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The Great Bustard: past, present and future of a globally threatened species

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Abstract Great Bustards are still vulnerable to agricultural intensification, power line collision, and other human-induced landscape changes. Their world population is estimated to be between 44,000 and 57,000 individuals, showing a stable demographic trend at present in the Iberian peninsula, its main stronghold, but uncertain trends in Russia and China, and alarming declines in Iran and Morocco, where it will go extinct if urgent protection measures are not taken immediately. Our knowledge of the behaviour and ecology of this species has increased considerably over the last three decades, allowing us to control the major threats and secure its conservation in an appropriately managed cereal farmland. This species became '**The Bird of the Year**' in Hungary in 2014.

Keywords: conservation, Great Bustard, demographic trend, world status

Összefoglalás A túzok populációit napjainkban is veszélyezteti a mezőgazdaság intenzifikációja, a légkábelekkel való ütközésekből eredő elhullások, és az emberi hatásokra bekövetkező tájváltozások. A faj világállománya 44 000 és 57 000 egyedre tehető. Az Ibériai-félszigeten található legerősebb populáció stabil demográfiai trendet mutat, az orosz és a kínai állományok változásait jelentős bizonytalanság terheli, valamint Iránban és Marokkóban riasztó állománycsökkenés figyelhető meg, ami megfelelő védelmi intézkedések hiányában a lokális populációk kipusztulásához fog vezetni a közeljövőben. Az elmúlt három évtizedben a faj magatartásbiológiájára és ökológiai igényeire vonatkozó ismeretek jelentősen bővültek, ami lehetőséget biztosít a jelentős veszélyeztető tényezők kontrollálására, valamint a túzok védelmével összeegyeztethetően hasznosított mezőgazdasági területeken a faj megőrzésére. Ez a faj lett 2014-ben az **Év Madara.**

Kulcsszavak: természetvédelem, túzok, állományváltozás, világállomány

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Current world status and recent demographic trends

The recent history of published estimates of the Great Bustard world population shows an increasing trend, from the ca. 28,000 individuals in the early 1990's to the 44,000-57,000 individuals in 2010 (details in Alonso & Palacín 2010). However, we are convinced that this trend is partly influenced by the increasing quality of the counts during the last three decades and should therefore be interpreted with caution. During previous centuries (years 1600's-1800's), the species had been reported as a breeding bird in many more European countries than nowadays, from Great Britain to Greece, and as far north as in Sweden (Glutz *et al.* 1973). The marked declines during the 19th and 20th centuries in most central Europe are attributed to agricultural intensification, but surely hunting, and in the last decades collision with power lines also played an important role. The effects of hunting are well documented in Spain, where official hunting bags reached up to 2057 birds annually in the decades just before a hunting ban was established in 1980 (Trigo de Yarto 1971). A 70% of the leks for which we have been able to assess the cause of extinction disappeared between 1960 and 1980, the period when hunting pressure was presumably the highest in Spain. We guess that approximately half of these leks disappeared due to hunting (Alonso *et al.* 2003b, 2004a).

Although census accuracy has generally improved through the last years in most countries, and some areas might contribute to exaggerate the real increases, we think that the world total of Great Bustards has not decreased significantly during the last two or three decades (Palacín & Alonso 2008, Alonso & Palacín 2010). This conclusion is based on the trend observed in the Iberian Peninsula, where a major fraction (60-70%) of that world total lives, and where many regional populations have shown stability or even a tendency to increase in the last years. We suggest that in Spain, after several decades of decline the hunting ban established in 1980 allowed a recovery of the species in most regions, whereas in other regions populations had no capacity to recover any longer after having been decimated to just a few birds, and just continued decreasing to extinction (Alonso *et al.* 2003b).

The positive demographic trend in the Iberian Peninsula contrasts with those of Morocco and Iran, where the two most endangered populations of the species face a real threat of extinction (Alonso *et al.* 2005, Barati *et al.* 2014, Palacín *et al.* 2014). The species has also probably decreased in other main parts of its distribution range, e.g. Russia and China (Chan & Goroshko 1998, Antonchilov 2008, 2011). Finally, even in the Iberian peninsula, where the species seems to be doing better, a contraction of its distribution range is apparently occurring in many areas, due to habitat deterioration linked to a conspecific attraction tendency, which leads to the disappearance of smaller and marginal breeding groups while dispersing birds aggregate at large breeding groups (Alonso *et al.* 2004b, Pinto *et al.* 2005). All of these negative facts have been fundamental when international experts made the recent status assessment of the species, and finally agreed on the convenience of maintaining the Great Bustard listed under the *vulnerable* category (BirdLife International 2013), at least until better information is gathered in those countries where its current status and trends are not well known.

Today the world population of Great Bustards is estimated to be between 44,000 and 57,000 individuals, of which the largest fraction (60-70%) occurs in Spain *(Table 1)*. Compared to the last published estimate (Alonso & Palacín 2010), there is little new data for most of the countries with the largest populations, therefore the conclusions presented four years ago are still valid today. Perhaps the only interesting observation we can appreciate in the last four years is a slow but consistent recovery of the species in Austria and Germany, and a decrease in Iran and Morocco. Interestingly, numbers of Great Bustards in Iran and Morocco are at present similar to the minimum numbers reached two decades ago in Germany and Austria (in both countries, ca. 60 individuals in the 1990's; www.grosstrappe.at, www.grosstrappe.de), which shows that extinction could theoretically be avoided in Iran and Morocco. Unfortunately however, socio-economic conditions in Iran and Morocco are not equal to those in the two central European countries, making the recovery of the species much more difficult. International efforts should be urgently devoted to try to save the Iranian and Moroccan bustards from extinction.

	min-max	reference	year of estimate	quality of estimate
Spain	29,400 – 34,300	Alonso & Palacín 2010	2004-2010	high
European Russia	8000 – 12,000	Malikov *et al.* 2000, Khrustov *et al.* 2003, Antonchikov 2006, Watzke *et al.* 2007	1995-2005	low
NW China (Xinjiang)	400 – 2400	Gao *et al.* 2008, Ying *et al.* 2010	1990-2002	low
Mongolia + SE Russia +NE China [b]	1200 – 2200	Tian & Wang 2001, Tseveenmyadag 2002, Goroshko 2010, Kessler *et al.* 2013, Tian pers.com.	1961-2002	low
Portugal	1893	Pinto & Rocha pers. com. 2010	2009	high
Hungary	1466	L. Miklós pers. com. 2014	2014	high
Turkey	400 – 1000	Kiliç & Eken 2004, Özbagdatli & Tavares 2006, Karakas & Akarsu 2009	1990-2008	low
Ukraine	520 – 680	Yaremchenko & Bakhtiyarov 2006, Dudkin & Domashlinets pers. com. 2008	2006	low
Austria	275 – 364	R. Raab pers. com. 2015	2014	high
Germany	165	Staatliche Vogelschutzwarte Brandenburg & Förderverein Großtrappenschutz, unpubl.	2014	high
Morocco	50 – 80	Alonso *et al.* 2005, Palacín *et al.* 2014	2014	high
Iran	43 – 48	Barati *et al.* 2014	2011	high
Kazakhstan	0 – 50	Acad. of Sciences of Kazakhstan 1996	1990-1996	low
Serbia and Montenegro	35 – 36	Garovnikov 2004	2004	high
Slovakia	0 – 3	National report 2008 [c]	2008	high
Czech Republic	0 – 2	National report 2008 [c]	2006-2007	high
Romania	0 – 8	National report 2008 [c]	2008	high
Total	**43,847 – 56,695**			

Table 1. World status of the Great Bustard in 2014 (updated from Alonso & Palacín 2010). In countries not listed in this table the species is currently considered extinct [a]

1. táblázat A túzok világállománya 2014-ben

[a] Great Bustards released in Great Britain are not included in this *Table*, because they cannot be considered a self-sustaining wild population

[b] Subspecies *Otis tarda dybowskii*

[c] Communicated during the Second Meeting of the Great Bustard MoU held in Feodosia, Ukraine, in November 2008

Collision with power lines, a major concern

Collision with power lines represents today the most important cause of mortality of adult and immature Great Bustards (Palacín *et al.* 2004, Martín *et al.* 2007, Barrientos *et al.* 2012, Raab 2012). Mortality rate due to this cause may reach values of 6%-13% in some populations (Martín 2001, Alonso *et al.* 2007), and these mortality rates may seriously affect population viability (Martín 2008). An example of the devastating effect of a power line is the case of a lek in Madrid region, where numbers of males went down from 15 in 1988 to just a single male seen there at present in spring (Alonso *et al.* 2003a). Various possible causes of this high collision rate include their low manoeuvrability in flight due to their large size, their narrow field of view in the frontal plane, and possibly their low-resolution frontal vision (Martín & Shaw 2010, Martin 2011). Marking power lines with flight diverters to increase their visibility reduces bird mortality significantly but sometimes only slightly in terms of numbers of casualties (Alonso *et al.* 1994, Barrientos *et al.* 2011, 2012). The only way to completely eliminate mortality is burying the line, which is expensive and not affordable as an extensive conservation measure in most areas (Raab *et al.* 2012).

A brief history of the first Great Bustard captive breeding attempts

Captive breeding has traditionally been regarded as a suitable method to recover threatened wild Great Bustard populations. The first attempts to breed Great Bustards in captivity were carried out in Hungary (Chernel 1904), although the first successful reintroductions to the wild took place in Dobrudsha (Romania), where four individuals hatched by a Turkey *(Meleagris gallopavo gallopavo)* in 1919 were released after being kept in semi-wild conditions for several years (Rayner 1942). In the following years, similar programs were undertaken in different central European countries, urged by the alarming decreases of some populations due to agricultural intensification. The aim of these captive breeding stations was, on one hand, to reintroduce young reared from artificially incubated eggs into the wild, and on the other hand to create captive groups of breeding individuals that assured the survival of extremely threatened populations. Among those pursuing the former objective, the main stations were Steckby and Buckow in Germany, and Dévaványa in Hungary (Fodor *et al.* 1981, Dornbusch 1983a,b, Litzbarsky & Litzbarsky 1983, Sterbetz 1986, Faragó 1990). Other attempts were carried out in Portugal (Pinto 1981), Russia (Ponomareva 1983), and Slovakia (Randik & Kirner 1983). Attempts to establish a captive-breeding flock were made in Spain (Hellmich 1991), Poland (Graczyk 1980, 1983, Graczyk *et al.* 1980), and the United Kingdom (Collar & Goriup 1980, Goriup 1985, and more recently, www.greatbustard.org).

BirdLife International established an Action Plan for the Great Bustard in Europe, including among other points the study and evaluation of the current captive breeding programs, focusing on the survival and reproductive success of released individuals (Heredia *et al.* 1996). That year we made a preliminary evaluation of the efficiency of these captive breeding programs, in the light of the results from our long-term studies of the species' behaviour. We concluded that the success of these captive breeding and reintroduction programs had generally been low or very low, due to the absence of the long maternal dependence period in captive released birds, and their consequently high mortality. Young Great Bustards depend on their mothers until they are 6-18 months old, and this training period is vital for their subsequent survival and success as breeding adults (Martín 1997, Alonso *et al.* 1998). In addition, the success of these projects was often unknown due to the lack of adequate tracking of released birds (Martín *et al.* 1996). The lack of such maternal dependence period in all past and current captive breeding programs represents an important handicap that will always limit the success of such attempts. Finally, the delayed reproductive maturity and complicated mating system of this species adds further difficulties to these programs.

Current conservation projects

Since the publication of the European Action Plan in 1996 (Heredia *et al.* 1996, updated in Nagy 2009), and the Asian Action Plan in 1998 (Chan & Goroshko 1998), many habitat management programmes have been carried out in Spain, Portugal, Austria, Hungary, Germany, Serbia, financed with LIFE or other EU funding sources, and here we will not go through all of the details of these projects. However, we should say that most of them implement agri-environmental measures without appropriate tests of their efficiency, and without optimizing costs. However, habitat management is the best way to invest in conservation of the Great Bustard, including some good examples that show how declines of small populations have been stopped just through habitat improvement measures (e.g. www.grosstrappe.at, www.juntadeandalucia.es). On the opposite, reintroduction trials still show little or no success.

Below, we briefly review only some of the historically most significant conservation projects or recent reintroduction trials.

Germany:
Intensification of agriculture caused a dramatic decline of the Great Bustard population in Germany, from ca. 4000 birds in 1940 to 55 counted in 1995. The continued conservation efforts of the association Großtrappenschutz e. V. resulted in the recovery of this population to 165 birds counted in March 2014 (www.grosstrappe.de). In spite of the high predation rate by foxes, white-tailed eagles and ravens, the protection of the small remaining habitat patches and the captive breeding program running since 1973 have succeeded in the prevention of the extinction of the species in Germany. This program started at the Biological Station Steckby and continued since 1979 in Buckow. The eggs from wild nests are collected and incubated artificially. In the past, only eggs from disturbed nests were collected, but nowadays first clutches are taken systematically (40-74 yearly during the last years) based on the assumption that first clutches suffer from much predation pressure, and on the fact that females usually lay a replacement clutch. The eggs collected are incubated artificially, and young birds are fed by hand and moved to increasingly larger pens. During fledging, they eventually fly out to join adult groups. There is evidence that the artificial breeding program prevented the German population from extinction, and today insemination rate, hatching rate and release success have improved much compared to the first years, although survival of the released birds is still highly variable depending on predation pressure.

Austria – Western Hungary:

The West-Pannonian Great Bustards (birds living in Austria, Western Hungary and Slovakia) declined from 3500 individuals in 1900 to 130 in 1995 (ca. 60 of them in Austria), mostly due to agricultural transformations, the development of human infrastructures, and hunting (Raab *et al.* 2010). As a result of intensive and cross-border habitat protection measures, including establishment of protected areas, habitat management, agri-environmental measures, and burying of power lines, the population has recovered to around 400 birds (ca. 300 of them breeding in Austria, Raab 2013, Faragó *et al.* 2014, Raab pers. com., www.grosstrappe.at).

Hungary:

Dévaványa, in the region of the Körös-Maros National Park, is one of the most important areas for Great Bustards in Hungary. Dévaványa Landscape Protection Area was established there in 1975 to safeguard Hungary's largest population of Great Bustards. Around 30-40 eggs found to be endangered are taken each spring from wild nests, replaced by fake ones made of wood, and incubated artificially at the Great Bustard Conservation Centre. The chicks hatched at the Centre are later released in the wild. In addition, a large pen holds up to 40 displaying males and some 50 females in spring, and the numbers of females nesting in that area have increased in the last years due to active land management, including the creation of a mosaic of grassland, wheat, alfalfa, rape and fallow fields. More information can be found at www.tuzok.hu.

Russia:

Russia holds the second largest Great Bustard population in the world, with an estimated 8000-12,000 birds, most in the region Oblast, near Saratov, some 850 km southeast of Moscow. Since the 1980's the A. N. Severtsov Institute of Ecology and Evolution, a branch of the Russian National Academy of Science, has been collecting eggs from doomed nests for artificial incubation. Chicks from this scheme were originally used in various captive breeding projects across the former Soviet Union, which had so far been unsuccessful. In the last years, the Institute has been running a captive rearing and release project instead, lead by Dr. Anatoli Khrustov, bypassing the apparent pitfalls of captive breeding, and releasing Great Bustards back into the wild in Russia. They have also provided the chicks for the UK reintroduction between 2004 and 2013.

United Kingdom:

Great Bustards were once part of British wildlife but they became extinct in Britain in the 1840's, mainly because of hunting. After a failed trial to reintroduce the species in the UK in the 1970's, the Great Bustard Group was formed in 1998 specifically to run a new UK reintroduction project. Great Bustards for this new reintroduction into UK came from Russia during the first ten years of the project. Each year a number of young bustards were imported to the UK from Saratov. In this region, a large number of eggs were collected from doomed nests and incubated artificially in a local breeding station. When the young were 3-4 months old they were sent to UK, where they were released after a period spent at the release pen on Salisbury Plain. The low success during the first 10 years of the trial was due to different causes, but one was surely the migratory instinct of the Russian birds. The natural tendency of these birds to migrate to southwest in autumn became clear to the project managers only after ten years, in spite of our advice that this would be going to be the case, and of evidences from sightings of several released birds in southern England and even some in France. In 2014, eggs were taken for the first time from Spain, and the chicks hatched in the UK. However, a new mistake has been made, since only a fraction of the birds released carry radio-transmitters. This goes against the most fundamental condition of any reintroduction project, i.e. following the fate of all released individuals in order to be able to evaluate the success of the trial and to avoid mistakes in following years. The decision not to tag all birds was based on the fallacious argument of a significant mortality caused by transmitters, whereas the opposite was indeed shown by an analysis of the first seven years of release, where no significant negative effect of tagging was found on post-release survival (Burnside *et al.* in prep). More information about this reintroduction trial can be found in www.greatbustard.com.

The future of the species

As for the prediction of what will happen with Great Bustards in the future, we cannot be too optimistic, in spite of the apparent good health of the main population of the species in the Iberian Peninsula. The first reason for our cautious impression is the apparently rapid decreasing trend in Russia in recent years due to changes in agricultural practices (Antonchikov 2008, 2011), plus the uncertainty about real numbers and trends in other important populations like Mongolia, China, Turkey or Ukraine. This prevents us from providing a more precise guess about the overall global trend of the species. We can only say that establishing reliable trends in the future needs carrying out rigorous surveys as soon as possible in all countries where Great Bustards occur, and that these surveys should be repeated periodically during at least a decade, in order to establish reliable trends and their causes.

The second reason for our caution is the fact that recent evidences of hunting in central Asia, land-use changes in Eastern Europe, Russia, Mongolia and China, and collision with power lines in all areas of their distribution range, may have a significant impact on the worldwide population in the coming decades. These are some of the reasons why the Great Bustard is still classified as vulnerable at a global scale (BirdLife International 2013). It is indeed in Russia and China where more census and conservation work is needed, in order to be aware of the threats to these populations, and to improve protection measures. The fact that the species is migratory in these countries adds obvious risk factors to its current uncertain status.

Third, some climate change models predict northward shifts and contractions of the distribution ranges of several bird species in the coming decades (Jetz *et al.* 2007, Brommer & Møller 2010, Jiguet *et al.* 2010, Araújo *et al*. 2011), although in the case of Great Bustards we think that human activities may be much more important than climate change at least in the near future. Agricultural intensification and infrastructure expansion on the negative side, and agri-environmental programs and other active conservation and management actions on the positive side, may counteract much of the negative climate change effect foreseen in these models.

Fourth, in some Spanish regions hunters are launching a very strong lobby to include

Great Bustards in the list of game species again, based on the species' recent overall stability and increase in some areas. Their arguments are that hunting of a small number of 'old' males which, they say, would not participate in reproductive activities, should render economic benefits that could be applied for the conservation of the species. However, the results of our research with individually marked birds show the opposite. Older males have a higher status in the lek hierarchy, and therefore more access to females and higher breeding success than younger males (Alonso *et al.* 2010a,b). In addition, trophy hunting in spring would cause such alterations in the complicated lek hierarchy and disturbances to other displaying birds, that all the breeding system would probably be distorted. Fortunately, these attempts to legalize Great Bustard hunting have failed up to now, but this doesn't guarantee that in Spain the species will enjoy a protected status forever.

All these reasons suggest keeping the species under a vulnerable status is today the best measure to protect it from all factors that caused the decline and extinction of many of its populations in the past. We should encourage the nature conservation administrations of those countries still lacking accurate surveys of their Great Bustard populations to carry out such censuses, and to take the necessary measures that ensure conservation of this species and its habitat.

The Great Bustard as a model species in scientific research

A research project centered on the Great Bustard started at the National Museum of Natural Sciences in Madrid in the late 1980's and is still active at present (www.proyectoavutarda.org, www.jcalonso.eu). Thanks to this study, our knowledge of the behaviour and ecology of this species has increased considerably over the last decades, and today the Great Bustard is one of the best studied among endangered species in Europe, with over 70 papers published in scientific journals, and 4 books, 6 book chapters, 8 PhD theses, and numerous contributions to international congresses produced only by our group in the last 25 years.

Another example of the profound knowledge of its biology is that it was selected to represent birds in a recent review of sexual size dimorphism in the animal kingdom (Fairbairn 2013). The Great Bustard is indeed one of the heaviest flying birds and the most sexually dimorphic among all living bird species (Alonso *et al.* 2009a). The high weight of males and their size difference to females have conditioned many of the physiological, behavioral and life-history traits of this species. Male-male competition is extremely intense, and high rank within the lek hierarchy, as well as access to females are age- and weight-dependent (Alonso *et al.* 2010a,b). This strong sexual selection has likely pushed male weight up to the limit imposed by powered flight. But the other sexual selection mechanism, female choice, is also very strong in Great Bustards. Females are exceptionally choosy before accepting a male as her mate. They prefer the heaviest, old, and most intensively displaying males, and female choice acts reinforcing the male competition mechanism, making sexual selection a powerful driving force of their sexual size dimorphism, and ultimately of many aspects of their life.

Our project was based on individual marking and radio-tracking from the very beginning in July 1987, when we tagged our first chick in Villafáfila. The number of marked birds has grown since then up to over 1000 individuals, which we have followed throughout their lives, totaling over 19,000 locations on different days.

A big male has obvious advantages at the lek. High-rank males are involved in fewer aggressions during the mating season, because they are accepted by other males as dominant (Magaña *et al.* 2011). But if it comes to a real fight, a big male has also more chances to win. Honest signaling of the status of males to each other through sex traits can prevent these fights and their dangerous consequences and has therefore an important adaptive value (Alonso *et al.* 2010b).

However, getting big does not only bring rewards, it also entails some costs. The faster growth rate of young males implies higher nutritional needs and, when these are not fulfilled during periods of low food abundance, young males suffer higher mortality due to starvation. However, if a mother is able to rear a good, healthy male, that male will integrate earlier in the adult male flock, and gain an easier access to dominant positions in the male group, which in turn increases his lifetime reproductive success (Alonso *et al.* 1998).

But a higher body mass implies higher adult male mortality. Not only a higher natural mortality. Besides, males suffer from higher human-induced mortality than females through their entire lives. They were prosecuted as a hunting species through the whole human history, either as a prey in prehistoric and Middle Age times, or as trophies in modern times until hunting ban was established. And today they suffer from power line collision as their major mortality cause, which in males reaches 6%, doubling the rate of females (Martín 2008).

Sexual size dimorphism has also a negative effect on physiology. Heat dissipation is an important problem in males due to their body mass/surface ratio, and therefore in the Iberian Peninsula, males from southern, hot breeding areas migrate after breeding to cooler summering areas in the north to avoid the summer heat. Males from southern regions migrate longer distances and in higher proportions than males from northern regions, and summer migration is absent in females (Alonso *et al.* 2009b, Palacín *et al.* 2009). Sexual size dimorphism is surely also the cause of the strong sexual segregation in this species, as males and females differ considerably in their nutritional needs (Bravo 2014). Finally, sexual size dimorphism determines important differences in life history parameters between males and females (delayed sexual maturity and shorter lifespan in males, and skewed sex ratio with more females in all populations), and important differences in breeding strategies (few successful males posses many offspring, contrasting with many successful females that nest every year, although on average each female rears a young successfully only every eight years).

In sum, to maximize their lifetime reproductive success a male's objective is to secure access to females, and to achieve this they invest four months fighting for dominance at the lek. This is the first mechanism of sexual selection, called male-male competition, which favors large size in males. In contrast, the main objective of a female is rearing their single chick, in which they invest 8-15 months of maternal care. Further, females also favor large size of males through a second mechanism of sexual selection, the female choice. This is how sexual selection acts on this species favoring the most extreme sexual size dimorphism among birds, and one of the strongest among vertebrates.

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