	12 (4)	40
San Carlos Tiradero	7 (7)	9 (15)	14 (14)	13 (7)	43
Shrublands					
Almodóvar	10 (17)	5 (17)	7 (0)	13 (1)	35
Betis	8 (14)	3 (16)	7 (1)	13 (0)	31

#### 2) Estimating wing shape parameters in wintering Robins

We used transformed values of the primary distances described above to estimate the variation in the wing shape of Robins wintering in Campo de Gibraltar region. For this purpose, we opted for transforming primary distances (P1-P9) into distances from the carpal joint (cP1-cP9) by subtracting, for each primary, its primary distance from the wing length. These transformed distances (cP1-cP9) were then standardized according to the method suggested by Senar et al. (1994), which provides more reliable measurements (cP1\*-cP9\*) that correct for the among-individual variation in wing size. These standardized values were used in a Principal Component Analysis (PCA) that gave rise to two principal components (KMO = 0.77; Bartlett's test of sphericity:  $\chi^2_{36}$  = 857.9, P < 0.001). PC1\* was interpreted as an index of wing concavity (eigenvalue = 4.07; explained variance = 0.45; factor loadings: cP9\* = 0.17, cP8\* = 0.19, cP7\* = 0.17, cP6\* = -0.12, cP5\* = -0.37, cP4\* = -0.44, cP3\* = -0.45, cP2\* = -0.44, cP1\* = -0.40); while PC2\* reflected variation in wingtip shape (eigenvalue = 1.97; explained variance = 0.22; factor loadings: cP9\* = 0.52, cP8\* = 0.58, cP7\* = 0.50, cP6\* = -0.16, cP5\* = 0.03, cP4\* = 0.12, cP3\* = 0.16, cP2\* = 0.20, cP1\* = 0.20).

Senar, J.C., Lleonart, J. & Metcalfe, N.B. 1994. Wing-shape variation between resident and transient wintering siskins *Carduelis spinus*. J. Avian Biol. 25: 50–54.

### 3) Bird morphology and its relationship with $\delta D_f$ values in migrants.

We explored the relationship of the development of flight morphology (PC1), structural size (PC2), wing concavity (PC1\*) and wingtip shape (PC2\*) with  $\delta D_f$  in the 110 migratory Robins wintering in Campo de Gibraltar. For this purpose, we performed Linear Mixed Models that analysed these variables (PC1, PC2, PC1\* and PC2\*) in relation to age, sex and their interaction as fixed effects,  $\delta D_f$  as continuous predictor, and year as a random effects factor. Results for each morphological trait are shown below:

**a.** Results for the analysis of the development of flight morphology (PC1)

0.8468

0.193649

Random effects	:					
Formula: ~1	year					
(Inter	cept) H	lesi du	lal			
StdDev: 0.33	51773 1	1. 1539	982			
Fixed effects:	PC1 ~	1 + a	age + sex -	+ age	e:sex + isc	ot
	I	/al ue	Std. Error	DF	t-value	p-value
(Intercept)	0.611	0034	0.6019319	104	1.015071	0. 3124
àgej uv	- 0. 565	51009	0.2733171	104	- 2. 067566	0.0412
sexmal e	2.214	3418	0.3550023	104	6.237541	0.0000
i sot	0.010	)3854	0.0071875	104	1.444938	0.1515
	Random effects Formula: ~1   (Inter StdDev: 0.33 Fixed effects: (Intercept) agej uv sexmal e sot	Random effects: Formula: ~1   year (Intercept) F StdDev: 0.3351773 1 Fixed effects: PC1 ~ (Intercept) 0.611 agej uv -0.565 sexmal e 2.214 sot 0.010	Random effects: Formula: ~1   year (Intercept) Residu StdDev: 0.3351773 1.1539 Fixed effects: PC1 ~ 1 + a Value (Intercept) 0.6110034 agejuv -0.5651009 sexmale 2.2143418 sot 0.0103854	Random effects:         Formula: ~1   year         (Intercept) Residual         StdDev: 0.3351773 1.153982         Fixed effects: PC1 ~ 1 + age + sex         Value Std. Error         (Intercept)         0.6110034 0.6019319         agejuv       -0.5651009 0.2733171         sexmal e       2.2143418 0.3550023         sot       0.0103854 0.0071875	Random effects: Formula: ~1   year (Intercept) Residual StdDev: 0.3351773 1.153982 Fixed effects: PC1 ~ 1 + age + sex + age Value Std. Error DF (Intercept) 0.6110034 0.6019319 104 agejuv -0.5651009 0.2733171 104 sexmal e 2.2143418 0.3550023 104 sot 0.0103854 0.0071875 104	Random effects:         Formula: ~1   year         (Intercept) Residual         StdDev: 0.3351773 1.153982         Fixed effects: PC1 ~ 1 + age + sex + age: sex + iso         Value Std. Error DF t-value         (Intercept)       0.6110034 0.6019319 104 1.015071         agej uv       -0.5651009 0.2733171 104 -2.067566         sexmal e       2.2143418 0.3550023 104 6.237541         sot       0.0103854 0.0071875 104 1.444938

agej uv: sexmal e

b. Results for the analysis of structural size (PC2)

0.0911411 0.4706501 104

Random effects: Formula: ~1 | year (Intercept) Residual 0. 222351 0. 9446133 StdDev: Fixed effects: PC2 ~ 1 + age + sex + age: sex + isot t-value p-value Value Štd. Error DF 3. 108872 (Intercept) 0.0024 agej uv 0.4388 -0.2334712 0.2904189 104 -0.803912 sexmal e 0.4233 i sot 0.0210896 0.0058831 104 3.584750 0.0005 agej uv: sexmal e - 0. 0651280 0. 3852394 104 - 0. 169059 0.8661

c. Results for the analysis of wing concavity (PC1\*)

Random effects:	vear				
(Inter	cent) Resid	lual			
StdDev: 7.86179	)7e-05 1.88	8228			
Fixed effects:	PC3 ~ 1 + a	age + sex +	age: se	x + isot	l
	Val ue	Štd. Error	DF	t-value	p-value
(Intercept)	- 2. 0649240	0.8977056	104 - 2.	3002241	0. 0234
àgej uv	0.3885365	0.4445330	104 0.	8740331	0.3841
sexmal e	0.4612881	0.5751271	104 0.	8020629	0.4243
i sot	-0.0332648	0.0117174	104 - 2.	8389206	0.0054
ageiuv: sexmal e	-0.9298825	0.7672414	104 - 1.	2119817	0. 2283

**d.** Results for the analysis of wingtip shape (PC2\*)

Random effects: Formula: ~1 | year (Intercept) Residual StdDev: 0.06590182 1.168917

 Fixed effects:
 PC4 ~ 1 + age + sex + age: sex + isot

 Value Std. Error DF
 t-value p-value

 (Intercept)
 0.5434921
 0.5599454
 104
 0.9706162
 0.3340

 0.5434921
 0.9706162
 0.9047520
 0.9047520
 0.9047520

agej uv	0. 7984189	0.2761976	104	2.8907520	0.0047
sexmal e	- 0. 5395059	0.3575834	104	- 1. 5087555	0.1344
i sot	0.0096474	0.0072773	104	1. 3256870	0. 1878
agej uv: sexmal e	0. 4430462	0. 4765132	104	0. 9297670	0.3546

# 4) Variation between habitats in the morphological characteristics of migratory Robins.

We tested for differences between habitats (shrublands vs. woodlands) in the development of flight morphology (PC1), structural size (PC2), wing concavity (PC1\*) and wingtip shape (PC2\*) in the 110 migratory Robins wintering in Campo de Gibraltar. For this purpose, we performed Linear Mixed Models that analysed these variables (PC1, PC2, PC1\* and PC2\*) in relation to age, sex, habitat and their two-way interaction as fixed effects, and year as a random effect factor. Results for each morphological trait are shown below:

**a.** Results for the analysis of the development of flight morphology (PC1)

Random effects: Formula: ~1 | year (Intercept) Residual StdDev: 0.2837229 1.165277

Fixed effects:  $PC1 \sim 1 + age + sex + habitat + age: sex + age: habitat +$ sex: habi tat DF Value Std. Error t-value p-value  $\begin{array}{c} -\,0.\,\,2459673 \ \ 0.\,\,3172294 \ \ 102 \\ -\,0.\,\,5399119 \ \ 0.\,\,3287123 \ \ 102 \end{array}$ - 0. 775361 - 1. 642506 (Intercept) 0.4399 102 agej uv 0.1036 2. 2172294 0. 3971552 102 sexmal e 5.582779 0.0000 habitatwoods 0.3647179 0.3869094 102 0.942644 0.3481 agej uv: sexmal e 0.0185935 0.4786796 102 0.038843 0.9691 agej uv: habi tatwoods -0.0456698 0.4580340 102 -0.099708 0.9208 sexmal e: habitatwoods 0.0424203 0.4856511 102 0.087347 0.9306

**b.** Results for the analysis of structural size (PC2)

Random effects: Formula: ~1   year (Intercept)	Resi dual	
Stapev: 0. 208793 (	0. 985/652	
Fixed effects: PC2 ~	1 + age + sex + habitat + age: sex + age: habitat	+
sex: habi tat		
	Value Std. Error DF t-value p-value	
(Intercept)	-0.0693375 0.2549520 102 $-0.2719629$ 0.7862	
agei uv	-0.1322375 0.2780068 102 $-0.4756629$ 0.6353	
sexmale	-0.3574871 0.3359634 102 -1.0640654 0.2898	
habitatwoods	0 1660262 0 3268262 102 0 5079955 0 6126	
agei uv. sexmal e	-0.2513887 0 4049097 102 $-0.6208513$ 0 5361	
agoj uv: babi tatwoods	$0.0450224 \ 0.3874730 \ 102 \ 0.1161950 \ 0.9077$	
age uv. habitatwoods	0.01002210.001170010200.01010000.0000000000	
sexillare: hadr latwoods	0.3243232 0.4103704 102 1.2770723 0.2043	

c. Results for the analysis of wing concavity (PC1\*)

Random effects: Formula: ~1 | year (Intercept) Residual StdDev: 8.372387e-05 1.91513

Fixed effects: PC3 ~	1 + age +	sex + habit	tat +	age: sex +	age: habita	at +
sex: habi tat				0	0	
	Val ue	Std. Error	DF	t-value	p-value	
(Intercept)	0. 5157192	0. 4032550	102	1.2788909	0. 2038	
agej uv	0. 0345225	0.5385727	102	0.0641000	0.9490	
sexmale	0.8177916	0.6524814	102	1.2533562	0. 2129	
habi tatwoods	-0.5718823	0. 6239014	102	- 0. 9166229	0.3615	
agej uv: sexmal e	-0.6104467	0.7859893	102	- 0. 7766603	0. 4392	
agej uv: habi tatwoods	0.6424007	0.7527642	102	0.8533890	0.3954	
sexmal e: habi tatwoods	-1.2695223	0.7867493	102	- 1. 6136301	0. 1097	

**d.** Results for the analysis of wingtip shape ( $PC2^*$ )

Random effects:	
Formula: ~1   year	
(Intercept) Res	si dual
StdDev: 5. 203198e-05 1. 1	.34659
Fixed effects: PC4 ~ 1 +	- age + sex + habitat + age: sex + age: habitat +
sex: habi tat	0 0 0
	Value Std. Error DF t-value p-value
(Intercept) -0.	4735655 0. 2389170 102 - 1. 9821345 0. 0502
agej uv 1.	0008093 0. 3190888 102 3. 1364604 0. 0022
sexmal e -0.	5688229 0. 3865764 102 - 1. 4714371 0. 1443
habitatwoods 0.	9235074 0.3696436 102 2.4983727 0.0141
agej uv: sexmal e 0.	3570352 0. 4656760 102 0. 7667031 0. 4450
agej uv: habi tatwoods -0.	5383149 0.4459910 102 -1.2070084 0.2302
sexmal e: habitatwoods 0.	1293235 0.4661262 102 0.2774430 0.7820