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Status and recent trends of the great bustard (*Otis tarda*) population in the Iberian peninsula

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Abstract

We present an updated estimate of the great bustard population in the Iberian peninsula. The sum of the most recent counts was 20,243, and the estimated total, 24,490 birds. During the last two decades bustards increased at five intensive study areas, remained stable at two, and declined or became extinct at eight. These population changes were determined by both variations in breeding success at each area and migration of birds between areas. Our results suggest that the population is probably concentrating at high quality areas, and disappearing from poor quality ones. We also identified 29 areas where bustards have become extinct during the last four decades, mostly due to hunting and agricultural transformations. In conclusion, although the population is apparently not decreasing at present, the concentration trend described could lead to a higher species' vulnerability, a loss of genetic diversity, and a further isolation of marginal groups. Strict conservation measures should thus be directed at preventing the decrease of the number of extant leks.

Keywords: Great bustard; *Otis tarda*; Status; Spain; Portugal

1. Introduction

The great bustard (*Otis tarda*) is a globally threatened species, classified as vulnerable under current IUCN conservation criteria (Collar et al., 1994; Heredia et al., 1996; BirdLife International, 2000). During the last two centuries its Palaearctic distribution range has decreased due to habitat changes caused mainly by agricultural transformations and human infrastructures, but also by hunting pressure (Glutz et al., 1973; Collar, 1985; del Hoyo et al., 1996; Chan and Goroshko, 1998; BirdLife International, 2001). Particularly during the last decades, many central European populations of the species have declined to extinction or are today severely endangered (Heredia et al., 1996; BirdLife International, 2000).

The greatest part of the world's population (> 50%) is found at present in the Iberian peninsula (Hidalgo, 1990; Tucker and Heath, 1994; Heredia et al., 1996; del Hoyo et al., 1996). However, the first detailed account of the species' numbers and distribution in Spain was published only five years ago, obtaining a total of ca. 17,000–19,000 birds and concluding that all figures published before had underestimated the size of the Spanish population (Alonso and Alonso, 1996). Based on this study, recent ornithological reviews increased world estimates from 25,640–30,480 (SEO-BirdLife, 1997) to 31,000–37,000 birds (del Hoyo et al., 1996; BirdLife International, 2000). Alonso and Alonso (1996) suggested that the Spanish population had probably declined due to high hunting pressure during the decades immediately before the species' legal protection in 1980, and later remained apparently stable at a national scale, although still showing a decreasing trend in some marginal areas. Other authors have published that Spanish and Portuguese populations are still decreasing at present (P. Goriup, in Tucker and Heath, 1994; Pinto, 1998). The most recent review proposes that numbers have decreased by 20–50% between 1970 and 1990 in both countries, and that the species' range has decreased in Spain but remained stable in Portugal (Heath et al., 2000). However, most of these population trend estimates are only guesses not supported by trustworthy series of censuses, and thus should not be considered reliable.

Although the last estimate of the Spanish population was published in 1996, many of the counts on which it

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was based were carried out up to two decades ago. During recent years many new counts have been carried out in different regions of Spain and Portugal, which have substantially improved our knowledge of the species' status and trends in Iberia (Diputación General de Aragón, 1997; ETI, 1998; Onrubia et al., 1998, 2000; Rocha, 1999; Junta de Andalucía, 2001; Rufino and Neves, 2000; own unpublished data; see other references in Table 1). In the present paper we evaluate the current status of great bustards in the Iberian peninsula, and for the first time

Table 1
Summary of most recent spring counts of great bustards in Spain and Portugal

Region	Province	No.of birds counted	Year of census	References	Current estimated no.of birds
Andalucía		289	1994–2002		380
	Cádiz	4	1999	Own unpublished data; Viada, 1998; Junta de Andalucía, 2001	10
	Córdoba	126	2002	Own unpublished data; Junta de Andalucía, unpublished data	140
	Huelva	14	2000–2002	Junta de Andalucía, 2001, and unpublished data; Barroso and Parra, 1994; Garrido, 1996	60
	Jaén	26	2002	Own unpublished data; Junta de Andalucía, unpublished data	30
	Sevilla	119	2001–2002	Own unpublished data; Junta de Andalucía, unpublished data	140
Aragón		95	1997–99		115
	Huesca	3	1995	Diputación General de Aragón, 1997	5
	Teruel	8	2001	Own unpublished data; A.Torrijo, personal communication	10
	Zaragoza	84	2001	Diputación General de Aragón, 2001; Own unpublished data; A. Torrijo, personal communication	110
Castilla-La Mancha		3309	1994–2001		3725
	Albacete	475	1994	Palacín et al., 1996	625
	Ciudad Real	349	2000, 2001	Suárez et al., 2000; Gosalvez et al., 2002	350
	Cuenca	225	1994	Palacín et al., 1996; Martín, 1987	400
	Guadalajara	448	1999–2001	Own unpublished data	450
	Toledo	1812	1994, 1999	Palacín et al., 1996; own unpublished data	1900
Castilla y León		10,117	1998–2000	ETI, 1998; Martínez, 1999	10,680
	Avila	586	1998	ETI, 1998	590
	Burgos	148	1998	ETI, 1998, Román et al., 1996	207
	León	994	1998	ETI, 1998	1000
	Palencia	1237	1998	ETI, 1998	1390
	Salamanca	817	1998	ETI, 1998; Aguilera, 1992	930
	Segovia	12	1998	ETI, 1998; Remacha, 2001	60
	Soria	3	2000	Own unpublished data	3
	Valladolid	2544	1998	ETI, 1998	2600
	Zamora	3776	1998	ETI, 1998; own unpublished data	3900
Extremadura		4135	1988, 1993		6900
	Badajoz	2160	1988, 1993	Sánchez et al., 1989, 1994, 1996	3950
	Cáceres	1975	1988, 1993	Sánchez et al., 1989, 1994, 1996	2950
Madrid	Madrid	1094	2002	Own unpublished data	1200
Murcia		8	1992	Martínez, et al., 1996	15
Navarra	Navarra	25	2001	Gobierno de Navarra, 2001	40
Total Spain		19,072			23,055
Beja		945	1996, 2001	Rocha, 1999; and personal communication; Rufino and Neves, 2000	1035
Portalegre		185	1996	Grimmet and Jones, 1989; Rufino and Neves, 2000	320
Evora		30	1996		50
Castelo-Branco		11	1996		30
Total Portugal		1171			1435
Total Iberian peninsula		20,243			24,490

draw a detailed distribution map based on precise locations of individual flocks in spring, except in Portugal, where such information was not available. We also discuss recent population trends, based on the most reliable series of counts available for several Spanish areas. These results will be fundamental to review the IUCN conservation categories of threatened species and to establish appropriate conservation measures (SEO-BirdLife, in press).

2. Methods

2.1. Numbers and distribution

We compiled all published and unpublished great bustard counts in Spain and Portugal, considering whether they were carried out following rigorous census guidelines (see Alonso et al., 1990). In most areas reliable counts were carried out between mid March and early April, when great bustards gather at their mating areas and thus are easier to count (see Alonso et al., 2000, 2001; Morales et al., 2000). Each census team consisted of two observers with experience in counting bustards and knowledge of the area to be surveyed. They drove four-wheel-drive vehicles slowly through most available tracks, trying to count all birds and to avoid duplicated counts. Each census was done from dawn to dusk, with a midday pause, when birds often sit down and are more difficult to see. Birds were sexed and aged and located on field maps.

We plotted all flocks from the different censuses on a digital map (Centro Geográfico del Ejército, 1999), and drew a distribution map joining locations from neighbouring flocks to build patches of areas used by bustards during the display season (early spring) (see Fig. 1). In Portugal, areas were drawn using the limits of the Important Bird Areas except in Beja district, where we used the limits given by the survey authors. After summing up all local counts to obtain provincial subtotals, we estimated the number of birds for each province. Estimates usually corrected the counts upwards where the observers themselves admitted they had underestimated the populations, or where the number of females counted was <1.6 times the number of males, which is the minimum bias in sex-ratio observed in Iberia (Alonso and Alonso, 1990).

Productivity was determined during censuses carried out in September. It was defined as the number of chicks surviving up to September from those hatched in spring, divided by the number of females older than 1 year.

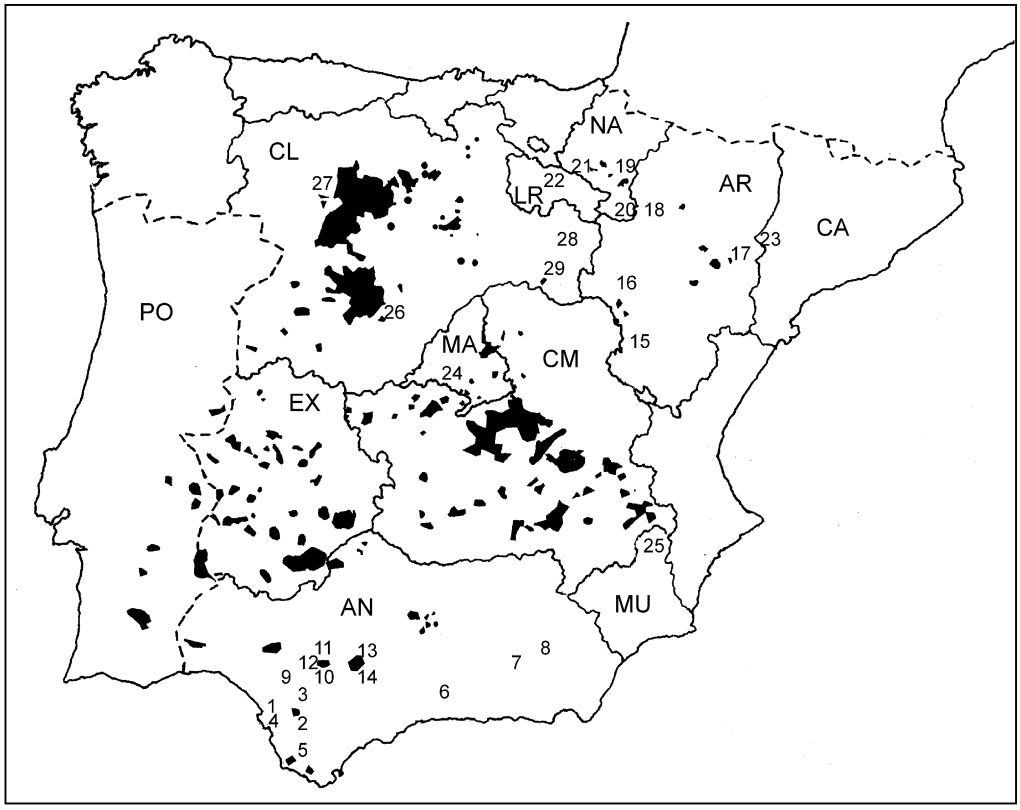

Fig. 1. Map showing the present distribution (in black) of great bustards in the Iberian peninsula. Dashed lines represent national borders (PO = Portugal), and continuous lines the limits between Spanish autonomous regions: CL = Castilla y León, LR = La Rioja, NA = Navarra, AR = Aragón, CA = Cataluña, MA = Madrid, CM = Castilla-La Mancha, EX = Extremadura, AN = Andalucía, MU = Murcia. The numbers show the location of areas where great bustards have become extinct during recent decades in Spain (see Tables 1 and 2 for further details and references).

2.2. Population trend

To establish demographic trends we selected all populations that had been surveyed through the last two decades, generally by the same observers, and in all cases using identical and rigorous methodology and following approximately the same itineraries in all years. As a further precautionary measure, at those areas where longer series of years were available (Llanos de Cáceres, Villafáfila, León, Madrid) we ignored the counts made during the first 2–3 years, assuming these were training years during which observers had not yet acquired enough knowledge of their study areas. Additionally, we listed all areas where local populations had become extinct during the last few decades, according to reliable information, either published or obtained through interviews with guards, hunters and farmers.

3. Results

3.1. Population estimate and distribution

Table 1 summarizes the results of the most recent great bustard counts available for Spain and Portugal. The Spanish region with the highest numbers of birds is Castilla y León, with 53% of the birds censused in the country, and the largest continuous population of the species (see Fig. 1). Extremadura holds 22% of the Spanish bustards, distributed in several small to medium-sized patches, and Castilla-La Mancha has 17%, with more than half of these birds in a continuous population in Toledo province. Madrid region, in spite of its small size, holds 6% of the Iberian total. The regions Navarra, Aragón and Andalucía hold much smaller and more fragmented breeding populations. Portuguese bustards are distributed in eight breeding areas and represent only 6% of the total censused in the Iberian peninsula. The species is absent in northern Spain, the Portuguese Atlantic provinces and the Spanish Mediterranean provinces.

3.2. Demographic trends

Fig. 2 shows the recent trends for 15 great bustard areas for which reliable information was available. The series of counts at five areas showed slight to moderate increases (Villafáfila, Moraña, León, northeastern Madrid, and Campo Real in southeastern Madrid), with relative stability at two areas (Llanos de Cáceres, Navarra), and a clear tendency to decline in all other areas, with recent extinctions at Navalcarnero and Cinco Villas (Fig. 2b). In Table 2 we have listed all other extinctions that have occurred during the last four decades and for which we have found references, either published or reported by local people, together with the presumed cause of extinction and the decade when they became extinct.

4. Discussion

4.1. Evaluation of local counts

This study represents the first complete and reliable estimate of the great bustard population in the Iberian peninsula. In contrast to our previous account, which was partly based on extrapolated estimates for several regions (Alonso and Alonso, 1996), all data used here are counts, most of them from very recent years (76% of the birds counted in 1998–2001). All surveys were carried out by observers with experience in censusing bustards, knowledge of their study areas, and rigorous methodology. With few exceptions, numbers are based on meticulous addition of individual flocks located during the censuses, which provide the first precise distribution map of the species in Iberia.

Castilla y León, in northwestern Spain, with a total of 10,680 great bustards, contains > 40% of the total estimated for the Iberian peninsula. It is also the region containing the largest expanse of breeding habitat without discontinuities (Fig. 1), and some of the highest breeding densities in Iberia (e.g. > 2000 birds in 330 km^2 in Villafáfila Reserve, Alonso J.C. et al., 1995, 1996). During a regional census in 1998 which covered most of the potential bustard habitat, 10,071 birds were counted (ETI, 1998).

In Castilla-La Mancha, central Spain, a recent survey covered most bustard areas in the region, obtaining a total of 2807 birds (Palacín et al., 1996). Adding our own counts at some areas not visited during that survey we obtained a new total of 3160, and estimated a minimum of 3675 bustards for this region.

Extremadura, in southwest Spain, is currently the region with the least accurate data. Several counts have been carried out in winter and spring between 1985 and 2002 (Sánchez et al., 1989, 1994, 1996; Grupo de Investigación en Conservación, 2002). However, none of the spring counts, which yielded totals of 2300–3528 birds, are completely reliable since they were done in late March–early April, when many females have already copulated at the male display areas and dispersed to their nesting sites, frequently outside the limits of the zones surveyed. In addition, not all areas were surveyed in all years, and thus we used figures from the best counts, in 1988 and 1993, to obtain a spring minimum of 4135 bustards for the region (Table 1). Nevertheless, since winter counts gave much higher numbers for this region (5720–7201 bustards) than spring counts, and it is rather unlikely that half the bustards counted in winter abandon Extremadura to breed somewhere else (based on our recent results of a radiotracking study of adult migration, own unpublished data), we conclude that the spring counts in this region largely underestimated the real population (see also discussions in Alonso and Alonso, 1996; Sánchez et al., 1996). Various

people participating in the surveys and working in the regional Department for Environmental Conservation supported our conclusion (A. Sánchez, A. Fernández, personal communication). Thus we provisionally propose 6900 bustards as a reasonable estimate for Extremadura.

Madrid province, in central Spain, is the fourth region by number of birds, with 1100–1200 bustards regularly censused during the last 5 years (Martín et al., 1999; Martín, 2001). As for the smaller numbers in the remaining Spanish regions, our estimates are quite close to actual counts in recent years.

In Portugal, the largest population is found in Castro Verde, Beja district, where 830 birds were counted in March 2001, of them 353 males (Rocha, personal communication). Adding 115 bustards counted at other areas gives a total for this district of 945. For the remaining areas of Portugal, the most recent counts give 226 bustards (Rufino and Neves, 2000), but considering maximum numbers counted at each area either in 1989 (Grimmet and Jones, 1989) or 1996 (Rufino and Neves, 2000), total numbers for these areas may be at least 400 birds. Our estimate of 1435 great bustards for Portugal agrees with Rocha's (1999) assertion that great bustards at Castro Verde represent ca. 60% of all Portuguese birds. In any case, earlier estimates of the Portuguese population were obviously wrong (500–700 great bustards

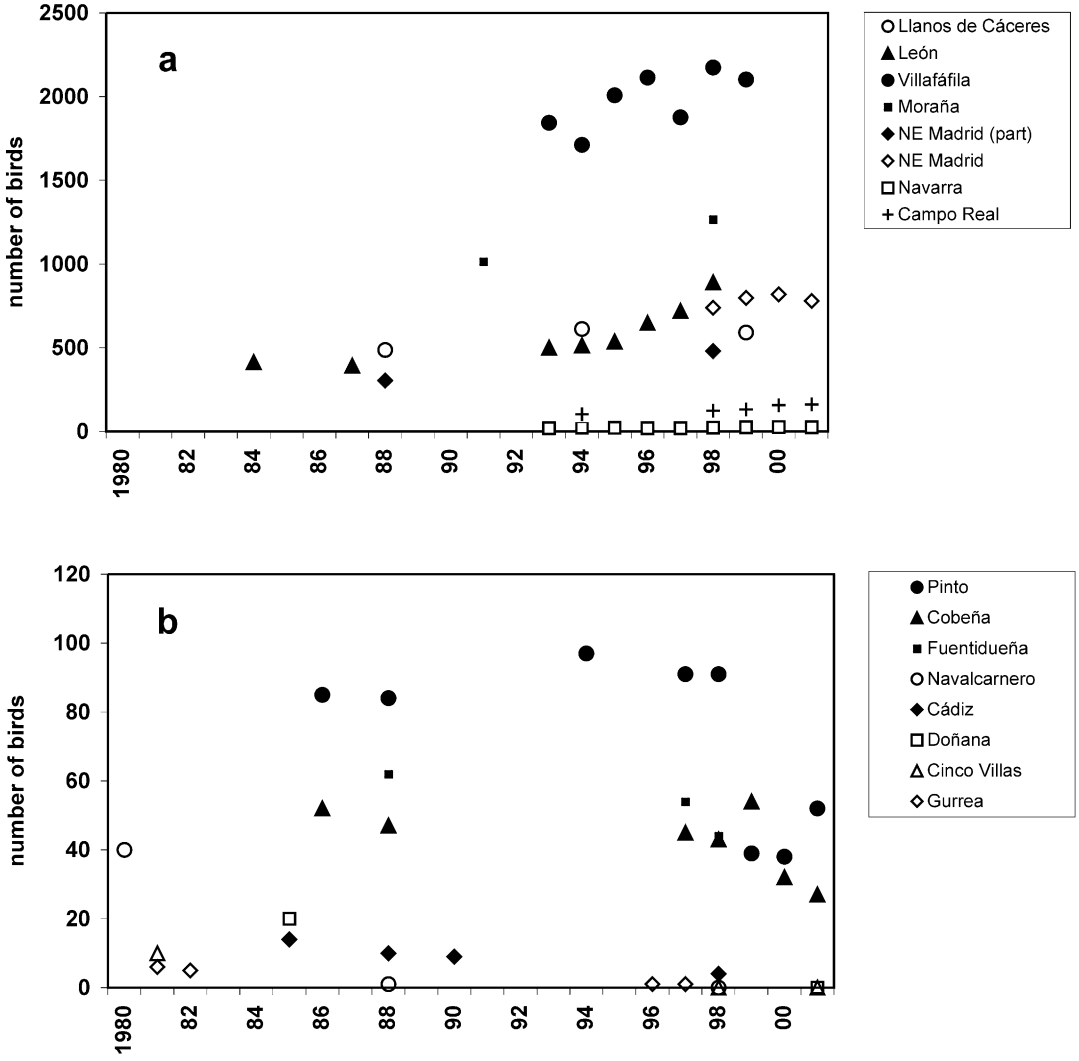

Fig. 2. Changes during the last two decades (1980–2000) in numbers of birds counted at all great bustard areas for which reliable information was available: (a) areas where populations increased or remained stable, and (b) areas where numbers decreased. In northeast Madrid, comparison between 1988 and 1998 was possible for only part of the area. Data from Hellmich, 1990, 1994; and SEO-BirdLife, personal communication (Llanos de Cáceres, Cáceres); Lucio and Purroy, 1990; ETI, 1998; and P. Purroy et al., personal communication (León); Alonso et al., 1996; and own unpublished data (Villafáfila, Zamora); Martín and Martín, 1989, 1994; ETI, 1998 (La Moraña, Ávila-Salamanca); own unpubl. data (northeast Madrid); Onrubia et al., 1998, 2000; Gobierno de Navarra, 2000 (Navarra); own unpublished data (Campo Real, Madrid); own unpublished data (Pinto, Madrid); own unpublished data (Cobeña, Madrid); own unpublished data (Fuentidueña, Madrid); Domínguez and Vigal, 1982; own unpublished data (Navalcarnero, Madrid); Junta de Andalucía, personal communication (Cádiz), Valverde, 1960; García et al., 1987 (Doñana, Huelva), Sampietro, 1998 (Cinco Villas, Zaragoza), Cabrera et al., 1987; Diputación General de Aragón, 1997 (Gurrea, Huesca).

Table 2
Areas where great bustards have become extinct during recent decades in Spain (Reference numbers as in Fig. 1)

Region Province	Ref. no.	Area	No. birds/status[a]	Year of estimate	Decade of extinction	Cause of extinction	References
Andalucía							
Cádiz	1	Jerez, Trebujena	60	1950	1970–1980	Agricultural transformations, hunting	Valverde, 1960; Parody, 1987
	2	San José del Valle	14	1960	1970–1980	Agricultural transformations, hunting	Parody, 1987
	3	Arcos de la Frontera	200	1960	1970–1980	Agricultural transformations, hunting	Parody, 1987
	4	Costa Noroeste	70	1960	1970–1980	Agricultural transformations, hunting	Parody, 1987
	5	Comarca de la Janda	100	1950	1960–1970	Agricultural transformations, hunting	Parody, 1987
Granada	6	El Temple	Breeding	1950	1960–1970	Intensification of agriculture	Pleguezuelos, 1991
	7	Hoya de Guadix	Cited	1972	1970–1980	Unknown	Pleguezuelos, 1991
	8	Hoya de Baza	Breeding	1950	1970–1980	Unknown	Pleguezuelos, 1991
Sevilla	9	Bajo Guadalquivir	Common nesting species	1960	1980–1990	Agricultural transformations	Valverde, 1960; García et al., 2000
	10	Morón de la Frontera	Abundant		1970–1980	Unknown	Palacios et al., 1975
	11	Carmona	5	1989	1990	Unknown	own data
	12	Utrera	20	1965	1970–1980	Hunting	
	13	Ecija	Abundant	1960	1970	Hunting	
	14	Estepa	Cited nesting	1970	1980	Unknown	
Aragón							
Teruel	15	Valle del río Jiloca	Cited nesting		1970–1980	Agricultural transformations, hunting	Lagares, 1988
	16	Campos Romanos	Cited nesting	1950–1970	1970–1980	Agricultural transformations, hunting	Lagares, 1988
Zaragoza	17	Bajo Cinca	Cited nesting	1960–1970			
	18	Cinco Villas	10	1981	1980–1990	Unknown	Sampietro, 1998
Navarra							
	19	Olite	Cited nesting	1972	1981	Hunting	Onrubia et al., 1998
	20	Tudela	Cited nesting	1980	1981	Hunting	Onrubia et al., 1998
	21	Mendavia	Breeding	1979	1981	Hunting	Onrubia et al., 1998
Rioja							
	22	Rioja Alta	12	1975–1980	1980–1990	Unknown	González, 1996
Cataluña							
Lérida	23	Alfarras-Fraga	Cited nesting	1962–1964	1970–1980	Agricultural transformations	Muntaner et al., 1983
Madrid							
Madrid	24	Navalcarnero	40	1980	1980–191990	Poaching?, urban development	own data, Dominguez and Vigal, 1982
Murcia							
	25	Yecla-Jumilla	Cited nesting	1970	1970–1980	Large vineyard plantation	Martínez et al., 1996
Castilla y León							
Avila	26	Centro-Este Moraña				Agricultural transformations	Martín and Martín, 1994
León	27	El Páramo	Common nesting species	1960	1970–1980	Agricultural transformations	Purroy et al., pers. com.
Soria	28	Campo de Gómara	10	1981	1980–1990	Unknown	Ena and Martínez, 1988; own unpubl. data
	29	Campo de Almazán	10	1981	1980–1990	Unknown	Ena and Martínez, 1988; own unpubl. data

[a] Initial estimated population size, or, if numbers not exactly known, status of the species in the area.

in Tucker and Heath, 1994, Heath et al., 2000; ca. 1000 birds in 1988, by M. Pinto, in Hidalgo and Carranza, 1990; BirdLife International, 2000).

4.2. Population trend

In our previous account of the species' status in Spain (Alonso and Alonso, 1996), we suggested that the population was apparently stable at a national scale, with a slight tendency to increase in some particularly well conserved areas, and a simultaneous tendency to decrease in marginal areas. This assumption is now supported by the series of annual counts presented in the current study. We have identified at least five areas where numbers have increased during the last 10–15 years (Fig. 2a). These are the south-eastern part of León province (66% increase between 1995 and 1998), Villafáfila Reserve in Zamora province (15% increase between 1993 and 1999), La Moraña, between the provinces of Ávila and Salamanca (25% increase between 1991 and 1998), the northeastern part of Madrid province (58% increase between 1988 and 1998 at least in part of the area, later numbers apparently stable), and Campo Real, southeast of Madrid (30% increase between 1998 and 2001).

These increases may have been caused either by (a) productivity exceeding mortality, or (b) immigration of birds from other areas. Productivity figures for two of these areas provide some evidence that annual recruitment of juveniles was indeed one of the causes of the increases observed. Fig. 3 shows that numbers of bustards at Villafáfila and Madrid were positively correlated with the breeding success of these populations, respectively, two and three years before. The 2–3 year delay in detecting the effects of productivity is due to juvenile dispersal, which in this species lasts 2–3 years (Alonso J. C. et al., 1995, 1998; Martín, 2001; Martín et al., 2001). Our radiotracking studies showed that most females were highly philopatric, establishing as adults at their natal leks, whereas males tended to settle at other leks, but usually at relatively close distances of their natal sites (<30 km), i.e. within the limits of our study areas. This marked philopatry explains why high productivity at a given area caused local population increases 2–3 years later.

With regard to immigration as a cause of population increase, the only evidence comes from our radiotracking results in Madrid (Alonso et al., unpublished). Dispersing bustards tend to settle as adults at larger, better quality leks, as predicted by conspecific attraction (Reed and Dobson, 1993; Danchin and Wagner, 1997). Both habitat quality and initial numbers of bustards were relatively high at the five study areas where we have recorded population increases in the present study (Fig. 2a). All of them are Important Bird Areas, and two (Villafáfila and northeastern Madrid) are Special Protection Areas for Birds (Viada, 1998). We suggest

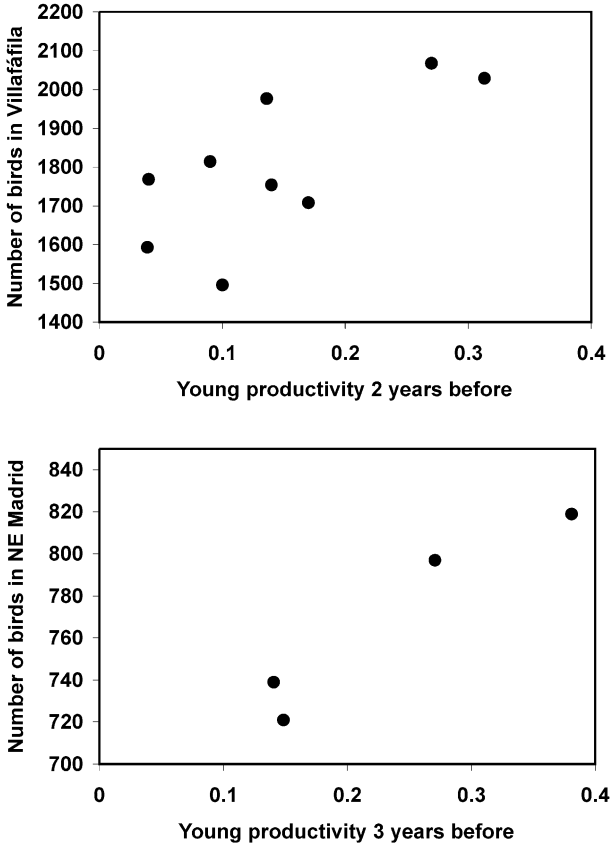

Fig. 3. Correlation between numbers of bustards at Villafáfila and northeast Madrid and the breeding success at these areas, respectively 2 and 3 years before. $r=0.70$, $P=0.036$, for Villafáfila (data from years 1991 to 1999); $r=0.96$, $P=0.038$, for Madrid (years 1998–2001).

that good conservation conditions at these areas may have favoured bustard immigration from neighbouring zones with poorer quality, as observed in our radiotracking study in Madrid. If this is true, the increase observed at these five areas would only be representative of good areas, but not of the overall trend in Iberia.

Although we cannot quantify their relative contributions, our data suggest that both productivity and immigration may have interacted to produce the increases observed in Fig. 2a. In Madrid, population viability models allowing for immigration between 1988 and 1998 (Alonso et al., unpublished) fit better the observed final population sizes of individual leks than models using only reproductive rate. In this area bustard numbers seem to have stabilized after a slight rise in the past decade (see Fig. 2a). In Villafáfila, the 15% increase observed between 1993 and 1999 could have mostly been due to intrinsic annual recruitment within this population, although we do not discard some immigration from neighbouring, less protected areas. For León we lack a series of breeding success values for the last years, but the numbers of first-year birds seen during the spring counts (average for 1993–1998: 0.08 birds per female, range 0.02–0.13, F.J. Purroy et al.,

personal communication) suggest that the steep increase between 1995 and 1998 (66%) would have been unaccountable through local productivity alone. We conclude that immigration must have contributed to the increase observed in this population. The same is true for Campo Real, where the 30% increase in only three years cannot be explained by the relatively low productivities of the previous seasons (annual values of 0.254, 0.034, 0.049 and 0.081 young/female for 1997–2000; all below average productivity for Madrid province, own unpublished data). Indeed, our radiotracking results show that several bustards that hatched at other areas have finally settled as adults at Campo Real. With respect to Moraña, an area with a large population and good feeding conditions, the increase observed may probably be explained by similar causes as in Villafáfila.

At two areas, bustard numbers have been more or less stable during the last few years (Fig. 2a). At Llanos de Cáceres, which has been declared a Special Protection Area for Birds since 1988, numbers could have increased slightly between 1989 and 1995, stabilizing later. Navarra is a small, isolated breeding population in northern Spain that has remained apparently stable for at least the last decade (Onrubia et al., 2000).

Finally, we identified some areas where great bustards have clearly decreased through the last two decades (Fig. 2b), and several more where they have become extinct between 1960 and 1990 (Table 2). All of them are small breeding groups, in most cases isolated from larger populations and at marginal areas of the species' distribution range (Fig. 1). In 1980, when the hunting ban was established, most areas in Fig. 2b were probably already close to the critical size below which demographic recovery is difficult. These areas can be grouped according to the probable causes of population decrease. Cobeña is a clear example of decrease due to the negative influence of human infrastructures: a highway and two powerlines have been built during the last 7 years, and at least five males died after collision with one of the powerlines in 1997. Today the last adult male from a flock of 15 males present a decade ago displays here in spring, and the female population has also decreased by a 25–30%. Other causes of decrease in some of the areas have been direct hunting and poaching of males, either in the past (Navalcarnero and Cádiz) or in recent years (Pinto, own unpublished data with marked birds), or disturbances caused by hunting of other species or by leisure activities (gliding, cross-country vehicles, mountain-bikes, walking). At least in Pinto, we have recorded very low productivity values during the last 4 years, and a progressive deterioration of the bustard habitat. Two young males we radiotagged in this area died from collisions with powerlines. Finally, Fuentidueña and Doñana have probably decreased mainly due to agricultural transformations, combined with high mortality and low productivity due to human interference. Particularly in Doñana, agricultural transformations from cereal fields and pastures into irrigated rice fields seem to have contributed to the extinction of some breeding flocks. As for the areas listed in Table 2, agricultural transformations and hunting are the two main causes determining great bustard extinction there, and most extinctions took place during the last decade when hunting was allowed (1970–1980).

Summarizing, the great bustard population of the Iberian peninsula can be estimated at present around 24,000–25,000 birds, 94% of them in Spain. The new estimate for the species' world population would thus be ca. 41,000–46,000 birds, higher than figures published up to now (14,000–21,000, in Collar, 1985; 28,000, in Collar, 1991; 25,640–30,480 birds in SEO-BirdLife, 1997; 31,000–37,000 birds in BirdLife International, 2000). However, it is still difficult at present to draw a definitive conclusion about the recent trend for the whole Iberian population. A marked decline probably occurred due to high hunting pressure immediately before the ban in 1980, when official hunting bags reached up to 2057 birds annually (Trigo de Yarto, 1971). We suggest that the hunting prohibition had allowed a recovery of most populations, and some of the increases shown in the present study could indeed be part of this recovery process. The overall increase in numbers of birds from the seven areas in Fig. 2a was 31% (from 4201 birds in 1988 to 5519 birds in 1998). In contrast, the overall decrease of the birds at the eight areas in Fig. 2b was 18% for the same period (from 223 birds in 1988 to 182 birds in 1998), and 60% for the last 20 years (from 283 birds in 1981 to 113 in 2001).

In conclusion, based on our analysis of current and past survey results we consider that the Iberian population of great bustards may have slightly increased after the hunting ban during the last two decades. However, some evidence showing alarming decreases and local extinctions at several sites even after hunting prohibition suggests that the population might now be concentrating in some high quality areas and simultaneously disappearing from marginal, lower quality sites.

4.3. Implications for conservation

Two facts merit special attention by conservation authorities. First, if conservation efforts are implemented only at high quality habitats, the tendency for concentration of numbers of birds will be enhanced and contribute to the extinction of the ever-decreasing small and marginal breeding populations. Even if the total number of bustards remains stable, the consequences of this trend could be a higher vulnerability to catastrophic events, a loss of genetic diversity, and a further isolation of small, marginal breeding groups. Therefore, strict habitat conservation measures should be directed at preventing the decrease of the number of extant leks.

Urgent conservation measures are particularly needed in Navarra, Aragón, Andalucía and Madrid, where bustard populations are highly fragmented and isolated from the main breeding nuclei.

Second, although most local extinctions seem to have occurred due to hunting up to 1980, agricultural transformations and other human-induced causes are still affecting many populations. At least in two areas with increase, León and Campo Real, and three areas with decrease, Pinto, Cobeña and Fuentidueña, the most pronounced changes have occurred during the last 5 years. Again, efforts should be directed towards conserving these breeding groups, putting particular emphasis on improving habitat quality.

Finally, we strongly recommend that annual censuses should be continued in the future at least at a sufficient number of selected test areas. These should include both high density areas and marginal or lower quality habitats in order to provide an overall view of the trend for the whole Iberian population. Meantime, great bustards should still remain in the IUCN category of Vulnerable, at least until a new complete census is carried out within the next 5–10 years.

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