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THE GREAT BUSTARD *OTIS TARDA* IN ANDALUSIA, SOUTHERN SPAIN: STATUS, DISTRIBUTION AND TRENDS

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SUMMARY.—*The Great Bustard* Otis tarda *in Andalusia, southern Spain: status, distribution and trends.* **Aims**: Between 2001 and 2004 the first comprehensive census of Great Bustards *Otis tarda* was carried out in Andalusia, southern Spain. This region holds one of the most endangered populations of the Iberian Peninsula. The aims were to establish the locations of current leks and the numbers of birds breeding at them, determine their age and sex structure and reproductive success, and discuss present and past population trends. These data are essential to plan the conservation of this threatened population.
Results and Conclusions: The total estimated number of birds in the region was 338, distributed in 16 leks plus two breeding sites with only females. The species is today extinct in Almería, Granada, and Málaga. The current distribution is highly fragmented, with two main aggregations of three and five leks in the Guadalquivir valley, respectively close to Osuna, in Sevilla province, and at the border between the provinces Córdoba and Jaén. Another group of three leks is located in the northwest border of the region, separated from the rest by Sierra Morena mountain chain. These birds are perhaps demographically more related to the Bustards of Extremadura than to other leks in Andalusia. The Guadalquivir subpopulation is the remnant of a formerly much larger population, which has declined due to the high hunting pressure before the hunting ban in 1980, and to agriculture intensification during the last decades. Great Bustards survive today in suboptimal habitat, but could go through a slow extinction process in the future if habitat conditions are not improved. Man-induced mortality causes have also probably contributed to the extremely female-biased sex-ratio, with an estimated 3.28 females per male, and several leks with only 1-2 males with 4-17 females. Throughout the study period numbers of males and females increased in Osuna, and adult males decreased in Arahal, Gerena and Bujalance. These decreases are not compensated for by the remarkably low productivity (0.08 young per female in September, range of annual values 0.04-0.12). In conclusion, the small numbers of birds, fragmented distribution, extremely biased sex-ratio, high adult male mortality, and low productivity clearly reflect the poor conservation status and serious extinction risk of the Great Bustard population in Andalusia. Conservation efforts should be urgently directed towards improving habitat conditions, in order to increase current productivity values and decrease mortality through collision with powerlines.
Key words: Andalusia, Distribution, Great Bustard, *Otis tarda*.

RESUMEN.—*La Avutarda Común* Otis tarda *en Andalucía: censo, distribución y tendencia de la población.* **Objetivos**: Entre 2001 y 2004 se realizó el primer censo detallado de la población de Avutarda Común *Otis tarda* de Andalucía, una de las más amenazadas de la península Ibérica. Los objetivos fueron determinar la cantidad de individuos reproductores, cartografiar la localización de los leks, establecer la proporción de sexos, la estructura de edades y el éxito reproductivo, y analizar las tendencias demográficas pasadas y actuales, con el fin de disponer de la información básica necesaria para emprender acciones de conservación.
Resultados y Conclusiones: El censo arrojó un total de 338 avutardas estimadas en la región, distribuidas en 16 leks más dos zonas con sólo hembras. Actualmente la especie está extinta en Almería, Granada y Málaga. La distribución es muy fragmentada, con dos agregaciones de tres y cinco leks, la primera cerca de Osuna, en la provincia de Sevilla, y la segunda, en el límite provincial entre Córdoba y Jaén. Una tercera agrupación de tres leks se encuentra en el límite noroccidental de la provincia de Córdoba, separada del resto por la Sierra Morena. Probablemente estas avutardas estén demográficamente más relacionadas con las extremeñas. La subpoblación del valle del Guadalquivir es hoy el resto de una población antaño mucho más numerosa, que ha sido diezmada por la caza antes del establecimiento de la veda total en 1980, así como por la intensificación agrícola en las décadas más recientes. Los grupos reproductores sobreviven en la actualidad en un hábitat subóptimo, de cultivos intensivos, y se verán probablemente abocados a un proceso más o menos rápido de extinción, de no mejorarse las condiciones del hábitat. El incremento de mortalidad motivado por la acción del hombre ha debido ser la causa del extraordinario sesgo observado actualmente en la proporción de sexos, con

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3.28 hembras por macho, y casos extremos de grupos de 1-2 machos con 4-17 hembras. A lo largo del periodo de estudio las cantidades de aves aumentaron en Osuna y las de machos disminuyeron en Arahal, Gerena y Bujalance. Dichos descensos no han sido compensados por la bajísima productividad observada (0.08 pollos por hembra en septiembre, con valores anuales entre 0.04 y 0.12). En conclusión, el pequeño tamaño poblacional, su distribución fragmentada, la proporción de sexos tan sesgada, debida a una elevada mortalidad de machos adultos, y la baja productividad reflejan el deficiente estado de conservación de esta población de avutardas, y predicen su extinción a medio plazo si persisten las condiciones actuales. Los esfuerzos de conservación deben procurar la mejora urgente de la calidad del hábitat, que facilite un aumento de la productividad, así como una disminución de mortalidad por colisión con tendidos.

Palabras clave: Andalucía, Avutarda Común, distribución, *Otis tarda*.

INTRODUCTION

During the last century most populations of Great Bustards, *Otis tarda*, have decreased and today the species is considered to be globally threatened and categorised as vulnerable under current IUCN conservation criteria (Collar *et al*., 1994; BirdLife International, 2000). More than half of the world population is found in the Iberian Peninsula, where a recent review has estimated *ca*. 24000 birds, > 90% of them in Spain (Alonso *et al*., 2003b). In spite of the seemingly large numbers obtained in that review, the species has also been recently considered 'vulnerable' in Spain at a national scale (Palacín *et al*., 2004). Moreover, it was found that marginal populations are much more threatened than the central Iberian ones, since individuals usually occur at small, separated breeding groups of a few tens of birds.

The Andalusia region in southern Spain holds one of these marginal populations, which has been categorised as critically endangered with extinction at a regional scale (Junta de Andalucía, 2001, 2003). Computer simulations predict a very high probability of extinction of this population if no active conservation management measures are implemented (Lane & Alonso, 2001). However, no reliable survey of Great Bustards in the whole region had been carried out up to now. Previous published data are either uncertain estimates or local counts (Trigo de Yarto, 1971; Garzón, 1981; Otero, 1987; Ena & Martínez, 1988, see other references to local counts in Alonso *et al*., 2003b). In this paper the results are presented of the first comprehensive account of Great Bustard numbers, distribution, and productivity in Andalusia, a study carried out during the last four years, comparing them with previous published estimates in this region. The aims were to establish precise lek locations and numbers of birds, determine age and sex structure of the breeding groups, and discuss past and current population trends in order to set up the basis for future monitoring of this endangered population and establishing appropriate conservation actions.

STUDY AREA AND METHODS

Great Bustards occur at present in five of the eight provinces of Andalusia (Fig. 1), in farmland cultivated mainly with wheat and barley, and locally abundant crops of sunflower and olives. Open oak-tree wooded areas with cereal and some pastureland occur in north-western Córdoba and western Huelva. The traditional two-year rotation system has been gradually substituted by intensive cultivation at most areas throughout the last 3-4 decades. Nowadays there is usually a rotation of cereal and sunflower crops at most areas, with very little fallow and pastureland. In some areas irrigation systems have been introduced and are currently increasing. Consequently, the dynamic mosaic of sown, ploughed and stubble fields typical of most bustard areas in other Spanish regions has been lost and now habitat is much more uniform and intensively cultivated.

One complete survey was carried out of all potential habitat in the region, i.e. flat to slightly undulated farmland, including all previously known areas where the species had been cited and those where it was known to have become extinct. The province of Sevilla was first surveyed in 2001, Córdoba and Jaén in 2002, and Huelva, Cádiz, Granada and Málaga in 2003. Almería was not surveyed as the species was considered to be extinct during the second half of last century (Trigo de Yarto, 1971; Pleguezuelos & Manrique, 1987; Hidalgo 1992). The

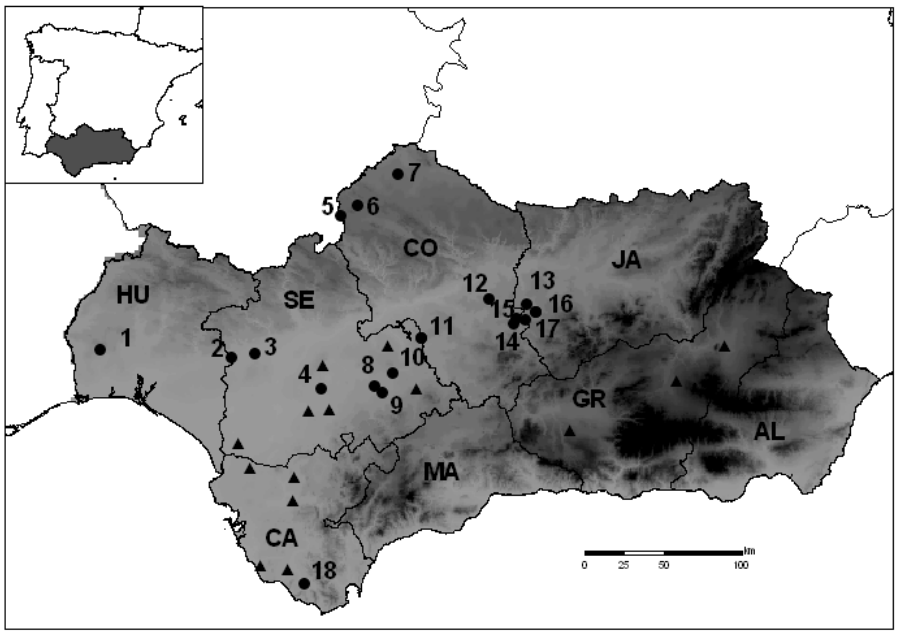

FIG. 1.—Map showing the locations of extant Great Bustard leks (black dots) and 14 extinct leks (triangles; see Alonso *et al*., 2003b for further details on the latter) in Andalusia. The shaded areas are mountains. 1: Villanueva de los Castillejos; 2: Aznalcóllar; 3: Gerena-Olivares; 4: Arahal-Carmona-Paradas; 5: Aldea de Cuenca; 6: Fuente-Obejuna-Los Blázquez-La Granjuela; 7: Belalcázar-Hinojosa del Duque; 8: Osuna B; 9: Osuna A; 10: Osuna C; 11: Santaella; 12: Bujalance; 13: Porcuna; 14: Baena A; 15: Baena B; 16: Torredonjimeno; 17: Santiago de Calatrava; 18: Tahivilla. AL = Almería, CA = Cádiz, CO = Córdoba, GR = Granada, HU = Huelva, JA = Jaén, MA = Málaga, SE = Sevilla.
[Mapa mostrando la localización de los leks actuales (puntos negros) y extintos (triángulos) en Andalucía (para el significado de los símbolos ver arriba).]

total area covered in that first survey exceeded 13,000 km^2, with > 8,500 km done on tracks. In subsequent years the census of all sites where bustards had been recorded during the first year was repeated. All surveys were carried out in March, when both sexes gather at their traditional display sites (*leks*), thus facilitating census work. Four or five teams working simultaneously in the same province carried out the complete surveys in the first year. Each team consisted of two observers with extensive previous experience in censusing Great Bustards, operating from a four-wheel drive vehicle, using binoculars and telescopes 20-60x, GPS and maps 1:50000. Surveys started at dawn and ended at dusk, with a pause during midday (10:00-15:30 h GMT), when bustards lie down and become difficult to see. During one observation period, morning or evening, each team surveyed an area of 40-100 km^2. The census itinerary was covered at low speed, with frequent stops at vantage points to carefully look for birds. Three age-classes of males were distinguished according to criteria recently developed with marked birds (Alonso *et al*., 2005a, see also age classes in Gewalt, 1959): first-year males, those hatched in the previous year; immature males, those aged 2-3 years; and adult males, $\geq$ 4 years. The location of the male flocks in March was considered to be indicative of the lek site at which individual males would later display and copulate. This was confirmed with marked birds at some leks (Osuna A, B and C, Bujalance). Female flocks were assigned to the lek closest to them, assuming no significant movements between March and early April. These assumptions are based on an extensive data set with many marked birds spanning over 15 years at

several study areas in Spain (Alonso *et al*., 2000; *unpubl. data*). The names given to leks were those of the closest towns. All local farmers, shepherds or gamekeepers met during the surveys were systematically interviewed, and the sample completed with more enquiries carried out during the midday pause, when more time was available. They were asked if they knew the Great Bustard, if the species was present nowadays or had been present in the past in the area, and the season of the year when they saw the birds. It was usually easy to evaluate the reliability of their responses through their answers to some key questions about the species` display and breeding behaviour.

Productivity was determined during censuses carried out in September, after the highest juvenile mortality phase in summer, once most non-breeding or unsuccessful females have gathered in small flocks, and the period of elusive behaviour of successful mothers with their chicks is over. Productivity was calculated as the number of young survived to September per female, as described in previous studies on this species (Alonso & Alonso, 1990; Morales *et al*., 2002; Alonso *et al*., 2004). During summer it is very difficult to make complete censuses, as the birds are more dispersed than in spring. Despite this, the sample with which annual productivity was calculated was reasonably high (70-71% of females counted in March) and thus the productivity estimates can be considered to be quite accurate. Since dispersal prevented assigning some of the birds sighted to specific leks when these were close together, at some sites average productivities for breeding areas were calculated rather than for single leks.

Results

The census results are shown in Table 1. A total of 16 leks was found in the provinces of Jaén, Córdoba, Sevilla, Cádiz and Huelva, plus two breeding sites where only females were seen (Santaella in Córdoba, and Torredonjimeno in Jaén). At one of the leks (Tahivilla in Cádiz) we saw only one adult male but no females, although a small group of females is suspected to occur either at 30-40 km north-west of this site (area Chiclana-Medina-Conil, Cádiz) or further north (area Trebujena-El Cuervo-Jerez). In the provinces of Málaga and Granada no breeding Great Bustards were sighted. The distribution of the leks was on the whole highly fragmented, with long distances between them. Most extant breeding groups are found in the Guadalquivir basin, with two main aggregations of three and five leks, respectively close to Osuna in Sevilla province, and at the border between Córdoba and Jaén provinces. Another group of three leks was located in the northwest border of the region, close to Extremadura, separated from those in the Guadalquivir valley by Sierra Morena mountain chain (Fig. 1).

Taking maximum counts for each lek and including young birds, the estimated number of Great Bustards for the whole Andalusia was 338 birds, of which *ca*. 74% belong to the Guadalquivir subpopulation and 26% to the subpopulation in northwestern Córdoba (Table 1). Approximately 30% of all birds were counted in Osuna, the largest breeding aggregation in the region. The sex-ratio was highly female-biased, with annual values of 2.99 and 3.12 females per male, respectively in 2003 and 2004, and several extreme cases of leks with only 1-2 males and 4-17 females (Table 1).

Interannual differences in the counts were small at most leks, and negligible in relation to the total population size in the two years in which the surveys covered the whole region, 2003 and 2004. However, at some leks the results suggested clear trends. Males and females increased in Osuna (leks A and B combined), and adult males decreased in Arahal, Gerena, Bujalance and Villanueva de los Castillejos (Table 1).

The average productivity for the whole region through the study period was 0.08 young survived to September per female (range of annual average values 0.04-0.12, Table 2). Apparently there were consistent local differences in productivity throughout the study period, with areas where values tended to be above average (*e.g*., Osuna, Gerena), and other sites with practically zero productivity in all or most years (*e.g*., Bujalance, Arahal).

Discussion

Numbers and distribution

The number of Great Bustards estimated in Andalusia was 338 birds. This represents 1.4%

of the Great Bustard population estimated for the whole Iberian Peninsula and, together with Aragón in NE Spain, the lowest average regional bustard density per unit of potential habitat in Iberia (Alonso *et al*., 2003b; Alonso *et al*., 2005c). The differences in the counts carried out in different years were generally small, both at the local and at the regional level, supporting the reliability of the census results. The current distribution of the species in the region shows two subpopulations separated by the mountain chain of Sierra Morena, the first along the Guadalquivir river, and the second in the northwest of the region, close to the border with Extremadura.

The Guadalquivir subpopulation is the remnant of a formerly much larger population (Trigo de Yarto, 1971, see below). Today it is highly fragmented due to hunting pressure in the past and to agricultural intensification in recent decades. These two factors have caused at least 14 well documented local extinctions through the last four decades (Alonso *et al*., 2003b, see Fig. 1). Some of these extinctions have occurred in the provinces of Granada and Málaga, where the species used to breed some decades ago (Pleguezuelos, 1991). The potentially negative effect of agriculture intensification in Andalusia was shown in a map of suitable habitat for Great Bustards derived from a model based on satellite data on habitat, topography and human disturbance (Suárez Seoane *et al*., 2002). Most of the current leks of the Guadalquivir basin occur in habitat qualified by that model as unsuitable, surely because the farmland is today intensively cultivated. Great Bustards simply survive nowadays here in suboptimal habitat, but will probably go through a slow extinction process in the future, if habitat continues to be intensive farmland. This basin still holds the largest continuous breeding aggregation of Andalusia, made up of three leks north of Osuna, including the largest one in the whole region, and comprising 30 % of Andalusian Great Bustards. Most other breeding groups in the Guadalquivir subpopulation are much smaller and located at relatively far distances from each other. An extreme case of an isolated group is that found in Cádiz, where a single adult male survives today from a formerly larger flock that was probably decimated by hunters in the past (see below).

The second subpopulation consists of three leks that are close to each other in the northwestern part of Córdoba province. The habitat here is more favourable, with a higher percentage of cereal surface cultivated in the traditional extensive way. Demographically speaking, these birds may be more closely related to the nearby leks in Extremadura, a region holding one of the largest Great Bustard populations in Iberia (Alonso *et al*., 2003b; Alonso *et al*., 2005c). The eastern border of one of the major breeding aggregations in this region, with close to one thousand birds, is practically in contact with the western limit of these Andalusian leks (Corbacho *et al*., 2005).

Population trends and conservation status

The results presented in this paper represent the first reliable census of the Great Bustard population in Andalusia. Previous published data are either estimates or incomplete counts that are not strictly comparable with these results. After an exhaustive review of all published and unpublished reports (Alonso *et al*., 2003b; Alonso *et al*., 2005b), it was found only four that give estimates for all Andalusia. The first guessed more than one thousand birds in the region during the early 1970s, based on information from hunters (Trigo de Yarto, 1971). This estimate was later repeated by Palacios *et al*. (1975).The second was an estimate of 508 Great Bustards made in 1977 by the Spanish Institute for Nature Conservation (ICONA) (Garzón, 1981). The third estimate was 194 birds in 1982, based on a census carried out in whole Spain in 1981-82 (Garzón, 1981; Ena & Martínez, 1988), and the fourth was 300 birds in 1984 (Otero, 1987). The accuracy of these estimates is difficult to assess, but all of them probably underestimated the size of the Great Bustard population in Andalusia. Thorough revisions at well monitored areas showed that in the national survey 1981-82 most populations were underestimated due to poor census coverage, census dates that were too late, and lack of experience of many observers (see Alonso & Alonso, 1996). However, it is believed that the decreasing trend reflected by these estimates is true. This seems also clear from the personal interviews with local people carried out during the complete survey of the

TAB

Spring census results of Great Bustards in Andalusia 2001-2004. Current estimates were calculated including juvenile we considered the last annual count. ad = adults (≥ 4 years), imm = immatures (2-3 years), juv = first-year males). *[Resultados de los censos de Avutardas en Andalucía durante 2001-2004. Las cantidades actuales se estimaron que la tendencia a disminución fue clara, prevaleciendo entonces el censo del último año.]*

Leks	2001					2002			
	♂♂			♀♀	Total	♂♂			♀♀
	ad.	imm.	juv.			ad.	imm.	juv.	
Subpopulation NW Córdoba:									
Fuente Obejuna- Blázquez-Granjuela						13	0		30
Aldea de Cuenca						1	0		4
Belalcázar-Hinojosa del Duque						2	0		11
Subtotal NW Córdoba						***15***	***0***		***45***
Subpopulation Guadalquivir basin:									
Bujalance						11	1	1	19
Baena A						2	0		11
Baena B						2	0		8
Santaella						0	0		6
Total Córdoba province						**31**	**1**	**1**	**89**
Arahal-Carmona-Paradas	4	1		15	20	2	1	1	11
Aznalcóllar	1	0		3	4	1	0		1
Gerena-Olivares	4	2	1	9	16	3	0		5
Osuna A	9	0	1	42	52	10	1	2	40
Osuna B	3	0		4	7	3	0		10
Osuna C	7	0	1	10	18	7	1	1	6
Total Sevilla province	**28**	**3**	**3**	**83**	**117**	**26**	**3**	**4**	**73**
Porcuna						1	0		9
Santiago de Calatrava						2	0		12
Torredonjimeno									
Total Jaén province						**3**	**0**	**0**	**21**
Tahivilla									
Chiclana-Medina-Conil and Trebujena-El Cuervo-Jerez									
Total Cádiz province									
Villanueva de los Castillejos									
Total Huelva province									
Subtotal Guadalquivir basin									
Total Andalusia									

[1] According to very reliable data from interviews with local people, a small group of 4-6 females was observer in 1999 and 2002 at

LE 1

birds and as a rule considering maximum counts at each lek, except where a decreasing trend was clear, in which case

incluyendo los jóvenes, y, como norma, considerando los censos máximos en cada lek, excepto en aquellos leks en los

2003					2004					Current estimates			
Total	♂♂			♀♀	Total	♂♂			♀♀	Total	♂♂	♀♀	Total	Sex-ratio
	ad.	imm.	juv.			ad.	imm.	juv.						
43	9	1		34	44	12	0		39	51	12	39	51	3.25
5	0	0		4	4	0	0		12	12	1	12	13	12.00
13	4	1	2	16	23	5	1	1	16	23	7	16	23	2.29
61	***13***	***2***	***2***	***54***	***71***	***17***	***1***	***1***	***67***	***86***	***20***	***67***	***87***	***3.35***
32	5	0		19	24	4	0		21	25	4	21	25	5.25
13	2	0	1	10	13	2	1	1	7	11	4	10	14	2.50
10	4	0		10	14	3	0		13	16	3	10	13	3.33
6	0	0				0	0		4	4		4	4	
122	**24**	**2**	**3**	**93**	**122**	**26**	**2**	**2**	**112**	**142**	**31**	**112**	**143**	**3.61**
15	1	0		11	12	1	0		17	18	1	17	18	17.00
2	1	0		3	4	1	0		4	5	1	4	5	4.00
8	2	1	1	13	17	1	2	2	11	16	5	11	16	2.20
53	12	0	1	46	59	14	1	1	42	58	16	46	62	2.88
13	5	0		14	19	5	0	1	18	24	6	14	20	2.33
15	6	1		12	19	6	0		9	15	6	12	18	2.00
106	**27**	**2**	**2**	**99**	**130**	**28**	**3**	**4**	**101**	**136**	**35**	**104**	**139**	**2.97**
10	1	0		6	7	1	0		5	6	1	5	6	5.00
14	2	0		1	3	2	0		10	12	2	10	12	5.00
	0	0		6	6	0	0		6	6		6	6	
24	**3**	**0**	**0**	**13**	**16**	**3**	**0**	**0**	**21**	**24**	**3**	**21**	**24**	**7.00**
	1	1		0	2	1	0		0	1	1		1	0.00
				0	0				0	0		6[1]	6[1]	
	1	**1**	**0**	**0**	**2**	1	**0**	**0**	**0**	**1**	**1**	**6[1]**	**7[1]**	**6.00**
	9	0		16	25	6	0			6	9	16	25	1.78
	9	**0**	**0**	**16**	**25**	**6**	**0**	**0**	**0**	**6**	**9**	**16**	**25**	**1.78**
	51	***3***	***3***	***167***	***224***	***47***	***4***	***5***	***167***	***223***	***59***	***192***	***251***	***3.25***
	64	**5**	**5**	**221**	**295**	**64**	**5**	**6**	**234**	**309**	**79**	**259**	**338**	**3.28**

25-35 km NW of the display site of the male; another small group of females could exist north of Jerez (J. A. Cabral, *pers. obs.*).

TABLE 2

Productivity of Great Bustards in Andalusia, as estimated from the September counts. Nearby leks have been grouped into breeding areas to give values based on larger sample sizes, and also because females of neighbour leks sometimes share the same feeding areas in summer. In bold, the resulting averages for larger regional sectors. juv = young birds, prod = juv/females. Average values for Andalusia were calculated dividing the total number of young birds by the total number of females for each year. Mean productivities are interannual means.
[Valores de productividad juvenil de las Avutardas en Andalucía, estimados a partir de censos realizados en septiembre. En el caso de leks muy próximos entre sí, se presentan valores globales para el conjunto de los mismos, y, en negrita, los globales para sectores regionales más amplios. juv = jóvenes del año, prod = n.º jóvenes/n.º hembras. Se presentan los valores medios de los cuatro años de censo, y los valores globales para Andalucía (average values = n.º jóvenes totales en un año/n.º hembras totales en un año).]

Breeding areas	2001			2002			2003			2004			Mean productivities
	♀♀	juv.	prod.	♀♀	juv.	prod.	♀♀	juv.	prod.	♀♀	juv.	prod.	
Arahal-Carmona-Paradas	18	0	0.00	25	0	0.00	17	2	0.12	13	0	0.00	0.03
Gerena-Olivares	11	0	0.00	5	2	0.40	2	2	1.00	11	2	0.18	0.40
Osuna	42	3	0.07	30	5	0.17	31	9	0.29	31	3	0.10	0.16
Total Sevilla province	71	3	**0.04**	60	7	**0.12**	50	13	**0.26**	55	5	**0.09**	**0.13**
Bujalance	9	0	0.00	16	0	0.00	11	0	0.00	1	0	0.00	0.00
Córdoba (Guadalquivir basin)	9	0	**0.00**	16	0	**0.00**	11	0	**0.00**	1	0	**0.00**	**0.00**
Fuente O.-Los Blázquez-La Granjuela + Aldea de Cuenca				25	1	0.04	40	2	0.05	54	3	0.06	0.05
Belalcázar-Hinojosa del Duque							34	1	0.03	27	2	0.07	0.05
Córdoba NW				25	1	**0.04**	74	3	**0.04**	81	5	**0.06**	**0.05**
Torredonjimeno										5	2	0.40	0.40
Zurraque (= Córdoba E + Jaén W) [1]							23	3	0.13	23	0	0.00	0.07
Jaén + Córdoba E							23	3	**0.13**	28	2	**0.07**	**0.10**
Andalusia average values	80	3	**0.04**	95	8	**0.08**	158	19	**0.12**	165	12	**0.07**	**0.08**

[1] This area is used in late summer-autumn by females mating probably at leks in eastern Córdoba (Baena A, Baena B) and Jaén (Porcuna, Santiago de Calatrava) (own data based on a small sample of marked birds).

region 2001-2004, most of which suggest that local populations were larger in the past. Adding to the current population, the numbers estimated only at the 14 sites where extinctions of leks in the last forty years were confirmed (Alonso *et al*., 2003b, see Fig. 1), the estimated total in the 1960s would amount close to the one thousand birds cited in the estimates of the early 1970s. Numbers of Great Bustards probably decreased steeply between 1960 and 1980, just before the hunting ban was established. This is suggested by the higher abundance of local extinctions recorded during that period, as well as by the large hunting bags reported for Spain, with details for some Andalusian sites (46 birds hunted in Sevilla, 19 in Córdoba, 22 in Cádiz 16 in Huelva, 16 in Jaén, 11 in Granada and 5 in Almería only in 1969-70, Trigo de Yarto, 1971). Other particularly reliable data support the decrease at some sites. For example, Valverde (1960) cited Great Bustards as a common nesting species in the plains around the border between Cádiz and Sevilla provinces, with aggregations of up to 200 males during the non-breeding season. García *et al*. (1987) estimated 500 Great Bustards in the 1950s in the Guadalquivir mouth area, and only 15-20 birds in the same area 30 years later. Pleguezuelos (1991) also reports on decreases and local extinctions in the eastern Andalusian provinces. The results reported in the present study suggest that numbers probably continued decreasing at a lower rate at some sites and remained more or less stable at others after 1980, when the direct effect of hunting ceased, but those of agricultural intensification and powerline proliferation continued and even increased.

As for current population trends, with this short series of spring counts it is not possible to reach a conclusion at the regional level. Based on our experience, some of the interannual changes in the counts do not reflect population trends, being attributable to random variation in census results. For example, the increasing trend suggested by the numbers of birds counted at Belalcázar-Hinojosa del Duque was probably because this lek was discovered in 2002, and perhaps the survey coverage of this area was poorer that year. Missing females at Santiago de Calatrava in 2003 or Villanueva de los Castillejos in 2004 were due to the difficulties of surveying these areas with few tracks and large stretches of, respectively, olive plantations and oak-trees.

However, the data here suggest some reasonably clear trends at some leks. For example, males and females seem to have increased at Osuna, and adult males have decreased at Arahal, Gerena and Bujalance. Although part of the decrease at Bujalance might be related with the apparent increase at the nearby Baena B, it could largely be due to the high incidence of collision with powerlines and some cases of possible poaching recorded in adult males at this site (*pers. obs*.). It is suspected that these two causes of mortality could also be affecting males in Gerena, where the lek centre is crossed by two powerlines. In the past, this area used to be a traditional site for Great Bustards hunters from the nearby city of Sevilla. The importance of collision with powerlines and illegal hunting is supported by a limited sample of 30 casualties recorded during the study: 30% died due to collision, and 7-10% were shot (Alonso *et al*., 2005b). As for Arahal, the decreasing trend of males was particularly clear there, and could be partly explained by the low productivity at this lek, and by the simultaneous increase observed at the nearby leks in Osuna. A radio-tagged male attending the Arahal lek as a 2-year and 3-year immature moved later to the largest of Osuna leks, where he established as a breeding adult up to present. This suggests that some dispersal of males is possible between these two leks and could contribute to the observed changes in numbers of males (own *unpubl. data*).

In a recent study in central Spain it was shown that the dynamics of a Great Bustard metapopulation was largely explained by differences in local reproductive success at the individual leks and by conspecific attraction (Alonso *et al*., 2004). Leks with higher productivity increased faster, and larger leks were preferred by dispersing Bustards to settle as breeding adults. The leks at Osuna indeed showed relatively high productivity values. In three of four years productivity there was above the regional average, suggesting that bustards usually breed reasonably well at this area, as compared to other Andalusian sites. The opposite was observed at two of the areas where we observed decreases in numbers of males, Bujalance and Arahal. Productivity values at these areas were 0.00 and 0.03, the lowest recorded in all Anda-

lusia. The consistently low productivity values at these areas are probably a consequence of the very poor habitat quality due to much greater agricultural intensification (*pers. obs.*). In a previous study modelling the extinction probabilities of Great Bustards in Andalusia it was found that the model output was particularly sensitive to low productivity (Lane & Alonso, 2001).

As for the birds in Cadiz, the single adult male seen is the last of a flock of 10-12 birds including perhaps some 5 males reported in the area in the 1980s (Alonso, 1985; Ceballos & Guimera, 1992). It has not been possible to confirm the presence of females in this province, although reliable reports from local people strongly suggest that a small flock of *ca.* 4-6 females might survive at some 25-35 km northwest of the display site of the male. This possibility is also supported by various other scattered observations made recently in winter at several sites of this province (4 males and 7 females near Jerez in January 2004, up to 24 birds reported at Tahivilla in February 2004, M.S. Páez, *pers. comm.*), although it is not sure if these were wintering birds that breed somewhere else. Anyway, the probability of extinction of this group in the next years is very high.

The decreases observed at some leks during the surveys and those suggested by previous reports at many other leks are certainly not compensated for by the very low productivity of Andalusian Great Bustards. The overall productivity in the region was 0.08 young surviving to September per female, by far the lowest value of those recorded in Spain (0.18 in León, Lucio & Purroy, 1990; 0.15 in Villafáfila, Morales *et al*., 2002; 0.16 in Madrid, Alonso *et al*., 2004, and *unpubl. data*), and well below the critical threshold of *ca.* 0.15 young per female, under which local groups within a metapopulation tend to decrease (Lane & Alonso, 2001; Alonso *et al*., 2004). The most probable explanation for these low values is the poor habitat quality derived from agricultural intensification during the past decades which has caused frequent clutch and chick losses due to early harvesting (*pers. obs.*), and a remarkable decrease in invertebrates, the main food for young birds (Lane *et al*., 1999).

The overall sex-ratio was 3.28 females per male, the most extremely female-biased value of all Iberian Great Bustard populations for which data are available (1.21-1.40 in Cáceres, Hellmich, 1990; 1.35-1.56 in León, Lucio & Purroy, 1990; 1.7 in Villafáfila, Alonso *et al*., 1996; 2.42 in Madrid region, Alonso *et al*., 2003a). This also suggests that an abnormally high male mortality has recently occurred and might still be occurring in Andalusia. There were several extreme cases where breeding groups consisted only of one male with several females, and the two groups of females found without males (Santaella and Torredonjimeno) suggest that males have probably become extinct there in recent years. The same could probably happen in the near future at Aznalcóllar and Tahivilla, where a single male survives, and at Arahal and Gerena, where the alarming decrease in numbers of adult males recorded in the surveys foreshadows their probable extinction in the near future.

In conclusion, the results show that the Andalusian Great Bustard population is extremely endangered. Its small total size, fragmented distribution, extremely biased sex-ratio, high adult male mortality, and low productivity reflect a poor conservation status and high vulnerability. This is particularly true for the subpopulation in the Guadalquivir basin, where alarming decreases of the number of adult males have been detected at several leks. Such decreases are not apparent in the subpopulation of northwest Cordoba, which could survive longer due to its proximity to some of the major breeding aggregations in Extremadura. Therefore, strict habitat management measures directed to reestablishing traditional extensive farming practices that stop and invert current agriculture intensification are urgently needed in the whole region, and especially at some critical areas of the Guadalquivir basin where the species is severely threatened with extinction. It is also essential to deviate or bury powerlines at some particularly dangerous sites. Finally, continuing yearly monitoring of numbers and productivity at all leks is strongly recommended in order to be aware of any changes in the trends observed in the present study.

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