

THE GREAT BUSTARD *OTIS TARDA* IN MOROCCO: A RE-EVALUATION OF ITS STATUS BASED ON RECENT SURVEY RESULTS



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SUMMARY.—*The Great Bustard Otis tarda in Morocco: a re-evaluation of its status based on recent survey results.*

Aims: Between 1999 and 2005 five spring censuses of the Great Bustard *Otis tarda* population in Morocco were carried out, one of which (2003) was finally discarded due to bad weather conditions. Some complementary, partial counts in autumn 2000, winter 2001-2002 and spring 2004 were also carried out. The aims were to survey new areas where occurrence of the species was suspected but not confirmed, re-evaluate all recently published counts, establish reliable productivity, sex-ratio, and age structure values, and assess the conservation status of this endangered population.

Results and Conclusions: Seven leks were identified, two of which had not been described in earlier studies (Chekbouchan, Mrhitane). The total numbers of birds counted in spring varied between 70 and 84. Based on these, 80-113 birds were estimated in Morocco. The annual estimates of 99, 98, 90 and 80 birds, respectively for 1999, 2001, 2002 and 2005, suggested a decline in numbers throughout the study period, particularly at the two northern leks. Compared to the scarce data from previous decades, these counts suggest that the population has suffered a moderate decrease. The sex-ratio was extremely female-biased, with 3.9 observed and 4.1 estimated females per male. The age structure of the male population was remarkably young, with 23.5% immature males (range 11.1-33.3%), a higher proportion than that recorded in Iberian populations of the species. Average annual recruitment was 0.10 juvenile birds survived up to March from the previous breeding season, per adult female (range 0.045-0.178), a reasonable value compared to Iberian populations. These data suggest that Moroccan Great Bustards are subjected to high adult male mortality. This was corroborated with numerous well-documented cases of illegal hunting. Poaching was identified as the main current threat for the population, followed by collision with powerlines. It is suggested that poaching, and particularly male trophy hunting, has caused the decreases in numbers observed at some leks during the present study. Other threats include the foreseeable extension of the powerline network, and the agriculture intensification at current breeding areas. Immediate conservation actions are urgently required to save this extremely endangered population from extinction.

Key words: Distribution, Great Bustard, Morocco, *Otis tarda*, status.

RESUMEN.—*La población de Avutarda Común Otis tarda de Marruecos: análisis de su estado de conservación basado en censos recientes.*

Objetivos: Entre 1999 y 2005 se realizaron cinco censos de la población reproductora de Avutarda Común *Otis tarda* de Marruecos, uno de los cuales (2003) fue descartado por sus pobres resultados como consecuencia de malas condiciones meteorológicas. Además se llevaron a cabo censos parciales complementarios en otoño de 2000, invierno 2001-2002 y primavera de 2004. Los objetivos fueron la prospección de nuevas zonas, en las que la presencia de la especie aún no había sido confirmada, la evaluación de la estima poblacional a la luz de los nuevos censos, la determinación de valores fiables de proporción de sexos, estructura de edades y productividad juvenil, y la diagnosis del estado de conservación de esta población de avutardas, una de las más amenazadas del mundo.

Resultados y Conclusiones: Se identificaron siete leks, dos de los cuales no habían sido descritos en estudios anteriores (Chekbouchan, Mrhitane). Los totales de aves censados en primavera variaron entre 70 y 84, sobre los que estimamos un total de 80-113 avutardas en Marruecos. Las estimas anuales fueron de 99, 98, 90 y 80 individuos, respectivamente en 1999, 2001, 2002 y 2005, lo que sugiere una tendencia decreciente a lo largo del periodo de estudio, debida sobre todo al declive en los dos leks más septentrionales. La comparación con

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los escasos datos de décadas pasadas sugiere que la población debe haber sufrido un descenso moderado a lo largo de las mismas. La proporción de sexos resultó ser extremadamente sesgada, con 3,9 hembras observadas —4,1 estimadas— por macho. Se encontró una estructura de edades llamativamente joven en la población masculina, con un 23,5% de machos inmaduros (rango 11,1-33,3%), valor claramente superior al de las poblaciones ibéricas de la especie. La tasa anual media de incorporación de jóvenes a la población, medida en marzo del año siguiente al de su nacimiento, fue de 0,10 jóvenes por hembra adulta (rango 0,045-0,178), valor superior al de algunas poblaciones ibéricas amenazadas. Estos datos sugieren que la población estudiada está sometida a una elevada mortalidad de machos adultos, lo que fue corroborado mediante numerosos testimonios de caza ilegal. El furtivismo se identificó como la principal amenaza para la especie en Marruecos, seguida de las colisiones con tendidos eléctricos. Los datos sugieren que la caza ha debido ser la causa del declive numérico observado en varios núcleos reproductivos a lo largo del periodo de estudio. Las otras amenazas más patentes son la previsible expansión de la red de tendidos eléctricos y la intensificación agrícola que probablemente se producirá en las zonas rurales en las que actualmente se reproduce la especie. Es urgente la aplicación de medidas de conservación si se pretende evitar la extinción de esta amenazadísima población de Avutardas.

Palabras clave: Avutarda Común, censo, distribución, Marruecos, *Otis tarda*.

INTRODUCTION

The only African population of Great Bustards *Otis tarda* breeds in northwestern Morocco (Glutz *et al.*, 1973; Cramp & Simmons, 1980; Collar, 1985; Del Hoyo *et al.*, 1996). Until recently, only a few incomplete reports were available on numbers and distribution of this population, which represents the southern limit of the world breeding area of this species. In the 1970s, three flocks totalling some 60 birds were counted between Tangier and Souk-el-Arba-du-Rharb (Pineau & Giraud Audine, 1977). Later, Thévenot *et al.* cited the presence of the species between Tangier and the middle course of the Sebou river. Finally, on 28 February 1982, 58 birds were sighted in three flocks between Tangier and Asilah (Goriup, 1983). Based on these reports, a total of 100 birds was estimated for Morocco in the mid-1980s (Collar, 1985; Urban *et al.*, 1986; Johnsgard, 1991; Collar *et al.*, 1994; Del Hoyo *et al.*, 1996).

More recently, various counts have been carried out in Morocco (Alonso *et al.*, 2000; Hellmich & Idaghdour, 2002). These studies represent the first serious attempts to census the current population in this country. The first surveys by Hellmich and colleagues greatly improved the knowledge of the species' distribution (see Hellmich, 1999), and Alonso *et al.* suggested that a decline in numbers had probably occurred during the last decades. However, due to the difficulties inherent in surveying this elusive species in a vast region with few passable tracks, some breeding groups

were discovered only after publication of the studies mentioned above. Here, an up-to-date account of the species' status in Morocco is presented, including a re-evaluation of all recently published counts, and new data on numbers and distribution. For example, males were found at a site where they had not been sighted in previous studies, and two sites are described as leks for the first time. New and detailed estimates of breeding success, sex-ratio and age structure of the population are also presented and their meaning discussed as indicators of various aspects of its conservation status. Finally, the six years elapsed between the first and last counts enable suggestion of a demographic trend for this endangered population.

STUDY AREA AND METHODS

The study area comprises ca. 5000 km² of habitat identified as potentially suitable for Great Bustards in previous studies between Tangier and Meknes (see Hellmich, 1999; Alonso *et al.*, 2000; Hellmich & Idaghdour, 2002). All of these sectors had been visited by Hellmich and his colleagues at least once, and in March 2001 most of ca. 30 zones recognized as the best ones for the species were surveyed. In subsequent years, work was concentrated on the seven zones where bustards had been seen during previous surveys (Fig. 1). Within each of these sectors, a so-called *lek area* was delimited, comprising all flocks seen and a fringe of suitable habitat surrounding them. For the purposes of this study, a *lek* is defined an aggrega-

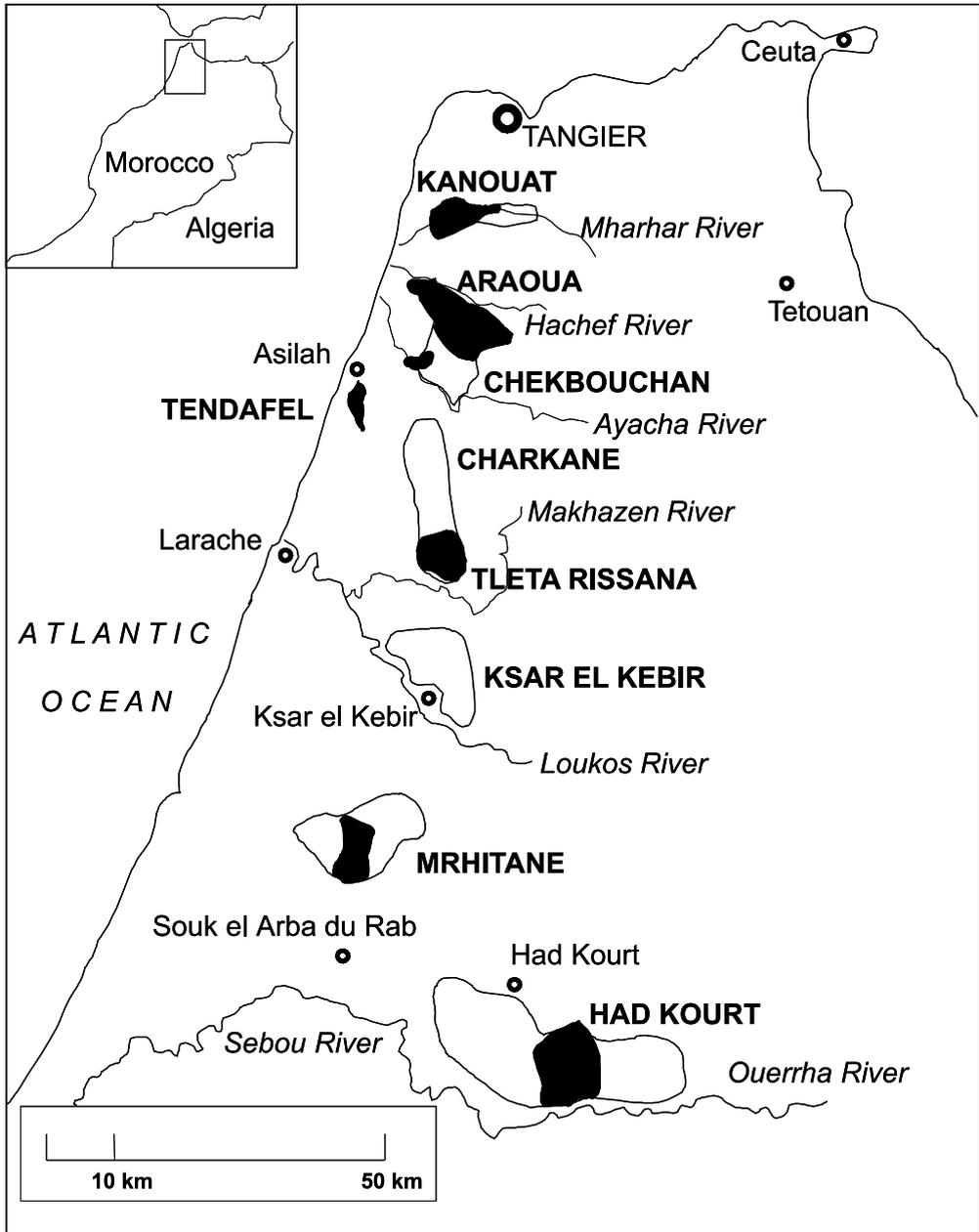


FIG. 1.—Map of the study area showing the intensively surveyed areas (white sectors delimited by a solid line), the seven Great Bustard lek areas (black patches) and two areas where bustards were seen only in winter (Charkane) or occasionally reported (Ksar-el-Kebir).

[Mapa del área de estudio mostrando las zonas prospectadas con mayor intensidad (sectores blancos delimitados por línea continua), las siete áreas de lek identificadas (zonas negras) y dos áreas más, una de invernada (Charkane) y otra con citas esporádicas sin confirmar (Ksar-el-Kebir).]

tion of one or more males with females at traditional places where they gather for mating every spring.

All spring surveys were carried out between late February and mid March: 11-13 March 1999, 4-10 March 2001, 28 February-7 March 2002, 2-8 March 2003, and 14-19 March 2005. Only 46 birds were counted in 2003, a significantly lower total than in other years, probably because some flocks were missed at several leks due to very bad weather conditions that year. Thus, it was decided not to use the 2003 census to calculate a population estimate that year. Each survey was carried out by one (1999), two (2003) or three (2001, 2002, 2005) teams working simultaneously as a rule in the same lek area, and being in contact through radio. Each team consisted of two observers, at least one of them with extensive previous experience in censusing the species, operating from a four-wheel drive vehicle, using binoculars and telescopes 20-60x, GPS and maps 1:50000. An additional survey was carried out by NM in March 2004 to confirm numbers of birds at Chekbouchan, and complementary counts were carried out continuously between June 2001 and February 2002 to confirm numbers at these leks and help arrive at the spring estimate for 2002. Surveys started at dawn and ended at dusk, with a pause during midday (11:00-15:30 h GMT), when bustards lie down and become difficult to see. The census itinerary was carried out at very low speed (≤ 20 km/h), with frequent and prolonged stops at vantage points to carefully look for birds. Because of the terrain difficulties, lack of tracks and inaccessibility due to water courses or wet ground, it was frequently necessary to leave the car and continue walking relatively long stretches to reach hilltops and survey some areas. Three age-classes were distinguished in males, according to criteria recently developed with marked birds (*unpubl. data*; 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, ≥ 4 years. Female ages cannot be distinguished in the field. The exact coordinates of leks are not given in the interests of security for this population. The names given to leks were those of the closest towns.

In spite of long experience surveying Great Bustards, it is extremely difficult to census

them in Morocco. First, because here there are very few flocks, missing one might alter the result notably. Second, accessibility to most lek sites was reduced due to lack of tracks. And third, birds were extremely shy and secretive, being active only during very short morning and evening periods, and remained hidden most of the daytime, probably due to the frequent disturbances caused by numerous shepherds and local people moving around in the lek areas.

Farmers and shepherds were interviewed during all surveys about the presence or absence of Great Bustards there in the present and in the past. They were also asked them about hunting and other mortality causes. Pictures of Great Bustards were shown and they were asked key questions about the courtship, nesting and other behavioural characteristics to see whether they knew the species and to judge the reliability of their reports. Only when reports from two or more persons coincided these were considered reliable and used to guess an estimated number of birds missed in the counts.

As an index of productivity, the annual recruitment of juveniles into the population was used and expressed as the number of juvenile birds counted in March per non-juvenile female. To calculate these figures, the juvenile males were counted and an estimated number of juvenile females added. The latter was obtained multiplying the number of juvenile males by 1.61, the mean sex-ratio of a sample of 843 juveniles counted in September between 1995 and 2004 in Madrid region. The sex-ratio did not change significantly between September and the following March in a sample of 328 radio-tagged juveniles tracked between 1991 and 2003 (*pers. obs.*). The total number of juveniles was then divided by the number of non-juvenile females (= total females minus the estimated number of juvenile females).

RESULTS

Numbers and distribution in spring

Seven Great Bustard leks were identified, all of them in the northern part of Morocco, north of the Sebou river, and west of the Rif mountain chain (Fig. 1). Previous studies had reported males only at four of them (Kanouat, Ara-

oua, Tendafel and Had-Kourt, Alonso *et al.*, 2000; Kanouat, Araoua, Tendafel and Tleta-Rissana, Hellmich & Idaghdour, 2002). At Chekbouchan and Mrhitane birds were found for the first time during the present study, in 2002 and 2001 respectively.

The total numbers of birds counted during the spring surveys varied between 70 and 84 (Table 1). However, these were minimum counts, which were used to calculate more realistic population estimates as follows. First, in 1999 and 2001 some leks had not yet been discovered and thus were not visited (Chekbouchan in 1999 and 2001, and Tleta-Rissana and Mrhitane in 1999). Therefore, to calculate an estimated total for these two years the numbers counted in later years at those three leks were added (see Table 1). In Chekbouchan this was justified by the apparent interannual stability of numbers suggested by the 2002 and 2005 counts, as well as by two counts made at this site on 7 and 26 March 2004 (2 males and 13 females on both dates). As for Tleta-Rissana and Mrhitane, the addition of a minimum estimate in 1999 was also justified by the relative stability in counts between, respectively, 2001-2005, and 2001-2002. Second, in 2002 the maximum numbers of females seen at Kanouat and Araoua during complementary surveys carried out in January-February, were considered as they were considered to be more reliable total estimates than the March count for these two areas. Finally, some reliable enquiry results for Mrhitane and Had Kourt were included. The estimates obtained this way for 1999-2005 were, respectively, 99, 98, 90 and 80 birds (Table 1).

The sex-ratio was highly female-biased, with more than 3 females per male in 1999-2002, and more than 5 females per male in 2005 (Table 1). Values derived from population estimates varied between 3.29 in 2002 and 5.67 in 2005, and the four-year means were 3.85 and 4.13 females per male, respectively for the birds counted and estimated. Sex-ratio varied considerably among leks, with more balanced values at Kanouat and Araoua, where numbers of males were highest and extremely biased values at Tendafel, where a big male was accompanied by 20-24 females and 1-2 immature males in 1999-2002. In 2005 the two males seen at this lek were apparently of similar size.

Winter census

During the survey carried out in winter 2001-2002, Great Bustards were found at four of the seven lek sites occupied in spring (Table 2). Enquiries with local people suggested that birds were also present at the two southern sites, Mrhitane and Had-Kourt, as well as at Ksar-el-Kebir, where a small flock of 5 birds was reported in December 2001. Only at Tendafel Great Bustards were missing, but a flock of 11 birds (10 females with an immature male) was found in Charkane, some 15 km southeast of Tendafel. No birds were found at Tendafel during additional surveys in November 2000 and October 2001 to January 2002.

The number of males counted in winter was similar to that counted in spring, suggesting that all males from Kanouat to Tleta-Rissana were found, but the number of females was lower. This was mainly due to the absence of birds at Tendafel, which was not compensated by the flock found at Charkane. This suggests that some female wintering area was probably missed.

During a partial count in November 2000, 5 males were seen at Kanouat, 12 females with a juvenile male at Oued-el-Hachef in the north-western part of Araoua, and no birds at Tendafel.

Annual recruitment and age structure

Annual recruitment figures were 0.107, 0.178, 0.094, 0.076 and 0.045 birds survived up to March 1999 through 2005 from the previous breeding season (average = 0.100, Table 1; figures calculated from numbers of juvenile males counted in March, as explained in Methods; 2003 was included, when 1 juvenile male and 36 females were counted). A relatively high number of immature males (mean = 23.5%, range = 11.1-33.3% of all non-juvenile males) were also observed in all years at several leks.

DISCUSSION

Current population estimate and distribution

The five complete spring surveys carried out in Morocco between 1998 and 2005 have pro-



TABLE 1

Great Bustard spring censuses and estimates (in brackets) in Morocco 1999-2005. Data for 1999 are based on Alonso *et al.* (2000), those for 2001 are based on our own count (12 adult males, 2 immature males, 2 juvenile males, 41 females) combined with that of Hellmich & Idaghdour (2002) (7 adult males, 4 immature males, 4 juvenile males, 60 females). See text for an additional census in 2003, and footnote 1 for a complementary count in Chekbouchan in 2004. The «Total estimated» represents a minimum population estimate, which includes, at areas not surveyed in 1999 and 2001, the numbers of adult birds counted in subsequent years, and for some other areas, very reliable enquiry results (see text and footnotes for details). ad = adults (≥ 4 years), imm = immatures (2-3 years), juv = first-year males.

[Censos y estimas (entre paréntesis) primaverales del número de Avutardas en Marruecos entre 1999 y 2005: Los datos de 1999 están basados en Alonso *et al.* (2000), aquellos de 2001 en nuestros propios datos (12 machos adultos, 2 machos inmaduros, 2 machos juveniles y 41 hembras) junto a los de Hellmich & Idaghdour (2002) (7 machos adultos, 2 machos inmaduros, 2 machos juveniles y 60 hembras). Para más información sobre los censos de 2003 ver el texto, y el primer pie de la tabla para censos complementarios en Chekbouchan en 2004. El total estimado representa una estimación mínima poblacional, que incluye las zonas estudiadas en 1999 y 2001, el número total de adultos contados en años posteriores, y para algunas otras zonas, datos realistas obtenidos en encuestas (ver texto y pies de la tabla para más detalle). ad = adultos (≥ 4 años), imm = inmaduros (2-3 años), juv = machos de primer año.]

Leks	1999			2001			2002			2005													
	♂♂		♀♀	♂♂		♀♀	♂♂		♀♀	♂♂		♀♀											
	ad.	imm.	juv.	ad.	imm.	juv.	ad.	imm.	juv.	ad.	imm.	juv.											
Kanouat	5	1	0	8	14	4	0	1	3	8	2	0	0	(1) ⁴	3	(5) ⁴	5	(8) ⁴	1	0	0	4	5
Araoua	4	1	2	19	26	5	1	1	19	26	5	1	0	(1) ⁴	11	(19) ⁴	17	(26) ⁴	2	0	0	14	16
Chekbouchan ¹	(1)	(0)	(0)	(12)	(13)	(1)	(0)	(0)	(12)	(13)	1	2	1	12	16	16	16	16	1	2	0	12	15
Tendafel	1	1	0	22	24	1	1	1	24	27	1	2	0	20	23	2	0	23	2	0	0	15	17
Tleta-Kissana ²	(1)	(0)	(0)	(9)	(10)	1	1	1	9	12	1	0	0	5	6	1	1	6	1	1	1	14	17
Mrhitanes ³	(1)	(0)	(0)	(5)	(6)	0	0	0	5	5	0	0	0	5	5	0	0	5	0	0	0	0	0
Had-Kourt	2	0	0	3	6 ⁵	1	0	0	5	6	0	0	1	3	4	0	0	4	0	0	0	1	1
Total counted	12	3	2	52	70⁵	12	3	4	65	84	10	5	2	59	76	7	3	76	7	3	1	60	71
(Total estimated)	(15)	(3)	(2)	(78)	(99)⁵	(14)	(3)	(4)	(77)	(98)	(12)	(5)	(4)	(69)	(90)	(8)	(3)	(90)	(8)	(3)	(1)	(68)	(80)

¹ Area not surveyed in 1999 and 2001, when we include the adults counted in 2002 as a reasonable minimum estimate, given the stability in subsequent years' numbers; in March 2004 one of us (NM) also visited this area and counted 1 adult male, 1 immature male and 13 females [Zona no censada en 1999 y 2001, años en los que se incluye el censo de adultos de 2002 como estimación mínima; en marzo de 2004 uno de nosotros (NM) censó de nuevo 2 machos y 13 hembras en esta zona, cantidad similar a la de 2002 y 2005.]

² Area not visited in 1999; we take the 2001 count as an estimate for 1999 [Zona no censada en 1999; tomamos el censo de 2001 como estimación para 1999.]

³ Area not visited in 1999; we take the 2001 count as an estimate for 1999, according to very reliable references from local people in 2002, one male has been seen displaying regularly in this area during the last years at least until 2002 [Zona no censada en 1999, tomamos el censo de 2001 como estimación para 1999; según encuestas muy fiables realizadas en 2002, un macho ha sido visto regularmente estos últimos años en la zona.]

⁴ In parenthesis, maximum counts during January-February 2002 at these areas, see Methods [Entre paréntesis, censos máximos obtenidos durante enero-febrero en estas zonas.]

⁵ Including a bird of unknown sex and age seen in flight [Incluyendo un indeterminado visto en vuelo.]

TABLE 2

Great Bustard 2001-2002 winter census in Morocco. Estimates based on reliable data from enquiries in brackets. ad = adults (≥ 4 years), imm = immatures (2-3 years), juv = first-year males.

[Resultados del censo de Avutardas en Marruecos en el invierno 2001-2002. Entre paréntesis, datos estimados a partir de encuestas muy fiables. ad = adultos (≥ 4 años), imm = inmaduros (2-3 años), juv = jóvenes nacidos el año anterior.]

	♂♂		♀♀	Total
	ad. + imm.	juv.		
Kanouat	3	1	5	9
Araoua	8	3	19	30
Ckekouchan	0	1	9	10
Tendafel	0	0	0	0
Charkane	1	0	10	11
Tleta-Rissana	0	0	5	5
Ksar-el-Kebir	(0)	(0)	(5)	(5)
Mrhitane	(0)	(0)	(2)	(2)
Had-Kourt	(0)	(0)	(10)	(10)
Total counted (estimated)	12	5	48 (65)	65 (82)

duced total counts ranging between 66 and 84 Great Bustards (Hellmich, 1999; Alonso *et al.*, 2000; Hellmich & Idaghdour, 2002, present study). The differences between counts are due to variable survey effort and success among years. For example, sites Chekbouchan and Mrhitane had not been mentioned at all in earlier studies, and in the recently published account by Hellmich & Idaghdour (2002), no males were reported in Had-Kourt. These defects of the first surveys are reasonable, considering the difficulties inherent in censusing Great Bustards in Morocco. However, this series of counts allows a good estimate of the whole Great Bustard population in this country, in two ways. First, adding to the counts the numbers estimated at areas not surveyed in some years, and the results of the most trustworthy enquiries. This was done for 1999, 2001, 2002 and 2005, obtaining relatively similar figures (80-99 birds), which should be considered the most reliable minimum estimates of the Great Bustard population in Morocco. An alternative way is to add maximum counts obtained at each area through the study period. This gave 113 birds (26 males, including juveniles, and

87 females). This is a reasonable way to estimate lek sizes, provided that breeding dispersal is rare in this species (Morales *et al.*, 2000; Alonso *et al.*, 2001; Alonso *et al.*, 2004).

Nevertheless, it cannot completely discard that some other breeding groups might have remained undetected, particularly in the central and southern parts of the surveyed distribution range. In some of these areas, reports from local people suggest birds might still breed (surroundings of Ksar-el-Kebir, Mrhitane, Had-Kourt, and even further south, at Sidi Kacem, where the species was considered to be extinct, see Alonso *et al.*, 2000). Hellmich & Idaghdour estimated 90-109 birds in spring, based on lower spring counts than the ones given here, with no birds at Chekbouchan and Mrhitane, and no males at Had-Kourt (66 birds in 1998, 30 in 2000, and 75 in 2001). To their maximum count they added 15-34 birds estimated from interviews with local people. If similar guesses are added to these figures, the estimated population size given here could amount to 100-150 birds.

The only complete winter count available supports these estimates at least for males, and



shows that some lek sites are abandoned in autumn and early winter (Tendafel), whereas some females use some sites preferably or only during the nonbreeding season (*e.g.*, Charkane, the mouth of Oued-el-Hachef, and probably an area close to Ksar-el-Kebir, see Fig. 1 and Hellmich & Idaghdour 2002). Up to 50 birds were observed in Oued-el-Hachef, at the northwestern edge of Araoua lek area, in December 1993, 33 in December 1995 (Chahlaoui *et al.*, 1994; Cantrounght & Cantrounght, 1995), 30 in December 1998 (Hellmich, 1999), and 12 and 8, respectively in November 2000 and 2001 (this study).

Recent and past trends

Although this series of annual counts is still too short, both the total numbers of birds counted and those estimated suggest a decreasing trend for the population. This trend is particularly remarkable among males, which have apparently decreased from 12-15 adults in 1999 to 7-8 in 2005. The two leks contributing to the decreasing trend are Kanouat and Araoua. In Kanouat only one male remained in 2002 at the traditional display place. The second male observed there in 2002, but not in 2005, was at more than 2 km east from that place. The decreasing trend at this lek started in 1998, when 7 males and 11 females were counted (Hellmich & Idaghdour, 2002), and might be in great part attributable to illegal hunting (see below). However, the most remarkable changes have been noticed after the setting up in January 2000 of a shepherd's hut only 100-200 m south of the traditional display centre. The second lek showing a decrease in the last three years is Araoua, where the number of males was relatively stable until 2002, but went down to only 2 males in 2005. Numbers of females have also apparently decreased at these two leks.

The exceptional sex-ratio at Tendafel, the most extreme we have found in a Great Bustard lek (the second most extreme case was a group of 17 females with a male in Andalusia, Alonso *et al.*, 2005), could best be explained by the effects of repeated male trophy hunting. At other leks males have been either missed (Mrhitane), or apparently disappeared in the last years (Had-Kourt), and trends in females are

uncertain due to the small numbers, so further counts are needed to confirm tendencies at these sites. The last trustworthy reference of a male at Mrhitane was in 2002, when at least two separate farmers stated they had seen every year a displaying male at a very precise site, where we didn't find it that year, nor in 2005. As for Had-Kourt, the presence of young birds in our 2002 survey and reliable reports of chicks seen or captured in some other years strongly suggest that at least one male survives nowadays. Detailed reports to us in 2002 describing how two large birds (respectively, 16 kg and 9 kg) were shot more than a decade ago confirm that the number of males has decreased recently at this site. Finally, various reports gathered during our surveys described local extinctions at some areas: a group near Ksar-el-Kebir that disappeared during the mid 1990s, and presence of Great Bustards 20-30 years ago north of Fez and near Tetouan, where today no birds are seen any more.

In conclusion, with the data available it is believed that the Great Bustard population in Morocco is still suffering a decrease that started some decades ago. Considering the small size and fragmentation of this population, any decrease would seriously threaten its survival. Surveys should be carried out every year in the future to confirm this. With respect to the trends in earlier decades, in a previous study it was suggested that Moroccan Great Bustards decreased at least during the second half of the past century (Alonso *et al.*, 2000). The estimate of 100 Great Bustards made by Collar in the mid-1980s surely underestimated the population at that time. However, the scarce observations of Great Bustards cited in the literature from the beginning of last century (Whitaker, 1905; Cabrera, 1914) suggest that the species was probably never abundant in Morocco, so the maximum number of birds might have probably never exceeded a few hundred birds.

Threats and conservation prospects

Two results of this study suggest a relatively high turnover rate for the Great Bustard population in Morocco. First, the annual recruitment values were relatively high, when compared with Iberian Great Bustard populations for which such data are available. The mean num-

ber of first-year birds counted in spring was 0.10, higher than that recorded in Andalusia (0.07 for 2001-2004), and similar to the value in Madrid region (0.11 for 1997-2004) (own unpubl. data). Second, a high proportion of immature males was found (11-33% of all non-juvenile males, in comparison with only 7-10% in Andalusia, and 6-22% in Madrid; own unpubl. data). The highest number of immature males was recorded in spring 2002, in agreement with the high number of juvenile males counted in March 2001. It is thought that the extreme proportions of immature males cited in Hellmich & Idaghdour for 1998 (5 adults, 12 immatures) and 2001 (7 adults, 4 immatures) are unrealistic and should be attributable to wrong aging. Data here indicate a remarkably young age structure of the male population, and suggest that Moroccan Great Bustards are subjected to a high adult male mortality.

Hunting and other man-induced factors are surely contributing to such increased adult male mortality, as suggested by the reports obtained from local people during the surveys (Table 3).

In spite of legal protection of the species in Morocco, poaching was by far the main mortality cause reported. Although a precise quantification of mortality rates due to different causes cannot be made from data obtained through interviews, Table 3 shows that illegal hunting is still a major threat for the species in Morocco, with at least 20 birds shot in the last 8 years. Hunting might have been not only responsible of the marked decrease of the population suspected to have occurred since about the middle of last century in the whole country (Alonso *et al.*, 2000), it might also be the factor causing the decreases observed nowadays at Kanouat and Araoua during the present study. Well-documented cases of poaching were recorded at six of the seven leks, being particularly important in Kanouat, Tleta-Rissana and Had-Kourt, in terms of number of casualties compared to number of birds at the lek. The reported cases included birds shot by local hunters at most areas, trophy hunting by foreign hunters in Kanouat and Mrhitane, killing of males by a shepherd in Kanouat, and shooting of males and fe-



TABLE 3

Main causes of man-induced mortality of Great Bustards in Morocco. Data from 1997 to 2003, based on literature review (see details in Hellmich, 1999; Alonso *et al.*, 2000; Hellmich & Idaghdour, 2002), and from interviews with local people during the present study.

[Principales causas de mortalidad de Ayutardas provocada por actividades humanas en Marruecos. Datos de 1997-2003, procedentes de revisión bibliográfica (ver detalles en Hellmich, 1999; Alonso *et al.*, 2000; Hellmich & Idaghdour, 2002), y de encuestas realizadas durante el presente estudio.]

	Illegal hunting [Caza ilegal]	Collision with powerline [Colisión con tendidos eléctricos]	Capture of young birds [Captura de aves jóvenes]	Other causes [Otras causas]	All causes [Todas las causas]
Kanouat	2	1			3
Araoua	3	1			4
Chekbouchan	2				2
Tleta-Rissana	7				7
Mrhitane	1				1
Had-Kourt	4		2		6
Other areas ¹	1	5		1	7
Total casualties	20	7	2	1	30

¹ Hunting southwest of Had-Kourt; collisions with powerlines east of Ksar-el-Kebir in 1997; collision with aircraft at Tangier airport in 1997.

males at waterholes in Araoua. The shepherd who settled at the lek centre of site Kanouat in January 2000 used to hunt Great Bustards. He described in detail how he shot at a male that finally escaped on the morning of 25th March (Hellmich & Idaghdour, 2002). In that area several people reported us that they had seen there three hunters from Saudi Arabia in 1998. At least two adult males were known to be killed in March that year (Hellmich, 1999). In March 2003 we found two cartridge-cases at the display site in Tleta-Rissana, and the local shepherd confirmed us that poachers used to come to hunt bustards. Finally, the incidence of hunting in Had-Kourt could be the cause of male disappearance at this site. Two farmers told us that some local people used to hunt them for their meat.

The second most important mortality cause identified was collision with powerlines, with seven casualties reported in the last years, in spite of the poor development of the electricity network in most Great Bustard areas. Finally, at least in Had-Kourt there are reports of local people capturing young birds in summer.

In Spain hunting has been identified as the main factor determining population decrease before the hunting ban was established in 1980. It caused the extinction of many breeding groups at marginal areas of the species' distribution range (Alonso *et al.*, 2003). Today the main adult mortality cause, not only in Iberia but also in other European countries, is collision with powerlines (Reiter, 2000; Martín, 2001, T. Langgemach, *pers. comm.*, R. Raab, *pers. comm.*). Hunting and collision with powerlines affect males more than females (*pers. obs.*). These mortality causes have surely contributed to the extremely female-biased sex-ratio found in Morocco. In the Andalusian population in southern Spain, which has been subjected to severe hunting pressure during the last decades, sex-ratio is also markedly biased towards females (3.28 females per male in Andalusia, southern Spain, Alonso *et al.*, 2005). These values contrast with those of other Spanish populations with a better conservation status (1.35-1.56 females per male in León, and 1.21-1.40 in Cáceres, Alonso & Alonso, 1990; 1.7 in Villafáfila, Alonso *et al.*, 1996; 2.42 in the Madrid region, Alonso *et al.*, 2003).

The development of Moroccan rural areas that might be expected at an early date will su-

rely bring about an expansion of human infrastructures, as well as an intensification of agriculture. The growth of the current powerline network will mean an increase in Great Bustard adult mortality. As for the progress in road building and farming techniques, they will produce a decrease in habitat quality and a consequent decline in productivity, as has happened in many Iberian populations (Palacín *et al.*, 2004). One of these roads, the new highway Rabat-Tangier, will cause a significant reduction of the habitat available, particularly at Kanouat and Tendafel. At Kanouat the highway crosses the western and eastern sectors of the display area, and at Tendafel it has been built at less than 500 m of the male display site. The western part of Kanouat will also be affected by the recently opened 350-400 megawatt power station at the Tadahart river mouth. In Had Kourt a network of wide roads for farm traffic has been built in 2004. It is conceivable that hunting pressure, currently the major threat for Moroccan Great Bustards, will decrease in future years, but probably not before all other negative factors have begun to show their effects.

Finally, the Moroccan population is probably too isolated to receive dispersing males from the Iberian Peninsula. Two genetic studies of the Afro-Iberian Great Bustard population have shown that Moroccan birds descend from Iberian ones (Alonso *et al.*, *in press*), and that both populations have been isolated from each other for a long time (Broderick *et al.*, 2003). This is corroborated by the absence of direct observations of birds crossing the Straits of Gibraltar, in spite of frequent birdwatching in this region (Finlayson, 1992; SEO/BirdLife, 1999; 2001). Moreover, the extremely endangered status of Great Bustards in southern Spain, and particularly in Cádiz, the southernmost Andalusian province, where only one adult male but no females have been sighted in the last years (own *unpubl. data*), make immigration from Iberia even more improbable. Thus, the survival of Moroccan Great Bustards depends on protection measures taken at their breeding areas.

In conclusion, it seems that the Great Bustard population in Morocco has suffered a moderate decrease through the last decades, which continues nowadays, at least at some leks. However, the scarce data available suggest that numbers were never very abundant in this country. Perhaps natural and man-induced mor-



tality has been compensated for many decades by the species' productivity, which is not as low as one would expect from the high density of rural people and domestic animals moving around in the field. More concerning are the very recent and current decreases at some leks, caused mainly by illegal hunting, and the negative prospects derived from development projects, mainly the foreseeable extension of the powerline network, and the agriculture intensification. Immediate conservation actions are urgently required if this population, one of the most endangered of this species worldwide, is to be saved from a very probable extinction in the next few decades.

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