Linking processes: effects of migratory routes on the distribution of abundance of wintering passerines

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Abstract

Linking processes: effects of migratory routes on the distribution of abundance of wintering passerines.— Movements of migratory birds across the western Paleartic concentrate populations along Atlantic and Mediterranean coasts, thus producing flows of migrants that converge at both extremes of the Pyrenees. Here we analyse the effect of these corridors on the winter distribution of some passerines (F. Motacillidae, F. Turdidae and F. Fringillidae). The number of ring recoveries of migrants at the edges of the Pyrenees was higher than expected, a pattern that was also observed in the case of winter recoveries. In addition, there was a significant decrease in the abundance and species richness of the bird assemblages of the three families analysed wintering in the coastal farmlands of northern Iberian peninsula as their location was further away_ from the western corridor of the Pyrenees. These results suggest the existence of links between the routes of migratory passerines and their winter densities in northern Iberia.

Key words: Iberian peninsula, Migratory routes, Passerines, Wintering grounds.

Resumen

Relacionando procesos: efectos de las vías migratorias sobre la distribución de la abundancia de pájaros invernantes.— Los movimientos de las aves migratorias en el Paleártico occidental producen concentraciones en las costas atlánticas y mediterráneas que convergen en ambos extremos de los Pirineos. En este estudio se analiza la relación entre esas vías de paso y la distribución invernal de ciertos pájaros (F. Motacillidae, F. Turdidae y F. Fringillidae). El número de recuperaciones de anillas de aves migratorias a ambos lados de los Pirineos fue mayor del esperado, una tendencia también observada en las recuperaciones invernales. Además, se observó una menor abundancia y diversidad de especies de las tres familias de aves analizadas en las campiñas costeras del norte de la península ibérica conforme aumentaba la distancia entre dichos lugares y el corredor occidental de los Pirineos. Estos resultados sugieren la existencia de una relación entre dichas vías de entrada y las densidades de pájaros invernantes en el norte de la península ibérica.

Palabras clave: Península ibérica, Rutas migratorias, Pájaros, Áreas de invernada.

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Introduction

Ecological barriers may produce variations in the direction of migratory birds, producing local concentrations of migrants along coastlands and mountain passes (Alerstam, 1990; Berthold, 1993). Movements of migratory populations across the Western Paleartic may cause, for instance, concentrations of birds along Atlantic and Mediterranean coasts of South–western Europe that produce flows of migrants converging in both extremes of the Pyrenees (Bernis, 1966–1971; Ferrer et al., 1986; Fortin et al., 1999; fig. 1). Several studies have shown the importance of these two corridors for the movements of large species and soaring birds (e.g. cranes, pigeons, raptors; Fernández Cruz., 1981; Purroy, 1988; De Juana et al., 1988; Madroño et al., 1992). However, there is a lack of comprehensive studies on their effect on the distribution of passerines (O. Passeriformes) passing through the north of the Iberian peninsula.

In addition to the effect of these corridors on the distribution of migrants, they could also play a role in the distribution of abundance of migratory passerines in wintering areas. This has been poorly studied to date, perhaps because it is commonly accepted that, at the end of the migratory period, other factors, such as weather or food availability, are the main determinants of bird abundance (Wiens, 1989a for review). However, migratory passages might strongly affect the wintering distribution of birds in regions which receive huge numbers of migratory birds , such as the Iberian peninsula (Tellería et al., 1988). Thus, it could be hypothesised that areas further from the main migratory routes will support fewer wintering individuals and species than those located closer to them.

This paper explores the relationship between the winter distribution of passerines in northern Iberia and the migratory corridors at the two edges of the Pyrenees (fig. 1). For this purpose, the distribution of birds belonging to the three most abundant families wintering in open habitats of northern Spain was studied (Motacillidae, Turdidae and Fringillidae) following two complementary approaches. First, the potential influence of corridors on the abundance of migratory passerines was evaluated by using ring recoveries. Second, whether these migratory routes determine the winter distribution of bird abundance in northern Iberia was analysed. This latter point was assessed by means of two complementary analyses: i. The distribution of ring recoveries was studied during the winter; ii. Whether bird abundance and richness of the bird assemblages of the three

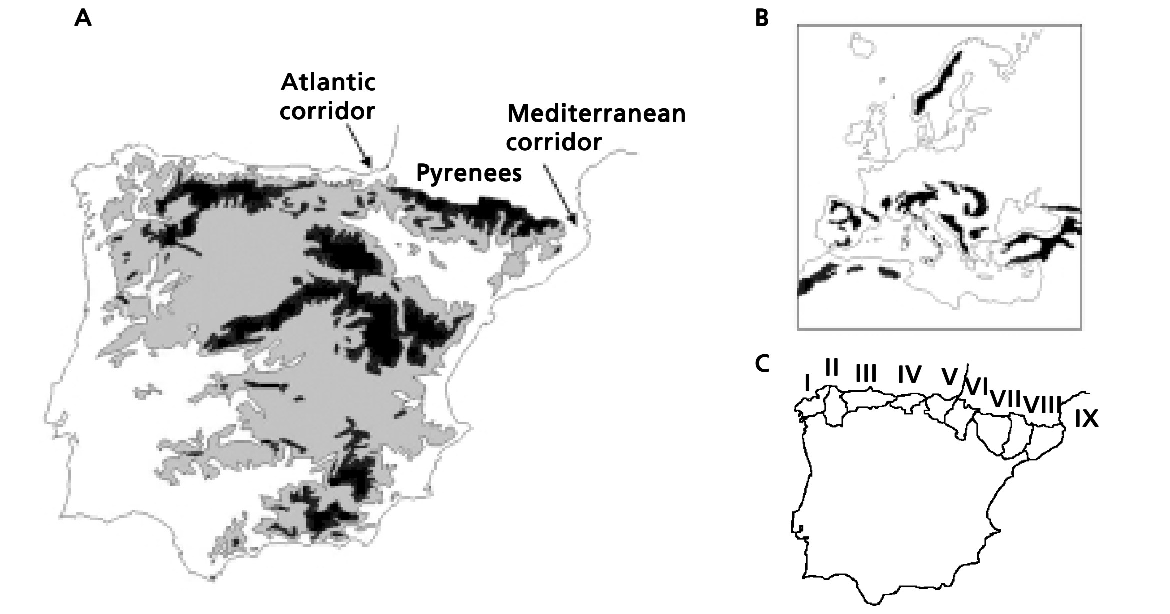

Fig. 1. A. Topographical features of the Iberian peninsula (areas of 500 m a.s.l. in grey and those of 1000 m a.s.l. in black) and location of the studied corridors. B. Distribution of the main mountain ranges in the Western Paleartic. C. Sectors delimited in this study.

Fig. 1. A. Rasgos topográficos de la península ibérica (en gris las áreas por encima de los 500 m s.n.m. y en negro las ubicadas por encima de los 1000 m s.n.m.). B. Distribución de las montañas más importantes en el Paleártico occidental. C. Sectores delimitados en este estudio.

studied families wintering in coastal farmlands of northern Iberia decrease from the Atlantic corridor westwards was evaluated.

Methods

Ring–recovery data

Ring–recoveries were used to evaluate the abundance of migratory birds. Trapped birds appear to be a proper index of migratory intensity (ZEHNDER & KARLSSON, 2001) even after accounting for the effects of biases related to variation in reporting rates (BAIRLEIN, 2001). Recoveries of birds ringed outside the Iberian peninsula and belonging to the three studied families were reviewed (BERNIS, 1966–1971; SANTOS, 1982; ASENSIO, 1983, 1985a, 1985b, 1985c, 1986, 1987; BUENO, 1990, 1991, 1992a, 1992b, 1998; PÉREZ–TRIS & ASENSIO, 1997a, 1997b; appendix 1). In order to analyse their distribution in northern Iberia, nine sectors were delimited following BERNIS (1966–1971; fig. 1). Recoveries were considered as belonging to either wintering or migratory birds according to the criterion used by each author consulted. Postnuptial and prenuptial recoveries were not distinguished, as they were not differentiated in some of the studies reviewed in this paper. However, prenuptial recoveries represent only 13.4 % of those of small Turdidae during the migratory period in the Iberian peninsula (BUENO, 1990, 1991, 1992a, 1992b, 1998), 10.5 % of wagtails (G. *Motacilla;* PÉREZ–TRIS & ASENSIO, 1997a, 1997b) and 5,1 % of thrushes (G. *Turdus;* TELLERÍA & SANTOS, 1982).

Bird abundance during winter

In order to explore the effect of the distance to the Atlantic corridor on the distribution of wintering birds, the abundance of the species considered in this study was quantified in the five sectors delimited along the Atlantic coastal belt (sectors I–V; fig. 1). Birds were counted by line–transects without census belt over units of 500 m long (appendix 2). Censuses were conducted during the last week in December 1997 and the first two weeks of January 1998. To prevent the effect of factors other than distance to the Atlantic corridor on the abundance of wintering birds, the potential effect of habitat structure and climate was controlled. To do this, all censuses were carried out in similar Atlantic farmlands dominated by meadows, scattered hedges and small woods. All these farmlands were located within 15 km from the shoreline and below 250 m a. s. l. to avoid the effects of weather (more extreme in inland areas and higher altitudes) on bird abundance. These coastal farmlands are in fact considered, the main wintering habitat of passerines in the north of the Iberian peninsula (TELLERÍA & GALARZA, 1990).

Data analysis

Chi–square tests were used to analyse whether the observed distribution of recoveries in the corridors (sectors V, VI and IX) was higher than expected according to an even distribution of recoveries along the study region (all sectors). To do so, the expected number of recoveries in sectors with and without corridors was calculated by multiplying their area for the mean density of recoveries observed in the whole study area. Spearman rank correlations were used to test for relationships between abundance and richness along the study sectors. Differences in the structure of wintering bird assemblages (abundance and species richness) along the Atlantic coast were tested by ANOVAs. Planned comparisons were used to test the hypothesis that the western sectors had lower densities and richness of wintering birds than the eastern sectors closer to the Atlantic corridor (contrast vectors: -2, -1, 0, 1 and 2 for sectors I, II, II, IV and V respectively). In these analyses, abundance and richness were log-transformed.

Results

Distribution of migratory birds

There was a significant difference in the distribution of the ring recoveries of migrants along northern Spain (fig. 2). As predicted, recoveries in both corridors of the Pyrenees (sector V, VI and IX) were higher than expected for the three studied families (Motacillidae: $\chi^2 = 54.65$; Turdidae: $\chi^2 = 150.82$, Fringillidae: $\chi^2 = 442.31$; df = 1, $P < 0.001$). Furthermore, the number of recoveries in the Atlantic corridor were higher than the number recorded in the Mediterranean corridor (Motacillidae: $\chi^2 = 26.96$; Turdidae: $\chi^2 = 84.72$, Fringillidae: $\chi^2 = 31.20$; df = 1, $P < 0.001$). Patterns in the richness of species moving across northern Iberia were related to the total number of recoveries (Motacillidae, $r_s = 0.94$, $P < 0.001$; Turdidae, $r_s = 0.93$, $P < 0.001$; Fringillidae, $r_s = 0.74$, $P = 0.022$; fig. 2).

Distribution of wintering birds

Recoveries of ringed birds

The distribution of the total number of winter recoveries followed a pattern similat to that observed during the migratory period ($r_s = 0.75$, $P = 0.019$, $n = 9$), and the corridors (sectors V, VI and IX) had many more records than expected for each family (Motacillidae: $\chi^2 = 52.80$, Turdidae: $\chi^2 = 73.70$, Fringillidae: $\chi^2 = 94.79$; df = 1, $P < 0.001$). In winter, the number of recorded species showed a similar pattern to the total number of recoveries (Motacillidae: $r_s = 0.76$, $P = 0.018$; Turdidae: $r_s = 0.83$, $P = 0.005$; Fringillidae: $r_s = 0.85$, $P = 0.004$; $n = 9$ in all cases; fig. 2).

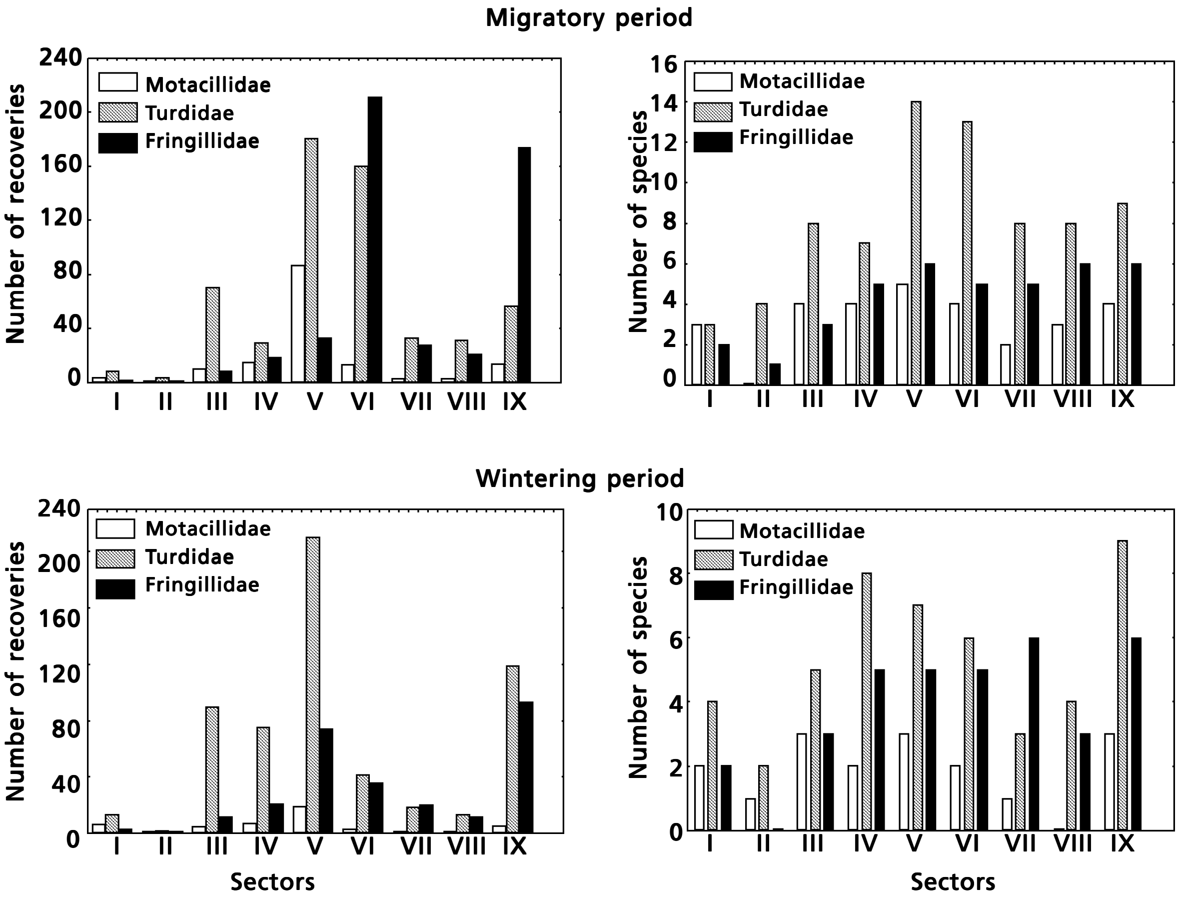

Fig. 2. Number of ring recoveries and number of species recovered in the study sectors (see fig. 1) according to migratory and wintering periods.

Fig. 2. Número de recuperaciones y de especies recuperadas en los sectores estudiados (ver fig. 1) según periodos de migración o invernada.

Bird abundance and richness

Despite strong inter–specific differences in the distribution of abundance (appendix 2), there was a significant decrease in abundance and species richness in the wintering bird assemblages of the three studied families as the location of farmlands was further away from the Atlantic corridor (fig. 3). Abundance and richness of farmland bird assemblages in these sectors suggested trends similar to those observed with ring recoveries ($r_s = 0.80$, $P = 0.109$, $n = 5$) and species ($r_s = 0.95$, $P = 0.058$, $n = 5$).

Discussion

Effects of migratory routes on the distribution of passerines

Results of this study corroborate the significant role of the Atlantic and Mediterranean extremes of the Pyrenees as corridors for migratory passerines of the three studied families and illustrate how the Pyrennees act as a barrier for these small birds, despite their ability to cross mountain ranges (e.g. HILGERLOGH et al., 1992; BRUDERER, 1996) or wide tracts of sea (BERNIS, 1963, HILGERLOGH et al., 1992). They also suggest that, given the observed differences in the number of recoveries, the Atlantic corridor is used by a larger number of migrants than the Mediterranean. This pattern is possibly related to the size of the area from where migrants move to the Iberian peninsula. During the autumn migration, birds crossing the Atlantic corridor come from an area which extends from Northern Germany, the Netherlands, North–western France and the British Islands to Scandinavian and Baltic countries (fig. 1). This area is larger than the breeding quarters of the passerines crossing through the Mediterranean corridor, which come mainly from Switzerland, Southern Germany and Eastern

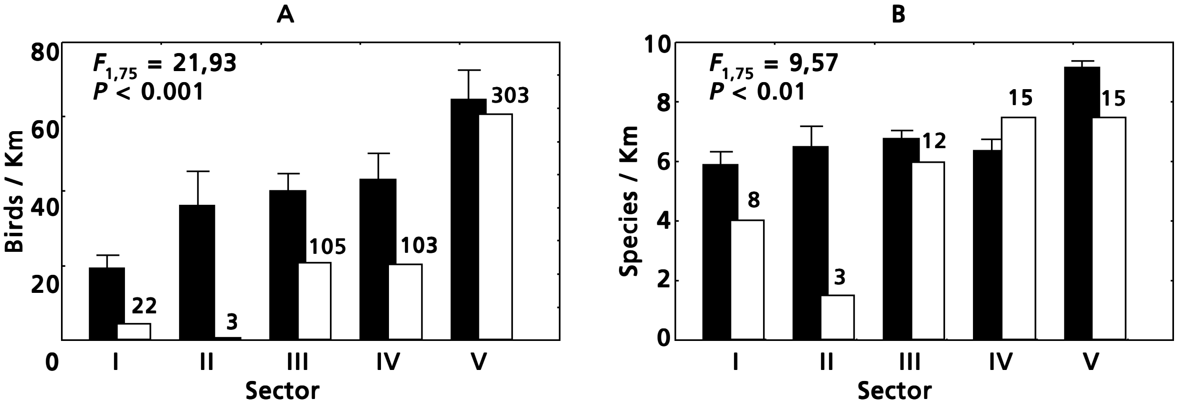

Fig. 3. Mean number (± s.e.) of individuals (A) and species (B) counted per transect in the five sectors delimited in the Atlantic coast of the Iberian peninsula (fig. 1; black bars) and their relationships with the results obtained by using ring recoveries (white bars with the corresponding number of recoveries and species). Results of ANOVA planned comparisons testing for differences in abundance and richness of wintering birds between western sectors are also shown (see text for details).

Fig. 3. Número medio (± e.e.) de individuos (A) y especies (B) registrados por transecto en los cinco sectores de las costas atlánticas ibéricas (fig. 1; barras negras) y su relación con los resultados obtenidos de las recuperaciones de aves anilladas (barras blancas, con sus correspondientes valores). Se dan también los resultados de sendas ANOVA planificadas para ver las diferencias entre los valores obtenidos en los transectos de los diferentes sectores (ver texto).

France (Bernis, 1966–71; Santos, 1982; Asensio, 1983, 1985a, 1985b, 1985c; 1986, 1987; Bueno, 1990, 1991, 1992a, 1992b).

Our results also show that the distribution of migrants in northern Iberia is a good predictor of their winter distribution, as suggested by the effect of the two corridors on the winter distribution of migrants (fig. 2). However, we agree, that the role of these corridors on the distribution of wintering individuals is likely blurred further south due to the increasing dispersion of individuals in the open valleys and plateaux of the Iberian peninsula and their active search for the best sectors to cope with winter restrictions related to climate, food availability, etc. Mountains and plateaux therefore seem to be avoided by many wintering passerines that will converge in the mildest sectors of the Iberian peninsula (Mediterranean and Atlantic coasts, and South–western Iberia) (Tellería et al., 1988, 1999).

The westwards decreasing abundance of wintering birds along the belt between the Atlantic coastline and the mountains on northern Iberian peninsula could be interpreted as additional evidence of the role of corridors on the organisation of wintering bird assemblages (fig. 3). This interpretation was also supported by the similar pattern obtained from ring recoveries and censuses in the northern sectors. There are several hypotheses that could explain this effect. First of all, increasing winter densities in the eastern farmlands could be a mere "sampling effect" of migrants crossing the corridor from one side to another in relation to the almost permanent movement of many migratory birds throughout the winter in response to weather stress or food availability. Secondly, the use of Atlantic farmlands by wintering birds could be affected by a seasonal peninsula effect (Brown & Lomolino 1998). In this case, western sectors are less likely to be occupied by wintering birds arriving at the Iberian peninsula through the Atlantic corridor than eastern sectors. Lastly, evolutionary adjustments, related to the advantages of wintering near the breeding grounds (e.g. early occupancy of the best breeding territories), could penalise the use of the western, farthest sectors (Alerstam & Hedenström 1998 for review). However, there is an alternative hypothesis to the effect of the Atlantic corridor on the abundance distribution of wintering birds in Northern Spain: the bulk of European migratory populations are connected (see Webster et al., 2002 for a review of this concept) to extensive wintering grounds in Southern Mediterranean areas of the Iberian peninsula and Morocco, and this connection could decrease the use of the North–western corner of Spain as wintering grounds. The geographical situation of North–western Spain, marginal to the main flux of the migratory population arriving at the Iberian peninsula (Bernis, 1966–1971; Tellería et al., 1999), could also affect the observed distribution of ring recoveries during the migratory period. Obviously, all these hypotheses need to be tested by more specific approaches.

Implications for the conservation of wintering birds

It is commonly argued that studies carried out on different spatial and temporal scales are needed for a more complete understanding of which factors affect the numerical evolution of migratory bird populations (TERBORGH, 1989; BAILLIE & PEACH, 1992; SHERRY & HOLMES, 1996; ESLER, 2000). Habitat quality is usually considered the main determinant of the abundance of migratory birds and, it is consequently accepted that their population levels will be strongly determined by changes in the availability and suitability of habitats in breeding and wintering grounds (DOLMAN & SUTHERLAND, 1994; SUTHERLAND & DOLMAN, 1994). Local changes in habitat suitability due to depletion of key resources or landscape modifications will thus be related to concomitant changes in the regional size of bird populations. As a result, functional relationships between the local management of habitats and the regional evolution of populations are, as in other animal groups, at the basis of current strategies of bird conservation (VERNER et al., 1986; MORRISON et al., 1998). An increasing body of theory and empirical evidence however, suggests that bird abundance and distribution are also affected by scale dependent, hierarchical processes that can affect their patterns of abundance (WIENS, 1989b).

Our results support this view since they suggest an effect of large scale, geographical processes related to migratory corridors on the regional abundance of migratory and wintering passerines. Further investigations are required to show the potential of this relationship between corridors and densities of migratory passerines in the design of proper management strategies directed to the conservation of these animals. Habitats in areas under the effect of flows of migrants must be of particular conservation concern as they contribute to maintaining the bulk of migratory populations during the passage and, in regions suitable for wintering (as the Iberian peninsula is), present the highest densities of many migratory species. This will probably affect any integrated approach to the management of migratory populations from a meta–population perspective (ESLER, 2000) given the reduced probability of occupation by migrants of habitat patches located at increasing distance of corridors.

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Appendix 1. Number of recoveries of birds ringed outside the Iberian peninsula according to sectors and periods (migration *vs.* wintering).

Apéndice 1. Numero de recuperaciones de aves anilladas fuera de la península ibérica según sectores y períodos de captura (migración vs. invernada).

		Sector								
		I	II	III	IV	V	VI	VII	VIII	IX
Km^2		7900	9800	10500	5300	7200	10400	15600	12000	13600
Motacillidae										
Motacilla alba	Migr.	1	0	4	1	17	5	0	1	5
	Win.	5	1	2	0	4	2	0	0	2
Motacilla flava	Migr.	1	0	1	5	21	4	1	1	1
Motacilla cinerea	Migr.	2	0	1	3	10	0	2	0	4
	Win.	1	0	1	2	6	0	1	0	1
Anthus pratensis	Migr.	0	0	4	6	33	3	0	0	4
	Win.	0	0	1	5	9	1	0	0	2
Anthus trivialis	Migr.	0	0	0	0	5	1	0	1	0
Turdidae										
Erithacus rubecula	Migr.	0	1	12	4	36	52	7	6	18
	Win.	3	1	7	8	18	9	3	7	36
Luscinia svecica	Migr.	0	0	0	0	2	1	1	0	0
	Win.	0	0	0	0	0	0	0	0	1
Luscinia megarhy.	Migr.	0	0	1	0	1	0	0	0	0
Phoenicurus phoenic.	Migr.	0	0	0	0	12	37	10	12	3
	Win.	0	0	0	1	1	1	0	0	1
Phoenicurus ochruros	Migr.	0	1	1	0	5	2	0	1	7
	Win.	0	0	0	1	0	0	0	1	13
Oenanthe oenanthe	Migr.	0	0	0	1	6	6	0	1	1
Saxicola rubetra	Migr.	0	0	0	1	9	10	1	0	0
Saxicola torquata	Migr.	0	0	0	2	5	2	0	1	2
	Win.	0	0	0	1	0	0	0	0	4
Turdus philomelos	Migr.	5	0	24	13	41	29	4	4	14
	Win.	7	0	24	36	95	20	7	3	30
Turdus iliacus	Migr.	1	1	12	7	27	8	1	1	2
	Win.	0	0	35	10	38	3	-	2	4
Turdus merula	Migr.	2	1	15	1	28	15	4	6	8
	Win.	1	1	13	14	42	7	8	0	27
Turdus viscivorus	Migr.	0	0	2	0	1	3	5	0	1
	Win.	0	0	1	0	2	0	0	0	1
Turdus pilaris	Migr.	0	0	3	0	4	1	0	0	0
	Win.	2	0	10	4	14	1	0	0	2
Turdus torquatus	Migr.	0	0	0	0	3	2	0	0	0
	Win.	0	0	0	0	0	0	0	0	0
Fringillidae										
Carduelis cannabina	Migr.	0	0	1	4	80	6	6	10	48
	Win.	1	0	2	3	18	8	3	1	14
Carduelis chloris	Migr.	0	0	0	1	13	4	3	2	8
	Win.	0	0	1	1	6	0	2	2	7

Appendix 1. (Cont.)

		Sector								
		I	II	III	IV	V	VI	VII	VIII	IX
Km^2		7900	9800	10500	5300	7200	10400	15600	12000	13600
Carduelis spinus	Migr.	0	1	4	7	73	13	6	2	26
	Win.	2	0	6	6	16	1	4	0	12
Carduelis carduelis	Migr.	1	0	0	5	105	81	8	3	29
	Win.	0	0	0	4	19	18	6	1	10
Fringilla coelebs	Migr.	1	0	3	1	54	7	4	3	49
	Win.	0	0	2	7	15	7	4	6	37
Serinus serinus	Migr.	0	0	0	0	5	0	0	1	14
	Win.	0	0	0	0	0	1	1	0	13

Appendix 2. Mean abundance (number of individuals / km ± s.d.) of bird species censored in the five sectors of the Atlantic coast (fig. 1).

Apéndice 2. Abundancia media (número de individuos / km ± d.e.) de las especies de aves censadas en los cinco sectores de la costa atlántica (fig. 1).

	Sector				
	I	II	III	IV	V
Transects (n)	10	10	20	20	20
Motacillidae					
Anthus pratensis	4.6±4.8	29.8±25.8	29.7±29.9	19.0±17.2	26.3±13.3
Motacilla alba	1.4±1.6	2.2±3.2	5.5±5.4	4.8±5.4	9.4±7.7
Turdidae					
Saxicola torquata	1.6±2.8	3.4±2.8	1.4±2.6	0.6±1.5	2.8±1.9
Erithacus rubecula	6.2±3.2	2.2±1.7	4.4±2.8	4.6±3.9	7.3±3.9
Phoenicurus ochruros	0	0	0	0.1±0.4	0.2±0.6
Turdus merula	6.6±4.7	2.6±2.6	6.6±4.7	5.1±4.2	5.8±5.4
Turdus philomelos	3.0±6.9	2.2±3.3	4.7±6.6	4.4±5.4	5.8±5.2
Turdus iliacus	1.2±2.1	11.2±14.2	7.9±14.9	6.9±14.6	13.1±16.4
Turdus viscivorus	0	0	0	0	0.2±0.6
Turdus pilaris	0	0	0	0.1±0.4	0
Fringillidae					
Carduelis chloris	6.4±14.8	0	0.2±0.6	0	1.0±2.6
Carduelis spinus	0	0	1.9±6.7	0.6±2.7	2.2±7.2
Carduelis carduelis	1.8±2.2	1.9±3.11	5.6±8.3	9.5±18.1	11.7±12.3
Carduelis cannabina	0	1.0±2.5	0	0	0.1±0.4
Fringilla coelebs	6.0±5.2	5.0±3.2	12.0±12.0	30.3±44.4	40.4±55.3
Serinus serinus	0	0	0.2±0.9	0.4±1.2	2.6±4.4
Pyrrhula pyrrhula	0	0	0	0	0.1±0.5