Guidelines for radio-tracking Great Bustards

JUAN C. ALONSO

Museo Nacional de Ciencias Naturales,
Consejo Superior de Investigaciones Científicas (CSIC)
José Gutiérrez Abascal 2, 28006 Madrid, Spain
jcalonso@mncn.csic.es

Introduction

Individual marking is a useful method to study wild animals in the field (reviews in BUB & OELKE 1985, BUB 1991). Compared to other marking techniques, radio-telemetry has clear advantages for recording behaviour and demography. It makes animals accessible to systematic sampling, thus reducing many sources of bias (see Table 1), and it does this for specific individuals for which other characteristics such as age and physical condition are known, as in the case of birds released from artificial breeding programmes, or that can be recorded during capture for tagging or through subsequent monitoring (AMLANER & MCDONALD 1980, BUB & OELKE 1985, WHITE & GARROT 1990, KENWARD 2001).

Obtaining true estimates of some demographic parameters, home range and dispersal rates is fundamental in the case of threatened species, for which management and conservation actions must be based on high-quality knowledge of their biology. Such information is also of prime value to evaluate the success of artificial breeding or rearing programmes, in which all birds released should be marked to allow monitoring of their dispersal and survival. There has been a debate on the possible negative effects of capturing and marking procedures on animals, which would be subject to higher mortality, behaviour alterations, or worsening of their physical condition (HESSLER *et al.* 1970, GREENWOOD & SARGEANT 1973, CRAIGHEAD & DUNSTAN 1976, LANCE & WATSON 1977, SNYDER 1985, SMALL & RUSCH 1985, PERKINS 1988, KENWARD 2001). However, most authors admit that capture and marking should be acceptable research methods if the mortality risks they imply are compensated by the benefits derived from the application of the research results to the conservation of the species studied, provided that mortality risks remain low and controlled by the researcher.

The Great Bustard *Otis tarda* is considered *Globally Threatened* and qualifies as *Vulnerable* in the Red List of Threatened Species (BIRDLIFE INTERNATIONAL 2004a & 2004b, IUCN 2006). Its population trend was clearly declining worldwide in the last century due to hunting, agricultural intensification and infrastructure expansion, a tendency that still persists today, when the species has become extinct in several European and Asian countries (CRAMP & SIMMONS 1980, BIRDLIFE INTERNATIONAL 2001). Scientific research was identified as one of the priorities to stop these declining trends in the Action Plans established some years ago (HEREDIA *et al.* 1996). A long-term project based on radio-tracking and aimed at increasing the knowledge of the biology of Great Bustards was started in 1987 in Spain (www.proyectoavutarda.org, see ALONSO *et al.* 1992, 1995, 1998, 2000, 2001, 2004, 2006, MARTÍN *et al.* 2000, 2002, 2007, MORALES *et al.* 2000, 2002), where the main stronghold for the species survives (with an estimated total of ca. 25,000 birds, ALONSO *et al*. 2003, 2005a).

Here we review the current experience with various methods of capturing, marking and radio-tagging Great Bustards, identifying the advantages and risks involved with each technique. Our purpose is to share available experience and best practices with other researchers.

Capture methods

Juvenile birds

Juvenile Great Bustards should be captured in late July to early August, when they are three to ten weeks old and still dependent on their mothers, by chasing them down. After one or two flights young birds usually separate from their mother, lie down and remain immobile, hidden in the ground vegetation, trying to go unnoticed. Chicks less than three weeks old are more reluctant to fly, and thus sometimes easier to catch but too small to be marked. Chicks greater than ten weeks old are frequently impossible to catch by this method, because they fly well and do not tend to hide by lying down. In any case, birds weighing less than 1 kg should be released unmarked, at least with the wing-tags or radio-transmitters recommended below, since juvenile mortality is still too high at that age (MARTÍN *et al.* 2007), and the weight of tags and transmitters could increase natural mortality rates. In our study the average weight at capture was 2,131 g in males (n= 186, maximum weight = 3,800 g) and 1,433 g in females (n= 175) (MARTÍN *et al.* 2007).

The whole capture process, from starting chasing to release, should not last more than 30 minutes, and from capture to release, not more than 10-15 minutes. This method is considered safe and harmless for the species, if carried out by people with previous experience in handling wild birds. We did not observe any apparent negative effects of the marking procedure on the birds.

Comparing counts of young Great Bustards throughout the summer did not produce significant differences between the mortalities of marked and non-marked birds (MARTÍN *et al*. 2007).

Adult birds

After testing several methods to capture adults, the most effective was using rocket nets. However, this technique needs an experienced team, and to avoid problems related with capture myopathy, birds should be quickly removed from the net (from the net shooting to release of the last bird not more than ca. 30 minutes).

Smaller transportable nets have been used to capture a few females at their nests in Russia and Hungary (fired automatically or thrown by night over the female, WATZKE *et al.* 2001, WATZKE 2007, LORANT 2007). Similar nets have also been used to catch Little Bustards *Tetrax tetrax* and Houbara Bustards *Chlamydotis undulata* (LAUNAY *et al*. 1999, SEDDON *et al.* 1999, COMBREAU *et al*. 2001). Their use also needs experience, and the disturbance to incubating females may result in nest desertion.

Large nylon nets hung vertically between two trees or bushes have been successfully used to capture Kori Bustards *Ardeotis kori* in Namibia (T. Osborne, pers. comm.). Kori Bustard apparently do not see the net when driven by car or foot into it, and get entangled. We tested this method in Spain without success.

Nylon snares have been successfully used to catch Houbara Bustards (LAUNAY *et al.* 1999, SEDDON *et al.* 1999, HINGRAT *et al*. 2000). Displaying males step on the laces and get entangled. However, Great Bustards are too heavy and could get seriously injured when trying to escape from the laces.

Finally, oral tranquilizers such as alpha-Chloralose have been used to capture several bird species. Although we had previously caught storks and cranes using this method, we tried catching Great Bustards without success.

Marking methods

The recommended method to mark Great Bustards is the use of radio-transmitters combined with wing tags. The transmitter allows locating the birds through radio-tracking and the wing tag facilitates a quick visual identification of the marked bird in a flock, and enables individual recognition when the transmitter batteries are exhausted. This is particularly important in a long-lived species, in order to maximize the benefits of having already caught and marked the bird, considering all the risks involved in capturing and marking a species classified as vulnerable.

Wing tags

Wing tags (also called patagial tags or wing markers) have been used to mark birds of several species (ANDERSON 1963, MATHISEN 1966, PARRY 1967, SOUTHERN 1971, BLACKMAN 1973, MORGENWECK & MARSHALL 1977, reviewed in BUB & OELKE 1985). They are particularly appropriate for Great Bustards, a large, ground-dwelling species that inhabits open grasslands with high horizontal visibility. Wing tags have been usually made of soft plastic (*e.g.* Saflag, Dantex, Herculite, *etc.*). Such wing-tags have been also recently used to mark Great Bustards in Germany (EISENBERG 2007) and Great Britain (D. WATERS, pers. comm.). Some authors have found that these soft materials do not reliably hold up after a few years, or that the original colour faded, making many tag colours impossible to distinguish. Furthermore, in the case of soft wing tags the numbers or letters are usually painted with permanent ink markers on the plastic, and could become difficult to read after some years.

The wing tags used in the Spanish Great Bustard Project are of rigid coloured PVC (Gravoply) (www.proyectoavutarda.org, see also Plate 2). If they are bent in the upper part to adapt to the wing shape and properly attached to the wing they do not flap when the bird flies, and do not fade even after 10 years (pers. obs.). Wing tags may be lost but this is very infrequent. We have used the same material to make colour rings for common cranes, and could distinguish the colours of the ring after several years.

The Gravoply plate is 1.5 mm thick, and has two layers of different colour (*e.g.* green-white, brown-white, yellow-black, *etc.*), and by engraving a letter, number or symbol on the upper layer it is possible to obtain many combinations of a symbol on a background of a different colour (*e.g.* a green 'A' on white background, or a white '3' on green background, *etc.*). The recommended size of the visible part of the tag is ca. 60 x 60 mm, and the width of the number or letter ca. 10 mm. Thinner symbols are difficult to read from normal observation distances.

The tag is attached to the wing patagium by piercing it with a rivet like those used for the sheep ears using special pliers (Allflex). While piercing it, care should be taken to avoid damaging any blood vessels, muscles or tendons. The total weight of tag plus rivet is ca. 10 g. We recommend covering the tag with thin brown paper painted with black imitating the plumage design of the birds to reduce as much as possible the visibility of the tag to predators during a few days after marking (Plate 1). The paper will usually fall off after some days, showing the design of the tag. Wing tags should have an address label to enable anyone finding a dead marked bird to contact the researcher responsible for the tracking project (Plate 2).

Plate 1: Great Bustard male chick released in Madrid, Spain, after being marked.
Photo: J. C. ALONSO

Plate 2: Wing tags used to mark Great Bustards by Alonso and co-workers in the *Project Great Bustard* in Spain (www.proyectoavutarda.org).
Photo: J. C. ALONSO

Dorsal tags

Dorsal tags similar to wing tags made of rigid plastic, described above, have been used successfully for adult males (Plate 3). They are not recommended for young or adult female bustards, because they would appear too bulky on them, and in the case of adult females, also because they would probably make them more vulnerable than wing tags during incubation. The plate is glued to the top of the backpack transmitter in a vertical position, thus showing the engraved letter or number to both sides of the bird. These tags are easily read from a distance, and apparently do not disturb the bird when flying, as they are quite aerodynamic. The main advantage of dorsal tags over wing tags is that piercing through the patagium is not necessary, which means less time is needed for marking.

Plate 3: Adult male Great Bustard marked with backpack transmitter and dorsal tag before release. Photo: J. C. ALONSO

Radio-transmitters

After testing several types of radio-transmitters and attachment procedures we strongly recommend backpack-mounted units, fitted to the bird with an elastic harness. Below we describe the various fitting methods and transmitter types we have tested (see also Table 1).

Patagial tags

Radio-transmitters were glued to small wing tags of rigid plastic, which were attached to the patagium as described above. This method obviously limits maximum transmitter weight and lifespan. We tested this type in 1991, and discarded it for its short lifespan and also after observing a high percentage loss a few weeks to a few months after marking (>80 %, ALONSO *et al.* 1996a). The relatively heavy transmitter fell off probably tearing the patagium, which however did not affect the survival of the bird. We do not recommend this tag type for Great Bustards.

Table 1: Main characteristics of transmitters and fitting methods used in the *Great Bustard Project* by J. C. Alonso *et al*. (see www.proyectoavutarda.org).

Fitting method	Age / sex	Manufacturer & model	Pulses per minute	Antenna length (cm)	Weight (g)	Estimated lifespan (months)	Transm. Size (mm)	Reception distance (km)[1]
Patagial tag[2]	juveniles of both sexes	Telonics CHP-4P	55	25	18	19	48x15x15	1-2
	juveniles of both sexes	Biotrack (TW2) 1 x AA x 1/3	30-35	25	24	8-12	45x15x15	2-3
Wing band[2]	juveniles of both sexes	Biotrack (TW2) 2 x AA x 2/3	30-35	30	40	30-42	44x29x16	2-3
'Poncho' & neck-collar	only juvenile & adult females	Biotrack (TW3) 2 x AA x 2/3	35-40	25-30	30	30-42	38x29x16	2
	only juvenile & adult females	Telonics 225	50	30	50	16-20	41x24x20	2-2.5
Backpack[3]	juveniles & adults of both sexes	Biotrack (TW3) 2 x AA	30-35	30	60	36-48 (>27)	70x30x18	2 - 3
	juvenile males	Biotrack (TW3) 1 x C	30-35	30	80	36-48	70x35x30	2 - 3
	juveniles & adults of both sexes	Biotrack (TW5) 2 x AA	30-35	30	60	48-60	70x30x18	2 - 3
	adult males	Biotrack (TW5) 3 x AA	30-35	30	100	72-96	70x45x18	2 - 3
	juveniles of both sexes	Biotrack (TW5) 1 x AA x 1/3[4]	30-35	30	10	7-9	25x15x15	1.5-2
	juveniles of both sexes	Microwave[4]	1	30	50	≥24[5]	100x30x20	satellite

[1] usual maximum reception distance from the ground; from top of hills or other elevated points this distance increases up to 10-20 km e.g. for TW3 Biotrack transmitters; from aeroplanes, the reception distance may increase up to 30-40 km when the bird is on the ground and >100 km for flying birds

[2] these attachment methods are not recommended for Great Bustards

[3] elastic band is recommended in all cases for the harness

[4] our satellite transmitters had small VHF transmitters attached, to facilitate the location of the bird with conventional receivers from the ground

[5] depending on power source (batteries, solar panels)

Wing band mounts

The transmitter is attached to a flexible plastic wing band which surrounds the humerus and is sewn with staples behind it. The staples would eventually break and the wing band should fall off with the transmitter. We indeed observed a percentage loss of wing band transmitters of ca. 20 % (ALONSO *et al*. 1996a), which we suspect was primarily due to the fixing system used. The weight of the transmitter should not exceed 20-30 g, and therefore its lifespan is also limited to ca. 2 years, the main reason to also consider this type suboptimal.

Ponchos or necklaces

There are various types of necklaces described in the literature (KENWARD 2001). We used some of these, and also a modified version of the 'poncho' attachment described by PERKINS (1988). Necklaces weighing ca. 20 g have also been used in Germany and UK, to mark females released from artificial rearing programmes (EISENBERG 2007, D. WATERS, pers. comm.). In poncho-mounts the transmitter was attached to a reinforced, flexible, ca. 10 x 10 cm plastic sheet. A 3.5 cm diameter hole was cut off the upper part of the plastic sheet through which the bird's head could easily pass, so the transmitter hung from the bird's neck and the antenna was directed upwards and slightly curved backwards. Since the plastic material used was not elastic, a cut was made at one side of the neck hole to allow for neck growth without damaging it. Both sides of the cut were then rejoined through 2-3 elastic rubber strips.

The main advantage of ponchos or necklaces is that both are easier and quicker to attach than backpacks. However, they cannot be used for male chicks because their neck has still to grow considerably. Ponchos or necklaces can be used on adult females, but again, their use is not possible on adult males, which inflate their necks during display. The disadvantage is that the weight of the transmitter, and therefore its lifespan, is also limited (the recommended maximum weight of poncho or necklace transmitters is 30 g, which allows for ca. two years transmission). Furthermore, the percent loss of this type of transmitter was higher (up to 15 %, ALONSO *et al*. 1996a) than that of backpacks (no losses at present, ALONSO *et al.* unpublished). This might be considered an advantage if one could predict the time when the transmitter would be lost, but this is not possible. In Germany necklaces were usually lost after one to three years (EISENBERG 2007). Although necklaces and ponchos might be useful for short-term studies, their weight limits their lifespan, and thus we prefer backpacks.

Tail mounted transmitters

They have been used in Germany during the last years to mark males released after artificial incubation (EISENBERG 2007), and in UK also in a few birds in 2005-06 (D. WATERS, pers. comm.). Their weight is 15-20 g and thus their life

is limited. Also, young birds usually moult their tail feathers at an age of 100-130 days, which limits the tracking period to 3-4 months (EISENBERG 2007). Considering the effort spent on catching young Great Bustards in the wild, or rearing them from artificially incubated eggs, this transmitter type is not recommended.

Back-packs and harness material

This popular and widely used attachment method (KENWARD 2001) is also the recommended one for Great Bustards of both sexes and all ages. Of the several harnessing ways described, we prefer the harness passing through transverse tubes across the front and back of the transmitter, and crossing at the ventral part, by the sternum of the bird.

After testing several harness materials (plastic, silicone, Teflon ribbon, over-braided rubber tubing, and metal wires covered with these), we strongly recommend using clothing elastic band of ca. 15 mm width. All tubing materials tested were, in general, less flexible than is desirable. According to manufacturers, Teflon (available from Bally Ribbon Mills and some tag suppliers) is biologically inert and does not change with time or cutting. It is said to be best for long-life attachments, with the only disadvantage that free ends must be sealed to prevent unravelling. However, after having attached many transmitters to Great Bustards, we are certain that the expensive Teflon does not last longer than the much cheaper elastic band we use. Teflon ribbon generally worked well, but we observed that it frequently got somewhat stiff after several months use and in many cases lateral cuts were noticed at the folding points of the harness.

The obvious advantage of the elastic harness is that it allows the chick's body to freely reach its final adult size, even in the case of males. The elastic band we use stretches up to ca. three times its normal length and keeps elasticity for many years. It also fits to the body very well and we observed no injuries to either feathers or skin after several years. The damage caused to young Great Bustards fitted with elastic harnesses in the first year of the British reintroduction project, in 2004, was due to the excessive tightening of the harness and too thin and less elastic band. We recommend an elastic band of ca. 15 mm width.

We have used various types of back-pack transmitters (Table 1), and recommend the 2xAA-battery model which lasts 4-6 years, with the following technical specifications: slow pulse rate (35 bpm), 30-40 ms pulse length, reinforced antenna base, heavy gauge, and 20 degrees antenna exit angle upwards. A heavier model (3xAA) may be used for adult males, which may last up to 8-9 years. As a rule, it is recommended that the weight of back-pack transmitters should not exceed 3 % of the bird's weight (AMLANER & MCDONALD 1980, KENWARD 2001).

Methods intended to reduce risk to animals by detaching or loosening tags may cause problems, and reliable time-release mechanisms are not yet available (KENWARD 2001).

Satellite transmitters

PTTs and more recently GPS tags, which are much more accurate (location resolution ca. 20-30 m), have been used on Great Bustards in Spain (1997, ALONSO *et al*. 2002), Russia (1999-2000, WATZKE *et al*. 2001, WATZKE 2007), Hungary (2006, LÓRÁNT 2007), and UK (2007, D. WATERS, pers. comm.). They are ideal for long-range migratory species but very expensive (ca. €3,000 per unit plus ca. €2-3 per day tracking costs). Therefore they may be recommended only to study migratory populations like the Russian one, or when funding is not a restriction. As an alternative, VHF back-packs combined with aerial tracking using small aeroplanes should be considered.

Other marking methods

Metal and colour rings

Numbered metal rings are being used to mark most Great Bustards released from artificial incubation and captive rearing programmes in various European countries (*e.g*. Germany and Hungary). Several types of coloured metal or plastic rings with alphanumeric individual codes have been also used, *e.g*. in Germany in 1982-92 and from 1999 to present (EISENBERG 2007). However, neither the conventional numbered metal rings nor the colour rings with numbers or letters are recommended, particularly in juvenile birds, because their tibias and tarsi will continue growing and ring diameters appropriate for adult size would stay too loose on juveniles and might cause some problems. There is a small risk that rings on the tibia or tarsus may cause some damage to the bird if they slip down and embrace, respectively, the tibio-tarsal joint or the fingers. However, the main reason for discarding this method of marking Great Bustards is that metal rings are meant to allow identification of the birds only when they are found dead, and this may also be achieved through the address labels of wing tags or radio-transmitters. Coloured leg rings with alpha-numeric codes are very difficult to read at observation distances tolerated by the birds, and combinations of colour rings allowing individual identification are also extremely hard to see as the vegetation is usually higher than the legs. We do not recommend them in Great Bustard studies.

Neck collars

The use of neck collars to mark Great Bustards is not recommended. In males they would prevent neck inflating during display, and for females we prefer wing tags.

Implants, transponders and microchips

These are not necessary if other marking methods are used. Implants and transponders usually give only short-term data, and have reduced detection ranges.

Tracking marked birds

Reception distance with conventional wildlife radio-tracking receivers varies usually between 2-5 km ground to ground for the 2xAA transmitter model recommended above. From elevated points this reception distance may increase to ca. 20 km.

All marked birds should be located with a pre-determined frequency depending on the objectives of the study. Usually at least once per month or even once per week throughout the marked birds' lives will be desirable. To reach scientifically supported conclusions researchers will need large sample sizes, and since in radio-tracking studies the sample unit is usually the individual, a reasonably large number of different birds should be tracked in order to calculate the averages of the behavioural patterns studied. Many radio-tracking studies end up with just a few data of a small number of individuals, during one or two years. In the case of long-lived species, particularly if they are protected, these studies should be prolonged as much as possible in order to exploit to the full the fact of having captured and marked individuals, considering the risks involved in such operations.

When a radio-tagged bird disperses outside the range usually covered by ground tracking, aerial searches should be carried out with small aeroplanes, to which directional antennae are attached using special brackets available from some manufacturers. Reception distances will then go up to 40-50 km for birds on the ground, and even more for flying birds.

After locating any signal from the aircraft the fate of the bird should be confirmed through visual contact with the bird from the ground, in order to check whether it is alive or dead. Moreover, visual contact with each bird is usually required in most radio-tracking studies, which as a rule are with the aim of studying specific behavioural patterns of the marked animals. In the case of short-distance migratory Great Bustard populations, with the aid of aerial radio-tracking, researchers should be able to locate all marked birds (*e.g.* in Spain, aerial location success of dispersing or migrating birds was nearly 100 %, ALONSO *et al.* 1996b). In these cases the main problem commonly affecting dispersal studies, *i.e.* the emigration of individuals outside the study area, may be solved (KOENIG *et al.* 1996). Otherwise, satellite tracking may be a better alternative to track the birds, for example in migratory bustard populations like those living in Russia.

Satellite tracking is much more expensive than ground or even aerial tracking, but also usually renders more locations per unit time, and is the only way to track Great Bustards that migrate long distances. The number of locations can be programed by the manufacturer, but again, usually visual contact with all marked birds will be desirable after satellite location, at least with a certain frequency (*e.g.* once per month). The cost of these periodical ground controls of marked birds should be added to the cost of satellite units plus transmission of data. Perhaps the ideal combination is to mark as many birds as possible with VHF transmitters, to reach sample sizes adequate for statistical treatment, and a few with satellite units, to ensure their location in case of long-distance migration or dispersal. Since Great Bustards tend to use the same breeding and wintering areas year after year, individuals marked with satellite units will help finding most birds provided with VHF units, thus keeping the cost of radio-tagging reasonably low.

Table 2: Some benefits of radio-tracking *vs.* alternative marking methods.

Study objective	Radio-tracking	Advantages
Natal and breeding dispersal	essential	no alternative method to track all birds
Mortality	essential	only way to establish true mortality rates
Migratory and seasonal movements	required	allows continuous tracking; satellite telemetry necessary for long-distance migration
Home range and space use	required	enables easy location and continuous tracking
Longevity	required	facilitates tracking until battery depletion
Viability modelling	required	allows estimation of demographic parameters
Census	useful	facilitates location of birds or flocks by tracking marked individuals

References

ALONSO, J.A., MARTIN, E., ALONSO, J.C., & MORALES, M.B. (1996a): Vergleichende Analyse der Markierungsmethoden für juvenile Grosstrappen (*Otis t. tarda* L., 1758) im Feld. *Naturschutz u. Landschaftspflege in Brandenburg* 1/2: 80-83.

ALONSO, J.A., MARTÍN, C.A., ALONSO, J.C., MORALES, M.B. & LANE, S.J. (2001): Long distance seasonal movements of male Great Bustards (*Otis tarda*) in central Spain. *Journal of Field Ornithology* **72**: 504-508.

ALONSO, J.A., MARTIN, E., MORALES, M.B. & ALONSO, J.C. (1996b): Aerial tracking of Great Bustards (*Otis tarda*) in Spain. In: J. FERNÁNDES & J. SANZ-ZUASTI (eds): Conservación de las Aves Esteparias y su Hábitat. Junta de Castilla y león, Valladolid, pp. 283-286..

ALONSO, J.C. & ALONSO, J.A. (1992): Male-biased dispersal in the Great Bustard *Otis tarda*. *Ornis Scandinavica* **23**: 81-88.

ALONSO, J.C., ALONSO J.A., MARTÍN C.A., PALACÍN C. & MAGAÑA M. (2002): Radioseguimiento de especies amenazadas: el caso de la avutarda. In: A. SÁNCHEZ (Ed.), *Actas de las XV Jornadas Ornitológicas Españolas*,. SEO/BirdLife, Madrid, pp. 101-113.

ALONSO, J.C., ALONSO, J.A., MARTIN, E. & MORALES, M.B. (1995): Range and patterns of Great Bustard movements at Villafáfila, NW Spain. *Ardeola* **42**: 69-76.

ALONSO, J. C., MAGAÑA M., MARTÍN C. A., PALACÍN C. & ALONSO J. A. (2006): Field determination of age in male Great Bustards (*Otis tarda*) in spring. *European Journal of Wildlife Research* **52**: 43-47.

ALONSO, J.C., MARTIN C.A., ALONSO J.A., PALACIN C., MAGAÑA M. & LANE S.J. (2004): Distribution dynamics of a Great Bustard metapopulation throughout a decade: influence of conspecific attraction and recruitment. *Biodiversity and Conservation* **13**: 1659-1674.

ALONSO, J.C., MARTIN, E., ALONSO, J.A. & MORALES, M.B. (1998): Proximate and ultimate causes of natal dispersal in the Great Bustard, *Otis tarda*. *Behavioral Ecology* **9**: 243-252.

ALONSO, J.C., MORALES, M.B. & ALONSO, J.A. (2000): Partial migration, lek fidelity and nesting area fidelity in female Great Bustards *Otis tarda*. *The Condor* **102**: 127-136.

ALONSO, J. C., PALACÍN, C. & MARTÍN, C. A. (2003): Status and recent trends of the Great Bustard (*Otis tarda*) population in the Iberian Peninsula. *Biological Conservation* **110**: 185-195.

ALONSO, J. C., PALACÍN, C. & MARTÍN, C. A. (eds.). (2005): *La Avutarda Común en la Península Ibérica. Población actual y método de censo*. SEO/BirdLife, Madrid.

AMLANER, C.J. & MCDONALD, D.W. (1980): *A Handbook on Biotelemetry and Radiotracking*. Pergamon Press. Oxford.

ANDERSON, A. (1963): Patagial tags for waterfowl. *J. Wildlife Management* **27**: 284-288.

BIRDLLIFE INTERNATIONAL (2001): *Threatened birds of Asia: the Birdlife International red Data Book*. Cambridge.

BIRDLIFE INTERNATIONAL (2004a): *Threatened Birds of the World 2004*. CD-ROM. BirdLife International, Cambridge.

BIRDLIFE INTERNATIONAL (2004b): *Birds in Europe: population estimates, trends and conservation status*. BirdLife Conservation Series 12. Cambridge.

BLACKMAN, J.G. (1973): Marking methods for studying Australian Crane. *Australian Bird Bander* **11**: 56-57.

BUB, H. & OELKE. (1985): *Markierrungsmethoden für Vögeln*. Brehm Bücherei.- Wittenberg-Lutherstadt.

BUB, H. (1991): *Bird Trapping and Bird Banding*. Cornell University Press.

COMBREAU, O., LAUNAY, F., & LAWRENCE, M. (2001): An assessment of annual mortality rates in adult-sized migrant houbara bustards (Chlamydotis [undulata] macqueenii). *Animal Conservation* **4**: 133-141.

CRAIGHEAD, F.C. & DUNSTAN, T.C. (1976): Progress towards tracking migrating raptors by satellite. *J. Raptor Research* **10**: 112-120.

CRAMP, S. K. & SIMMONS, E. L. (eds.) (1980): *The Birds of the Western Paleartic, vol. 2*. Oxford University Press, Oxford.

EISENBERG, A. (2007): Post-release Monitoring in Germany. Oral presentation at the Great Bustard Conference, November 2007, Salisbury, UK.

GREENWOOD, R.J. & SARGEANT, A.B. (1973): Influence of radio packs on captive mallards and blue-winged teal. *J. Wildlife Management* **37**: 267-274.

HEREDIA, B., ROSE, L. & PAINTER, M. (1996): *Globally threatened birds in Europe. Action Plans*. Council of Europe Publishing, Strasbourg.

HESSLER, E., TESTER, J.R., SNIFF, D.B. & NELSON, M.M. (1970): A biotelemetry study of survival of pen-reared pheasant released in selected habitats. *J. Wildlife Management* **34**: 267-274.

HINGRAT, Y., SAINT JAULME, M., YSNEL, F., LACROIX, F., SEABURY, J. & RAUTUREAU, P. (2000): Relationships between home-range, size, sex, and season with reference to the mating system of the Houbara Bustard *Chlamydotis undulate undulata*. *Ibis* **146**: 314-322.

IUCN. (2006): *2006 IUCN Red List of Threatened Species*. http://www.redlist.org [accessed 30 May 2007].

KENWARD, R.E. (2001): *A Manual for Wildlife Radio Tagging*. Academic Press. London

KOENIG, W.D., VUREN, D.V., & HOOGE, P.N. (1996) Detectability, philopatry and the distribution of dispersal distances in vertebrates. *Trends in Ecology and Evolution* **11**: 514-517.

LANCE, A.N. & WATSON, A. (1977): Further test of radio-marking on red grouse. *J. Wildlife Management* **41**: 579-582.

LAUNAY, F., COMBREAU, O., ASPINALL, S.J., LOUGHLAND, R.A., GUBIN, B. & KARPOV, F. (1999): Trapping of breeding Houbara Bustard (*Chlamydotis undulata*). *Wildlife Society Bulletin* **27**: 603–608.

LORANT, M. (2007): Satelite tracking in the Upper Kiskunság region. Oral presentation at the Great Bustard Conference, November 2007, Salisbury, UK.

MARTÍN, C.A., ALONSO, J.C., ALONSO, J.A., MORALES, M.B., & PITRA, C. (2000): An approach to sexing young Great Bustards *Otis tarda* using discriminant analysis and molecular techniques. *Bird Study* **47**: 147-153.

MARTÍN, C.A., ALONSO, J.C., ALONSO, J.A., PITRA, C. & LIECKFELDT. D. (2002): Great Bustard population structure in central Spain: concordant results from genetic analysis and dispersal study. *Proceedings Royal Society London B* **269**: 119-125.

MARTÍN, C.A., ALONSO, J.C., ALONSO, J.A., PALACÍN, C., MAGAÑA, M., & MARTÍN, B. (2007): Sex-biased juvenile survival in a bird with extreme size dimorphism, the Great Bustard *Otis tarda*. *Journal of Avian Biology* **38**: 335-346.

MATHISEN, J. (1966): Patagial tags on Evening Grosbeaks. *IBBA News* **38**: 129.

MORALES, M.B., ALONSO, J.C., & ALONSO, J.A. (2002): Annual productivity and individual female reproductive success in a Great Bustard *Otis tarda* population. *Ibis* **144**: 293-300.

MORALES, M.B., ALONSO, J.C., ALONSO, J.A. & MARTIN, E. (2000): Migration patterns in male Great Bustards. *The Auk* **117**: 493-498.

MORGENWECK, R.O. & MARSHALL, W.H. (1977): Wing marker for American Woodcock. *Bird Banding* **48**: 224-227.

PARRY, U.A. (1967): The patagial methods for tagging birds. *Austral. Bird Band.* **48**: 224-227.

PERKINS, P.J. (1988): Effect of poncho-mounted radio in Blue Grouse. *J. Field Ornithology* **59**: 46-50.

SEDDON, P.J., LAUNAY, F., VAN HEEZIK, Y. & AL BOWARDI, M. (1999): Methods for live trapping Houbara Bustards. *J. Field Ornithology* **70**: 169–181.

SOUTHERN, W.E. (1971): Evaluation of a plastic wingmarker for full studies. *Bird Banding* **42**: 88-91.

SMALL, R.J. & RUSCH, P.H. (1985): Backpacks vs. Ponchos: Survival and movements of radio-marked Ruffed Grouse. *Wildlife Society Bulletin* **13**: 163-165.

SNYDER, W.D. (1985): Survival of radio-marked hen ring-necked pheasants in Colorado. *J. Wildlife Management* **49**: 1045-1046.

WATZKE, H. (2007): Results from satellite telemetry of Great Bustards in the Saratov region of Russia. *Bustard Studies* **6**: 83-98.

WATZKE, H., LITZBARSKI, H., OPARINA, O. S. & OPARIN, M. L. (2001): The migration of Great Bustards *Otis tarda* from the Saratov region (Russia): First results of a satellite tracking study. *Vogelwelt*: **122**: 89-94.

WHITE, G.C. & GARROT, R.A. (1990): *Analysis of Wildlife Radio-Tracking Data*. Academic Press, New York.