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PRIORITISING RESEARCH IN STEPPE BIRD CONSERVATION: A LITERATURE SURVEY

PRIORIZANDO LA INVESTIGACIÓN PARA LA CONSERVACIÓN DE LAS AVES ESTEPARIAS: UNA PROSPECCIÓN BIBLIOGRÁFICA

Manuel B. Morales[1] * and Juan Traba[1]

Summary.—With the aim to identify priorities in conservation-oriented research, this paper reviews the level of scientific attention given to steppe birds in Spain during the last 50 years. We surveyed scientific literature using Thomson Reuters Web of Science and the journal *Ardeola*, using the English names of 28 species of steppe birds and the word "Spain" as search terms. Every species was assigned a Scientific Attention Index (SAI), based on the number of articles published on each of them. In addition, a vulnerability measure (Vulnerability Score; VS) was calculated for each species on the basis of the trend estimate provided by the Sacre or Noctua monitoring programmes, or according to expert criteria. The sample gathered (432 articles) was a significant and thus representative proportion of WOS and *Ardeola* contents on the species considered. The most studied species was the red-legged partridge *Alectoris rufa*, with 83 papers (20.15%); while the least studied was the short-eared owl *Asio flammeus* (1 paper; 0.24%). The most studied knowledge area was Habitat Selection (92 papers; 22.17%), while the least was Niche/Climate, with nine papers (2.17%). Preferred habitat (grass steppe, shrub steppe or mixed) was not a significant factor in the level of scientific attention given to the different species. However, large-sized species (non-Passerines) were significantly more studied than small-sized ones (Passerines), indicating a research bias for the former group. Finally, no significant relationship was found between SAI and VS, which suggests that research effort has been allocated irrespective of the species' conservation status. These results highlight the scarce scientific attention given to most steppe birds in Spain in spite of their overall high vulnerability, and for most of the knowledge areas considered. On the other hand, they also show the high relative importance of research carried out in Spain, in both the Mediterranean and world contexts. This work underscores the need to focus scientific effort on certain species, especially those that currently show more regressive trends or higher levels of vulnerability, and in most areas of knowledge.

Key words: Flagship species, grass steppes, Mediterranean, shrub steppes, scientific attention, Spain, vulnerability.

Resumen.—Con el objeto de identificar prioridades de investigación orientada a la conservación, en este trabajo se revisa el grado de atención científica recibida por las aves esteparias en España durante los últimos 50 años. Se realizó una prospección de la literatura científica utilizando el portal

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"Thomson Reuters Web of Science" (WOS) y la revista científica *Ardeola* y empleando el vernáculo inglés de 28 especies de aves y el término "Spain" como palabras de búsqueda. A cada especie se le asignó un Índice de Atención Científica (IAC) basado en el número de artículos publicados sobre la misma. Se calculó, además, una medida de vulnerabilidad (Puntuación de Vulnerabilidad; PV) para cada especie, sobre la base de la estima de tendencia poblacional proporcionada por el programa Sacre de seguimiento de aves comunes o, en su caso, por el programa Noctua o recurriendo a criterio experto. La muestra de estudios recopilada (432 artículos) constituye una proporción relevante y representativa de los contenidos de WOS y *Ardeola* sobre las especies seleccionadas. La especie más estudiada fue la perdiz roja *Alectoris rufa*, con 83 artículos (20,15%), mientras que la menos estudiada fue el búho campestre *Asio flammeus*, con un único trabajo (0,24%). El área de conocimiento más frecuentemente abordada fue la de Selección de Hábitat (92 artículos; 22,17%), en tanto que la que menos atención recibió fue la de Nicho/Clima, con sólo 9 trabajos (2,17%). La preferencia de hábitat de cada especie (estepa herbácea, estepa de matorral, hábitat mixto) no fue un factor significativo a la hora de explicar el grado de atención científica recibida por la misma. Sin embargo, las especies de mayor tamaño (no Passeriformes) fueron significativamente más estudiadas que las de pequeña talla (Passeriformes), lo que indica un sesgo de investigación a favor del primer grupo de especies. Finalmente, no se encontró ninguna relación significativa entre atención científica y vulnerabilidad, lo que sugiere que el esfuerzo de investigación se ha distribuido independientemente del estado de conservación de cada especie. Estos resultados ponen de manifiesto la escasa atención científica recibida por la mayoría de las especies de aves esteparias en España, a pesar de su globalmente elevada vulnerabilidad, lo cual afecta, además, a la mayoría de las áreas de conocimiento consideradas. Por otro lado, los resultados también muestran la gran importancia relativa de la investigación realizada en España sobre estas especies, tanto en el contexto mediterráneo, como en el mundial. Este trabajo subraya la necesidad de dedicar mayor esfuerzo científico a determinadas especies de aves esteparias, en especial aquellas que actualmente muestran tendencias más regresivas o mayores niveles de vulnerabilidad, y en la mayor parte de las áreas de conocimiento.

Palabras clave: atención científica, España, especie bandera, estepas herbáceas, estepas de matorral, Mediterráneo, vulnerabilidad.

Introduction

Steppe birds, i.e. those particularly adapted to flat open landscapes dominated by grass or dwarf-shrub vegetation, comprise the most threatened bird assemblage in the European continent (Santos and Suárez, 2005; Sanderson *et al*., 2005). Their decline can be attributed to the historical transformation of original steppe habitats (Santos and Suárez, 2005; Laiolo and Tella, 2006), and particularly to the intensification of agricultural practices in the dry cereal farmland and extensively grazed grasslands that currently constitute their main habitat in Europe (Santos and Suárez, 2005; Sanderson *et al*., 2005; Morales *et al*., 2013; Traba *et al*., 2013). Both due to its worrying conservation status and intrinsic biological interest, the steppe bird assemblage has been the subject of several reviews and analyses regarding its species' common adaptations to steppe environments, habitat preferences, biogeographic relationships, responses to land-use changes and agricultural management, and degree of cover by protected areas (Suárez *et al*., 1991; de Juana, 2005; Santos and Suárez, 2005; Sanderson *et al*., 2005; Traba *et al*., 2007; Morales and Traba, 2013; Morales *et al*., 2013). However, research attention, whether basic or applied, has not been uniformly distributed among the different species forming the group. Although there can be different views among authors regarding

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what exactly can be considered a steppe bird, there is a high level of coincidence in the species lists proposed in different works (de Juana, 1989; Suárez *et al*., 1997; Santos and Suárez, 2005; Traba *et al*., 2007; Traba *et al*., 2013), and all of them include both intensively studied species and others that have received scant scientific attention.

Species can be studied for different reasons. Factors such as adequacy as a model for particular biological processes, economic or social interest, or logistic limitations in their study (often related to size or abundance), among others, may determine the level of scientific attention devoted to a particular species. In a conservation context, species associated with threatened or disturbed habitats tend to receive more attention than others tied to less altered ones, and this is particularly the case for those considered to be indicator or keystone species (Tellería, 2012). In this respect, and due to the habitat transformations and environmental problems generated by agricultural intensification, those steppe birds that are more clearly associated with cereal steppes and pastures may have attracted more conservation concern, and thus research effort, than those linked to dwarf-shrub formations. Similarly, large species may have received more scientific attention partly because they are more easily identified and surveyed, which facilitates the use of such research strategies and tools as long-term monitoring, capture and tagging, or individual identification in the field.

In any case, once a species becomes the object of a more or less intensive research programme, published information about it begins to accumulate, helping refine questions or posing new ones that will eventually give rise to new published results. This process often diverts scientific interest and/or resources to better known species and may condemn others to scientific oblivion. On the other hand, when a particular bird community is threatened overall because its main habitat is undergoing important environmental changes (as is the case with steppe birds), prioritisation of conservation-oriented research should consider the species' conservation status and population trends in order to inform action on the most endangered ones.

Here we present the results of a scientific literature survey aimed at identifying understudied species in the Spanish steppe bird community, examining the areas of biological knowledge that have received more attention in the different species. We also evaluate two factors potentially related to the level of attention received: body size and habitat preferences. To assess this latter factor, we examined differences in scientific attention between grass-steppe species, shrub-steppe species and species preferring mixed habitats. Finally, we test the relationship between the level of scientific attention given to species and their conservation status, combining survey results with existing information on each species' population trends in order to suggest conservation-oriented research priorities.

Methods

Species considered

Before starting the bibliographic survey we made a selection of 28 species breeding in Spain that can be clearly considered as steppe birds (Supplementary Electronic Material: table S1). The core of this list is formed by 26 species breeding in the Iberian Peninsula and the Balearic Islands selected in accordance with Suárez *et al*. (1997) on the basis of four non-exclusive criteria: (i) species typical of, or very frequent in the Mediterranean region, (ii) ground-nesting species, (iii) species exclusive to treeless, mainly flat areas, and (iv) species whose main European populations are found in

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TABLE 1

List of species used in the study, in declining order of attention given. The number of papers, Vulnerability Score (VS) and Scientific Attention Index (SAI) are shown, as well the main habitat preference assigned. See text for details on index and score calculations.
[Lista de especies consideradas en el estudio, ordenadas por grado de atención científica recibida. Se presenta el número de artículos, la Puntuación de Vulnerabilidad (PV) y el Índice de Atención Científica (IAC), así como la preferencia de hábitat asignada. Ver texto para los detalles de cálculo.]

Scientific name	English name	Nº papers	SAI	VS	Habitat
Alectoris rufa	Red-legged partridge	84	10	8	Mixed
Otis tarda	Great bustard	74	10	2	Grass-steppe
Falco naumanni	Lesser kestrel	52	10	2	Grass-steppe
Circus pygargus	Montagu's harrier	40	8	6	Grass-steppe
Tetrax tetrax	Little bustard	39	8	8	Grass-steppe
Chersophilus duponti	Dupont's lark	20	4	10	Shrub-steppe
Pterocles alchata	Pin-tailed sandgrouse	11	2	2	Grass-steppe
Coturnix coturnix	Quail	9	2	8	Grass-steppe
Pterocles orientalis	Black-bellied sandgrouse	9	2	8	Mixed
Circus cyaneus	Hen harrier	8	0	6	Mixed
Burhinus oedicnemus	Stone curlew	7	0	6	Mixed
Alauda arvensis	Skylark	6	0	8	Mixed
Galerida theklae	Thekla lark	6	0	4	Shrub-steppe
Calandrella rufescens	Lesser short-toed lark	6	0	10	Shrub-steppe
Galerida cristata	Crested lark	5	0	6	Grass-steppe
Emberiza calandra	Corn bunting	5	0	6	Grass-steppe
Anthus berthelotii	Berthelot's pipit	5	0	6	Shrub-steppe
Melanocorypha calandra	Calandra lark	4	0	8	Grass-steppe
Calandrella brachydactyla	Short-toed lark	3	0	6	Grass-steppe
Oenanthe oenanthe	Northern wheatear	3	0	8	Mixed
Oenanthe hispanica	Black-eared wheatear	3	0	8	Shrub-steppe
Cisticola juncidis	Zitting cisticola	3	0	6	Grass-steppe
Sylvia conspicillata	Spectacled warbler	3	0	6	Shrub-steppe
Chlamydotis undulata	Houbara bustard	3	0	4	Shrub-steppe
Cursorius cursor	Cream-coloured courser	2	0	6	Shrub-steppe
Glareola pratincola	Collared pratincole	2	0	6	Mixed
Anthus campestris	Tawny pipit	2	0	6	Shrub-steppe
Asio flammeus	Short-eared owl	1	0	6	Grass-steppe

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Spain. This list additionally includes the lesser kestrel *Falco naumanni* which is not a ground nester but is clearly dependent on steppe habitats due to its preferential use of them (Bustamante, 1997; Negro, 1997) and species such as the skylark *Alauda arvensis*, which outside Iberia is not strictly considered a steppe bird but can be unequivocally assigned to steppe habitats in the Peninsula. On the other hand, species associated with semiarid climate but with preferences for rugged terrain and nesting in rock cavities, such as the trumpeter finch *Bucanetes githagineus* and the black wheatear *Oenanthe leucura*, were excluded. This selection has already been used by Traba *et al*. (2007) to determine high value areas (hotspots) for steppe birds in Spain and by Traba *et al*. (2013) to evaluate large-scale factors influencing species richness and composition of steppe bird communities. In order to encompass the entirety of the country, for the purpose of this paper we added two more steppe birds exclusively breeding in the Canary Islands, the houbara bustard *Chlamydotis undulata* and Berthelot's pipit *Anthus berthelotii*. The list of species included in the study is presented in table 1.

Literature surveys

We surveyed the literature using Thomson Reuters Web of Science (WOS). We carried out a search for each species in the list using the English species name and the word 'Spain' as search terms, which yielded papers that included any of the terms in either the title, the abstract or the key word list. The initial results of each search were refined through filtering by the WOS areas 'Environmental Sciences and Ecology' and 'Zoology'. Studies not considering any of the species present in the list were excluded, as well as those that were exclusively clinical-veterinarian (assigned to the 'Zoology' area) and those few involving study areas outside Mediterranean countries. This WOS survey yielded 383 studies, some of which (N = 16) were general articles centred on entire assemblages rather than on particular species. This search is probably incomplete, as it may have excluded studies carried out in this geographical area but not including any of the search terms in their title, abstract or keywords. However, the sample obtained can be considered representative of the WOS contents regarding these species in Spain and other Mediterranean regions. Nevertheless, in order to assess the representativeness of our sample in relation to WOS contents with respect to other Mediterranean countries and the world context, we made additional searches using, respectively, the terms 'France', 'Italy', 'Portugal', 'Greece' and 'Morocco', as well as a world search using only each species name, We used the results of these searches to calculate the proportion of studies containing the term 'Spain' over the total number of papers carried out worldwide and within the mentioned Mediterranean countries.

This search excluded any steppe bird studies carried out in Spain that were published as articles not included in the WOS. To account for this problem, we carried out a second survey restricted to *Ardeola*, the oldest and most important ornithological journal in Spain, using the same search terms and considering all issues from 1954, long before *Ardeola* was assigned an impact factor in the WOS (year 2003). This second survey yielded 49 more studies carried out in Spain (one of them being a general study), so that our final sample is 432 articles. Although our literature survey still leaves aside studies published in books and book chapters, as well as in other non-indexed journals, we consider that our sample is large enough and sufficiently non-biased to be treated as representative of the existing spectrum of available published studies on Spanish steppe birds.

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Data treatment and analysis

The 432 studies on steppe bird species compiled encompass a wide range of research topics that can be classified under different sub-areas of knowledge within the broad WOS areas considered in the survey. General articles (i.e. community-level studies, N = 17) were finally excluded from the analyses by species (N = 415 papers analysed). We have identified 12 specific knowledge areas in which the studies can be classified (table 2), trying to use categories as related as possible to basic biological and ecological information in order to better identify potential knowledge gaps. For each species we calculated a measure of research attention (Scientific Attention Index, SAI) based on the percentage of studies devoted to that species over the total number of articles compiled. That percentage was re-scaled from 0 to 10 so that species approaching the maximum possible percentage of research attention (10% or more) scored 10 in the SAI scale, those reaching between 8 and 9.9% scored 8, those reaching between 6 and 7.9% scored 6, those reaching between 4 and 5.9% scored 4, those with values between 2 and 3.9% scored 2, and those under 2% of the papers scored 0.

Species were also assigned a vulnerability value (Vulnerability Score, VS). These categories were based on the report by SEO/BirdLife on the results of the common breeding bird monitoring programme Sacre (SEO/BirdLife, 2013). We used the mean inter-annual trend for the periods 1998-2013 or 1998-2011 (for those species not included in the last report: stone curlew *Burhinus oedicnemus* and collared pratincole *Glareola pratincola*). For the only nocturnal species, the short-eared owl *Asio flammeus*, we used the trend extracted from the SEO/BirdLife Noctua programme (SEO/BirdLife, 2015). The remaining four species not included in monitoring programmes were categorised following expert criteria according to available information. Thus, the cream-coloured courser *Cursorius cursor* was considered stable (Carrascal *et al*., 2006); the houbara bustard was considered in moderate increase (Lorenzo *et al*., 2007); Dupont's lark *Chersophilus duponti* was assigned a strong decline (own unpublished data; Garza and Traba, 2016); and Berthelot's pipit was considered stable (Illera, 2007; Illera *et al*., 2016).

The mean inter-annual trends extracted from Sacre or Noctua, or the equivalent data provided by experts, were re-categorised into numerical classes from 2 to 10, in order to make the Vulnerability Score comparable with the SAI. No species received a VS of 0. The reclassification was as follows: Mean inter-annual trends greater than 5% scored 2 in the VS scale; mean inter-annual trends between 1% and 5% scored 4; mean inter-annual trends between –1% and + 1% scored 6; mean inter-annual trends between –1% and –5% scored 8; and finally, species with mean inter-annual trends smaller than –5% scored 10 on the VS scale.

In addition, we assigned a preferred habitat use to each species, according to the results reported by Carrascal and Palomino (2008) based on the data from the Sacre monitoring programme, or following expert advice. We reclassified birds according to their main habitat preferences in three classes: grass-steppe birds, shrub-steppe birds, or mixed habitat birds. Grass-steppe includes all birds inhabiting mainly cereal farmland, pastures and other similar human-modified landscapes; shrub-steppe includes birds showing preference for scrub- or shrub-dominated landscapes, with natural vegetation; mixed habitat includes birds with no clear preference for any of the previous classes (see Traba *et al*., 2013, for a similar classification). Finally, we classified birds into Passerines and non-Passerines in order to reflect size differences (small vs. medium to large-sized birds).

We have tested for differences in scientific attention (percentage of papers) between

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birds in relation to habitat preferences (three classes) and size (two classes) using the Kruskal-Wallis and Mann-Whitney U tests. In addition, we have tested for the relationship between scientific attention received by a species (SAI) and its vulnerability measure (VS) using Spearman correlation. The analyses have been carried out on Statistica 8.0 software (Statsoft, 2007).

Results

The most studied species was the red-legged partridge, with 83 papers (20.15%) followed by the great bustard, with 74 papers (17.96%), the lesser kestrel (52 papers; 12.62%) and Montagu's harrier *Circus pygargus* (40 papers; 9.71%). The least studied species were the short-eared owl (1 paper;

Table 2

Specific knowledge areas used in this study, with general description, numbers of papers and Scientific Attention Index (SAI) calculated for each, using the re-scaling described in the text.
[Áreas de conocimiento consideradas en el estudio, junto con su descripción general, número de artículos publicados e Índice de Atención Científica (IAC). Véase el texto para los cálculos del índice.]

Study Area	Description	Nº papers	SAI
Habitat Selection	Studies on macro and microhabitat preferences	92	10
Management / Conservation	Studies on habitat management, AES and effects on bird conservation	52	10
Physiology / Toxicology / Parasitology	Studies on physiology, toxicology and/or parasitology	52	10
Others	Studies on field methods, biotic interactions, behaviour, morphology, etc.	41	8
Movements	Bird movement between breeding and wintering areas	29	6
Genetics	Gene structure, gene flow	27	6
Population Dynamics	Data on population trends and factors driving these trends	26	6
Census / Status / Distribution	Data on population size and distribution areas	25	6
Reproductive Parameters	Breeding season, nest success, nest failure, clutch size, etc.	24	4
Life History	Studies on life span, body size, sexual selection, mate selection, trade-offs, etc.	20	4
Diet	Data on feeding habits	18	4
Niche / Climate	Studies on niche breadth, overlap, position, etc., both realized and Grinnellian (climatic)	9	2

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0.24%); and the cream-coloured courser, the collared pratincole and the tawny pipit *Anthus campestris*, with two papers each (0.49%). Another seven species had a low SAI, also with fewer than five papers published in the studied period (table 1; fig. 1).

The most studied knowledge area was Habitat Selection (92 papers; 22.17%), followed by Management/Conservation, which is closely related with the previous one, and Physiology/Toxicology/Parasitology (both with 52 papers; 12.53%), the latter heavily influenced by red-legged partridge studies. The least studied area was Niche/Climate, with nine papers (2.17%) (table 2).

Even relatively well-studied species showed differences between knowledge areas in the attention received; obviously, these differences were greater in the case of poorly studied species. For example, a species with very high SAI, the red-legged partridge, with 83 papers published in the study period, showed a very unbalanced distribution of studies, with an overabundance of papers on Physiology/Toxicology/Parasitology, and no papers on Movements, Census or Diet (fig. 2). A species with a medium to low SAI, such as Dupont's lark, with 20 papers, showed however a relatively more balanced distribution of studies, only lacking in Movements, Diet and Niche/Climate areas (fig. 2). In contrast, the corn bunting *Emberiza calandra*, a poorly studied species, had only five papers in the study period, all of them focused on Habitat Selection (fig. 2).

No difference was found in the SAI between preferred habitat categories (Kruskal-Wallis test: H = 3.58; p = 0.167).

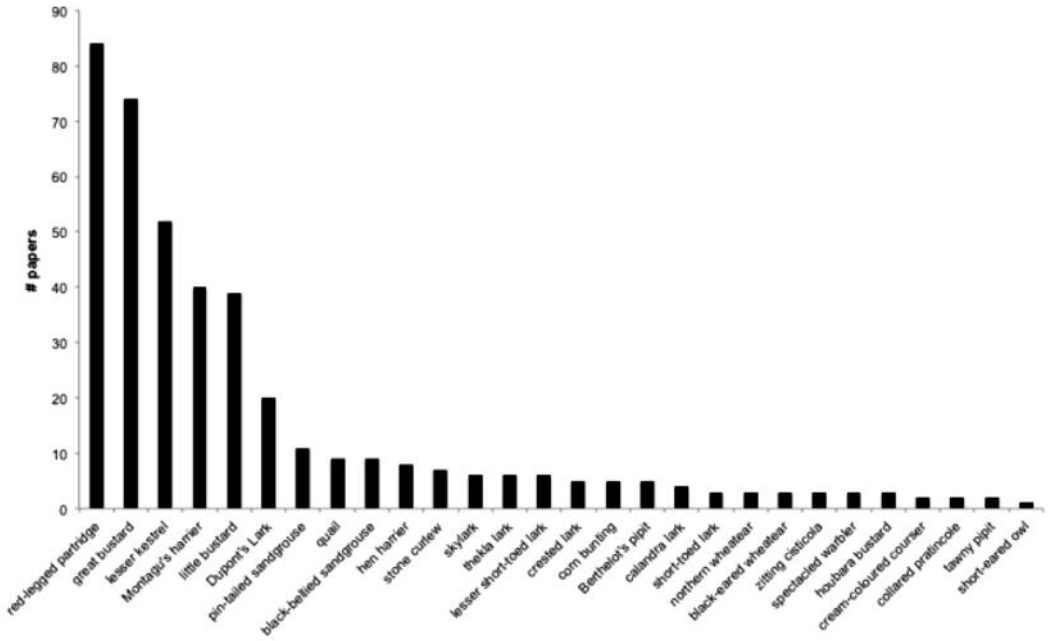

FIG. 1.—Number of papers per studied species published in journals included in Thomson Reuters Web of Science and in *Ardeola* from 1954 to 2014.
[Número de artículos por especie estudiada publicados en revistas incluidas en el portal Thomson Reuters Web of Science y en Ardeola *entre 1954 y 2014.]*

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Non-Passerine species showed a significantly higher SAI than Passerine species (Mann-Whitney U test; $U = 48.00$; $p < 0.05$). Finally, no relationship was found between SAI and VS (Spearman rank test; rho = −0.004; $p = 0.995$) (fig. 3).

Despite the small number of papers published in nearly all regions (Spain, Mediterranean countries and worldwide) for nearly all the species, Spain plays a significant role in scientific research on steppe-birds. Papers containing the term 'Spain' (N = 415) represented 60.5% of the studies carried out in the Mediterranean region (including France, Italy, Portugal, Greece and Morocco, N = 686), which supports the representativeness of our survey for this geographical region. In addition, these papers represent 47.3% of the entire WOS content (N = 878), which indicates that our sample encompasses a very sizable proportion of the studies carried out worldwide. For some species 100% of the Mediterranean studies, and nearly all the studies worldwide, have been carried out in Spain. Such is the case of the pin-tailed sandgrouse *Pterocles alchata*, the lesser short-toed lark *Calandrella rufescens*, and the spectacled warbler *Sylvia conspicillata*. However, there are some species largely investigated outside Spain.

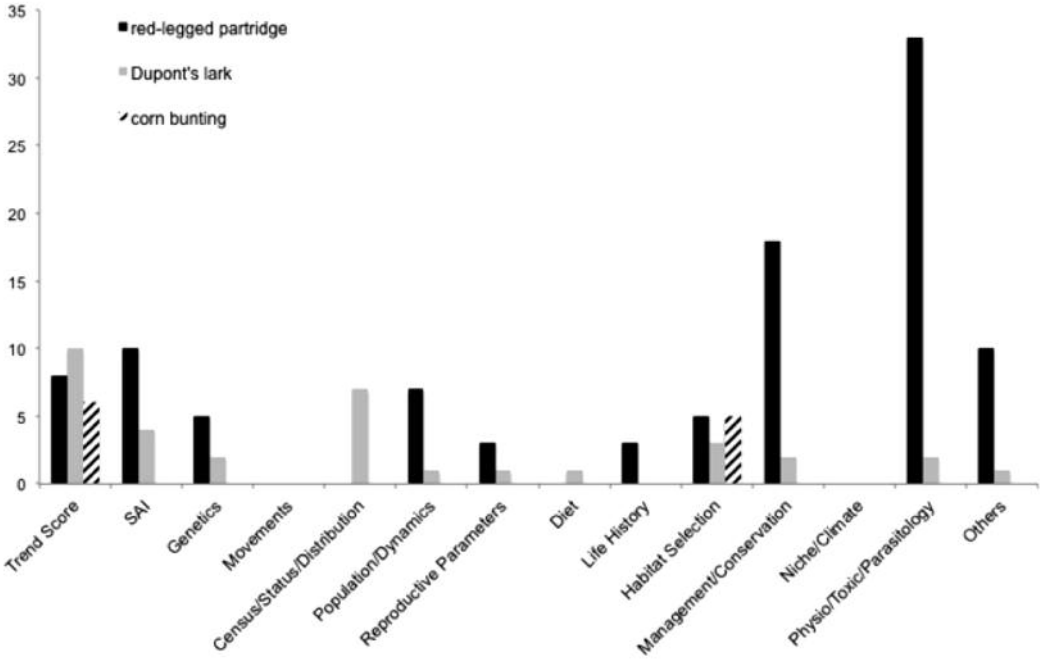

FIG. 2.—Vulnerability Score (VS), Scientific Attention Index (SAI) and number of papers published in the different knowledge areas analysed in this study for three species with very different SAIs: the red-legged partridge (from mixed habitats); Dupont's lark (from shrub-steppe habitats) and the corn bunting (from grass-steppe habitats).
[Puntuación de Vulnerabilidad (PV), Índice de Atención Científica (IAC) y número de artículos publicados en las distintas áreas de conocimiento consideradas para tres especies de aves esteparias con muy diferente IAC: la perdiz roja (especie de hábitats mixtos); la alondra ricotí (especie de estepa de matorral) y el triguero (especie de estepas herbáceas).]

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Within this group, studies containing 'Spain' are absolutely or relatively majoritarian in the world context for the great bustard, (N = 74 vs 104, 71.2%), the red-legged partridge (N = 84 vs 176, 47.7%), the little bustard (N = 39 vs 82, 47.6%), Montagu's harrier (N = 40 vs 108, 37.0%) and the lesser kestrel (N = 52 vs 157, 33.1%), while the role of Spain is minor for the quail *Coturnix coturnix* (N = 9 vs 309, 2.9%), the skylark (N = 6 vs 214, 2.8%), the northern wheatear *Oenanthe oenanthe* (N = 3 vs 110, 2.7%) and the short-eared owl (N = 1 vs 76, 1.3%).

Discussion

This paper presents updated information on the level of scientific attention given to steppe birds in Spain and other Mediterranean countries in the last 50 years. Nevertheless, since our survey was not intended to be an absolute account of published studies, results should be interpreted in relative and comparative terms. Results show that most steppe bird species and areas of knowledge considered have received a generally low level of scientific attention. For instance, 82% of the species reached a SAI value smaller than 6, which is the median value of this score (table 1). Therefore, our results highlight the need to allocate more scientific effort to most species of the group, particularly to those in which a low SAI score coincides with a high VS value denoting a declining population status (fig. 3). Our results also show that a significant proportion of the scientific research devoted to steppe

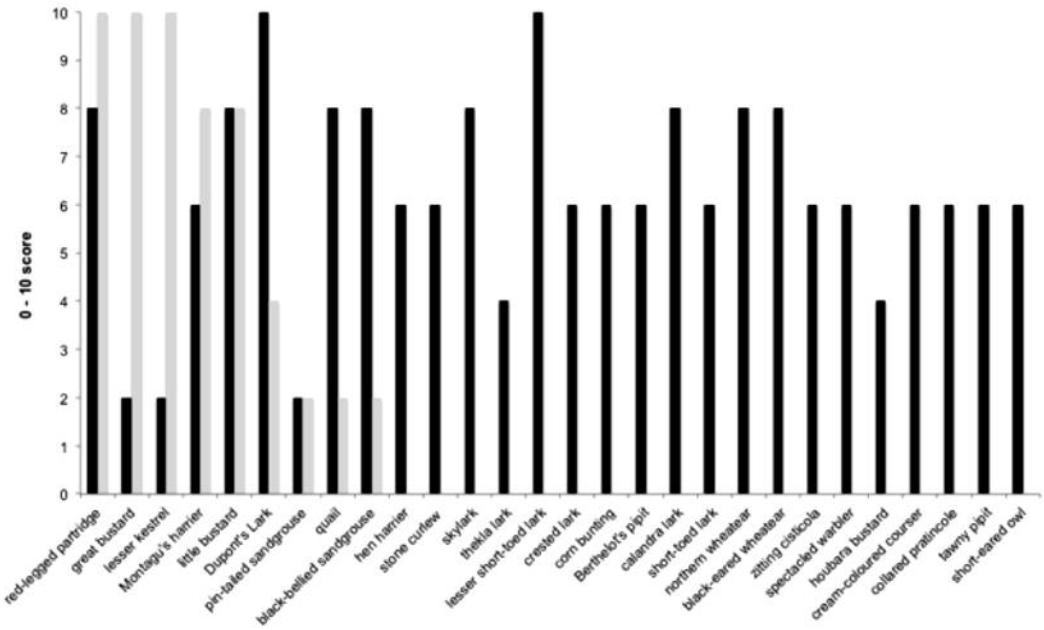

FIG. 3.—Vulnerability (black bars) and Scientific Attention Index (grey bars) scores for the whole set of steppe birds included in the study.
[Puntuación de Vulnerabilidad (barras negras) e Índice de Atención Científica (barras grises) para el conjunto de las especies de aves esteparias consideradas en este estudio.]

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birds both in the Mediterranean context and worldwide has been carried out in Spain (almost two-thirds and over a third, respectively). This indicates that attention paid to steppe birds in other countries is rather small, highlighting the important contribution of Spanish research to knowledge of this group. Nevertheless, it should be recalled that for several species research outside Spain is quite notable and, in some instances, clearly majoritarian (see Results).

Scientific attention is unevenly distributed between knowledge areas. Such bias may be due to the relatively simple and affordable methodologies of studies that do not require experimental manipulation of individuals and/or environmental conditions, as is the case for many Habitat Selection and Management/Conservation works, which together total nearly 35% of all studies (table 2). Globally, few studies have focused on evolutionary aspects such as life history traits, diet or reproductive parameters, highlighting the need for more research effort in these areas, particularly in those species with the highest biases. These traits, along with other basic biological aspects (Population Dynamics, Movements and Reproductive Parameters) are critical to evaluating the response of species to environmental changes (Tellería, 2012). Our results also highlight the need to intensify research in those areas most directly related to global change processes, such as Niche/Climate and Habitat Selection, particularly in the least-studied species. In this context, steppe and farmland birds are being negatively affected by land-use transformation, agricultural intensification and climate change (Donald *et al*., 2001; Suárez, 2004; Morales *et al*., 2013; Princé *et al*., 2015), and therefore basic knowledge on species' habitat selection and climatic envelopes is key to adequately forecasting their behaviour in the face of future habitat and climate changes (see, for example, Princé *et al*., 2015).

In the Iberian Peninsula, the so-called pseudo-steppes (Suárez *et al*., 1997) or grass-steppes (Traba *et al*., 2013) correspond to the traditional agricultural mosaic system, dominated by grassy crops that occupies a vast geographical expanse and is currently undergoing profound transformations due to agricultural intensification and CAP directives (landscape simplification, increased use of ploughing and chemicals, irrigation and use of water-demanding crops among others; Suárez *et al*., 2004; Morales *et al*., 2013). However, steppe birds that are more clearly dependent on this type of habitat do not seem to have attracted, as a whole, more scientific attention than those tied to other types of steppe landscapes, even despite including some of the more 'emblematic' species of the entire steppe bird group, such as the great bustard or Montagu's harrier. This result stresses the need to focus research on scarcely-considered species regardless of their habitat preferences. In this context, it is worth mentioning that although many studies have shown the above-mentioned transformations of cultivated systems, none has attended at all to the drastic changes occurring at all levels in shrub-steppes and mixed landscapes (ploughing, reforestation, transformation to tree orchards, grazing abandonment; Santos and Suárez, 2005), despite the worryingly negative trends of several of their most representative bird species, such as Dupont's lark (Garza and Traba, 2016).

Conservation-oriented studies are frequently centred on emblematic or *flagship* species that can catch the public's interest (Simberloff, 1998) and thus attract more research funds. Flagship species are usually large-bodied vertebrates that should ideally function also as umbrella species, so that their habitat's protection is expected to ensure the conservation of coexisting organisms (Simberloff, 1998). Among birds, raptors are frequently treated as flagship species due to their appeal to the public and ecological role

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as top predators (Sergio *et al*., 2006). In the particular case of steppe birds, larger species and/or diurnal raptors such as bustards, harriers and lesser kestrels seem to have traditionally attracted most scientific, as well as popular, attention (see, for example, Jiménez, 2015). Our results indeed corroborate this trend, as non-Passerine species had a significantly higher SAI than Passerines, irrespective of their Vulnerability Score. The great bustard represents a paradigmatic case of that trend. The largest and second most-studied species, the great bustard is a highly charismatic bird that may well be considered a relict of the ancient steppe megafauna (Jiménez, 2015) and it has frequently been treated as the flagship of Iberian (and Eurasian) steppe conservation. It is worth mentioning, nevertheless, that the only nocturnal raptor considered in this work, the sparsely distributed short-eared owl, was the least studied species of all.

However, not all non-passerine steppe birds owe their comparatively high levels of scientific attention to their role as flagship or umbrella species. Such is the case of the Red-legged partridge which has been intensively studied due to its high socio-economical interest as the main small-game species in Spain and other western Mediterranean countries (Casinello, 2013). An additional factor that may have favoured this size-biased distribution of scientific attention has to do with the logistic advantages of studying large birds, which are more easily detected, censused and probably also captured, than passerines. Large species also present smaller limitations to the use of some particularly powerful research tools such as tagging and radio-tracking. In any case, and regardless of the reasons for this bias, steppe passerines globally present an important research deficit that needs to be addressed given the alarming declines of many species.

The lack of significant correlation between the species' scientific attention index and vulnerability score indicates that the allocation of research effort has occurred irrespective of the species' population trends, that is, neither the more clearly declining nor the positively increasing species have been prioritised in research. This may be partly due to the fact that general trends have only been elucidated in recent years by the establishment of national or regional scale monitoring programmes like Sacre, Noctua or SOCC (the common breeding bird monitoring programme in Catalonia). Nevertheless, comparing SAI and VS of each species allows the identification of those that are both understudied and in decline, and thus more urgently require conservation-oriented research attention. According to our results (fig. 3), that is clearly the case of several small (passerine) steppe birds whose vulnerability score indicates decline (values higher than 6) while their scientific attention indices score 0, which occurs for all passerines except for Dupont's lark. Those species are the skylark, the calandra lark *Melanocorypha calandra*, the lesser short-toed lark, the northern wheatear and the black-eared wheatear *Oenanthe hispanica*. Regarding Dupont's lark, although this species is relatively well studied compared to other steppe passerines, it is rapidly declining and filling some of the existing gaps in our knowledge (e.g. movements, demography, spatial dynamics) may be critical to halting this trend (Suárez, 2010; Garza and Traba, 2016). This is reflected in the marked difference between Dupont's Lark scores shown in figure 3. In addition, some non-passerine species are also clearly understudied while showing a high vulnerability score. Such is the case of the quail and the black-bellied sandgrouse *Pterocles orientalis*. Therefore, these latter species should also be prioritised in research, while those whose populations show stability but are still scarcely investigated (eleven species in total, see table 1 and fig. 3) should not be neglected given the rapid changes that steppe habitats are currently undergoing.

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In summary, the results of our survey reveal that most steppe birds are still poorly known in spite of their overall high vulnerability. The total number of papers found in our search was relatively low (415 papers). Except for a small number of species (red-legged partridge, great and little bustard *Tetrax tetrax*, lesser kestrel and Montagu's harrier), each with over 30 articles published, most Spanish steppe birds have received extremely low scientific attention, with fewer than five papers per species on average. In this context, it is worth noting that some of the most intensively studied ones in fact show increasing population trends and have SAI values well above their vulnerability score. The great bustard is a good example, and its role as the cereal steppe flagship species may have favoured this outcome. However, other Iberian steppe birds decline where their habitats deteriorate due to land-use change and agricultural intensification and many may begin to decrease if habitat conditions worsen. Knowledge of their basic biology and ecology is largely lacking and will be urgently required if measures to reverse or avoid their decline are to be successfully applied. Consequently, a rethinking of funding and publishing strategies, both by institutions and scientific journals, to put the spotlight on little-studied species is needed.

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SUPPLEMENTARY ELECTRONIC MATERIAL

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Table S1: List of species analysed in this study, with the number of papers published by knowledge area.

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