Review of options for rear and release of great bustards in the UK

A report to the Great Bustard LIFE Project Steering Group, June 2012.

1. Background

The breeding population of the great bustard *Otis tarda* became extinct in the UK around 1830 probably due to hunting and agricultural changes (Burnside et al 2012). There was an attempt to re-establish this species in the 1970s by the Great Bustard Trust. The aim of this was to maintain breeding birds in captivity and release the young. This project was unsuccessful due to the inability of the captive population to produce sufficient fertile eggs to stock the reintroduction attempt. Sourcing the birds from a wild donor population was thought to be the only feasible method to successfully reintroduce birds. In 2004, the Great Bustard Consortium (GBC – the Great Bustard Group and Stirling University) gained a licence for a 10-year trial reintroduction that would transport young great bustards from a rearing facility in Russia to the UK to be released on Salisbury Plain. This project funded a joint conservation project, which included rebuilding the old field station in Russia, developing and implementing all the incubation and rearing procedures, and providing all equipment and staff costs.

At the Institute's steppe research branch at Saratov, great bustard eggs were collected for several decades from nests that would otherwise have been destroyed by agricultural operations. The eggs were incubated and captive rearing and release of the young was undertaken. The young birds were then transported to the UK at between one and three months of age, and spent 30 days in quarantine before being released on Salisbury Plain. However, since the release programme began, immediate post release mortality has been high. This may be due to the condition/behaviour of the birds being released. The GBC had long been aware of the benefits of moving eggs instead of moving chicks; however there had been political criticism of the collection or movement of eggs which had previously prevented this from being agreeable.

As part of the LIFE project, a Technical Working Group meeting held in July 2011 reviewed and discussed all factors that might affect the survival of the birds, from hatching in Russia through to release in the UK. The possibility of bringing eggs back from Russia to hatch in the UK was again discussed and it was agreed that this should be taken forward in the project in 2012 in order to improve rearing conditions and environmental habituation. The proposal is to undertake the importation of 50% eggs and 50% chicks, expecting a maximum of 20 eggs.

The main benefit of importing eggs is that all aspects of rearing and feeding can be controlled and monitored. Additionally this will provide a more consistent environment for the chicks to grow up in which will reduce stress. Data on survival of birds released so far (since 2004) has also shown that those released earlier survive longer (J. Burnside unpublished data). Although there are many variables which affect this, it is thought that releasing younger birds could help post release survival. One way to release birds earlier (due to UK DEFRA quarantine regulations) is to hatch them in the UK, instead of in Russia. Therefore, the stages of soft-release could begin earlier and the birds could be released around a month earlier in the year. This approach could therefore provide the opportunity for better development and growth before winter, and improve survival rates.

Although some rear and release methods and techniques have been developed in various projects, the knowledge and experience gained is not as great as for some other species, eg cranes. In some cases, the techniques have been poorly documented, may not have been scientifically tested and monitored, and the success of some projects may be difficult to gauge. Additionally, quarantine regulations may restrict the ability to carry out certain practices. The recently developed '*Guidelines for reinforcement and reintroduction of the Great Bustard*' prepared by Torsten Langgemach present a well documented and valuable source of information which has been included in this review.

The main limitation to the success of the reintroduction project in the UK is high mortality in the first six months following release, mainly due to predation of birds, by foxes and possibly badgers, and collision with fences and power lines. These problems are exacerbated by dispersal of birds away from the release sites shortly following release, limiting the ability of the project to reduce mortality through specific habitat selection and management for young bustards. Therefore there is a need to focus on increasing survival by producing birds that are better able to deal with these issues. In particular, we need to look carefully at rear and release methods that will: 1) help prepare birds for their new environment before release and 2) provide support for birds after release with the aim of maintaining a flock of newly-released birds longer around the release sites.

This review has been undertaken by the RSPB Species Recovery team following discussion at the Great Bustard LIFE+ Project Steering Group meeting.

2. ***Aims***

- To document rear and release methods employed in projects involving great bustards, and similar species.
- To highlight where there are different approaches between methods employed between projects.
- To identify issues requiring further investigation and where possible identify the most appropriate methods for adoption by the Great Bustard LIFE Project Steering Group.
- To make any findings available to other bustard project teams and interested groups/individuals.

3. ***Summary of most relevant great bustard projects***

Russia/UK
Estimates for the population of great bustards in Russia vary but are generally thought to be around 8000 individuals (Palacin & Alonso 2008), the majority of which are found in Saratov Oblast. The main threat to great bustards in this region is hunting and agricultural change and because of this the Saratov branch of the A.N. Severstov Institute of Ecology and Evolution has been rescuing eggs from destruction from cultivation since the 1980s (Dawes *et al* 2008). These eggs have been used for rear and release into the wild. Since 2004, some of the resulting chicks have been used in the UK reintroduction programme. Rear and release methods are described in Pereverzina & Waters 2008.

Germany
Great bustard conservation in Germany began in the 1970s. Having once been common in Germany (3000 were recorded in Brandenburg alone in 1939 (Langgemach 2008)) they declined steadily in the 20th century, with an acceleration in decline occurring in the 1970s when threats were magnified by the industrialisation of farming. During this time the only way to negate the detrimental effects of intensive farming was to rescue threatened clutches of eggs, incubate them artificially, and release hand-reared individuals back into the population. Since the 1980s habitat management has been a key delivery mechanism in the conservation of bustards in Germany but the ‘head-starting’ scheme is still essential to the survival of the population. The population reached its lowest point in the 1990s, but due to the intensive conservation effort has increased slightly once again to 123 birds in Spring 2012 (Torsten Langgemach pers comm).

As there are still three core areas remaining within the German population, only eggs from the indigenous population are artificially reared and no birds have been translocated from outside the country. Eggs collected are those that would otherwise be at risk from farming operations, or would have a low chance of survival eg from predation. Decision criteria for the collection of these eggs are shown in Langgemach 2008.

Hungary
The population of great bustards in Hungary was around 1300 individuals in 2007 representing about 3% of the global population (Palacin & Alonso 2008). Having once been

far more numerous and widespread, the population is threatened by agricultural operations, particularly mowing. Thus nest protection is undertaken to ensure the best outcome for nests. In some cases this means artificial incubation and can also result in captive rearing of chicks for later release if required.

Rearing bustards from eggs is not a new activity in Hungary (Czifark & Szelenyi 2008). Rescued eggs were historically reared under domestic fowl and were kept on farms. In the 1930s, hunters reared them in the same way, driving them out to fields for shooting stock once they were fully grown. In 1978, with conservation of the population in mind, the Great Bustard Rescue Station was opened by the government. Up until 2007, 574 chicks had been released from this facility (Czifark & Szelenyi 2008). This head-starting technique involves taking only eggs from endangered nests, which on average include 35 eggs annually (Ashbrook *et al* 2011). This is currently a great bustard LIFE nature project. Rear and release methods are described in Czifark & Szelenyi 2008.

4. ***Current methods and techniques in practice***

4.1 Egg transportation

4.1.1 Stage of incubation

As most great bustard translocation projects do not involve transporting eggs over long distances (most are within the same country), the data on and experience of this are limited. In great bustard projects transportation time may be no more than a few hours. The total transport time of live birds from Russia to the UK, including customs and security processes in Moscow and London, is about 43 hours (Pereverzina & Waters 2008). It is estimated that transportation of eggs from Russia will take approximately 48 hours.

The standard practice for egg transportation is that eggs should be transported at a late stage of development. In the Great Crane Project, it is recommended that eggs should have been incubated for between 20 and 24 days (ie more than 75% of the incubation period) before transportation (GCP 2010). It is equally important to make sure transportation is not too late to risk hatching during transit.

Fertility and timing of incubation is difficult to gauge in great bustards due to the thickness, structure and pigmentation of the egg. X-raying the eggs would be an alternative possibility to assess fertility although the risks involved in doing this are high. Very rough estimation of the age is possible by checking the egg-shell, which gradually changes from dull after laying to smooth and shiny towards hatching (Langgemach 2012).

In cranes the incubation stage of the egg is assessed by using the egg density loss technique. It has previously been suggested that determining the age of an egg based on weight loss (as described by Deeming 2000) does not work for bustards (Langgemach 2008). However, Pereverzina & Waters 2008 state that average daily weight loss for fertile developing eggs is 0.9g, and slightly less for infertile (0.6g) or dead eggs (0.7g). More up to date information (Langgemach 2012) suggests that 15% weight loss between laying and hatching is typical for great bustards. However, weight loss and an increasing size of the air space is also found in rotten eggs. It seems that accurately calculating the age of the egg using this method requires further investigation. A predictive hatch graph has been developed using data from Germany and Russia.

In the Hungarian project the stage of incubation is judged by a water probe (Czifark & Szelenyi 2008). Alternatively, if the laying date is unknown, the egg is placed on a flat surface to check for significant movement (which usually begins at around 18 days). In this project the eggs are weighed every 5-6 days.

Determining the stage of incubation of eggs is known at least to some degree of confidence will be vital in deciding when to transport eggs. However, there seems no reliable way to do this at this stage. Data from the German project is currently being analysed to further assess the accuracy of the egg density loss technique for great bustards.

4.1.2 Method of transportation

In Germany, eggs are transported over short distances in Styrofoam boxes, or in transport incubators for longer distances (up to 60km) (Langgemach 2008). Similarly in Hungary and Russia, eggs are transported in mobile incubators (at 37.6°C in the Hungarian project (Czifark & Szelenyi 2008)) and powered by the vehicles power supply (Pereverzina & Waters 2008).

In the US, Kori bustard eggs are transported between zoos and captive rearing centres very successfully. With this species, eggs are moved over land or by air. When transporting by road the eggs are put in an electronic portable brooder kept plugged in during the transport and during any overnight stays and set to 35°C (AZA 2011). The temperature in the unit is checked regularly and the unit should have built in thermometers to ensure a constant desired temperature. Proper packing of eggs is essential to reduce jarring and rough-handling.

Airline travel generally dictates that an insulated plastic container (e.g. coolbox) is used and a keeper accompanies the eggs during the entire transport process. The container is clearly marked “Live Avian Embryos” and the temperature in it is maintained by using portable self-warming pads (AZA 2011). This is monitored constantly via a temperature probe to ensure the eggs maintain a steady temperature (between 35°C-37°C). Arrangements for airlines will vary and experience from Kori bustards in the US has emphasised the importance of working closely with the airlines to be sure that they understand exactly the needs of transporting eggs (Sara Hallager pers. comm.). It is therefore vital to obtain all the information required from the airline with regards to the logistics e.g. if the container is x-rayed the eggs must be removed and provision should be made for this; a health certificate and an explanation letter may have to accompany the eggs; the container must be in an appropriate position in the aircraft i.e. accessible and secure. Although the internal flights regulations within the USA do not reflect the situation for international flights, some of these points will be useful for transporting eggs within the context of the UK project.

In the Great Crane Project, eggs are transported from Germany to the UK (an 18 hour non-stop road trip) and captive reared at WWT Slimbridge. A detailed protocol is followed for this transportation and includes the following points:

- Eggs are translocated in proven 12 volt DC portable incubators connected to the car battery using either crocodile clips attached directly to terminals, or plugged in to the cigarette lighter socket. The temperature of these incubators is set at 36 ºC, at an ambient relative humidity (i.e. no humidity added), and they are equipped with an overheating thermostat and alarm buzzer (set at 37.0 °C) with a digital temperature display unit (accurate to ± 0.1 ºC).
- The transportation of eggs takes place either by road, with the incubators carried in the rear seat of a car and driven to the destination at a speed appropriate to the road conditions and to protect the eggs from jolts, or by air, with the incubator positioned on the seat of the aircraft adjacent to the accompanying aviculturalist (subject to approval from the airline).

Conclusions

- Transportation boxes/incubators should be upholstered for protection against vibration and be maintained at temperature and humidity levels as described in the artificial incubation section below.
- With up to 20 eggs from different nests being transported, it will not be possible to ensure all eggs are at the same stage, or that all are at a late stage of development. However, it should be recognised that these are both important considerations and the development of a technique to measure the age of an egg would be highly beneficial. Any ways of improving such methods should be included eg collecting weight data on weight.

4.2 Egg management

In all projects, great care is taken over handling eggs with regards to hygiene. Eggs are handled as little as possible and only by thoroughly disinfected hands, or clinical gloves are worn (Langgemach 2008). If eggs are excessively dirty they are cleaned using warm water that is above the temperature of the egg (in a washing solution or under running water of about 35-40℃ ie above the temperature of the egg (Williams 2012)). Eggs suspected to be not developing well e.g. no movement, physical damages, slight smell, are removed to a separate incubator.

It is generally good practice to record biometrics at the collection stage (width, length and weight) (Czifark & Szelenyi 2008) and to mark each egg with a pencil in order to continue a good record of information for each egg from collection to hatching to release. It is also useful to take photographs where possible. Failed eggs have to be considered a valuable source of information. Immediate analysis in an experienced veterinary laboratory might provide results that are important for the rest of the breeding season, although it is difficult to do this with eggs in quarantine.

Conclusions
Egg management should follow standard practice followed in any incubation protocol. This will include the following:

- To avoid any contamination, the eggs should be touched as little as possible using rubber gloves or thoroughly cleaned and disinfected hands.
- Only badly contaminated eggs should be washed.
- Suspect eggs should be separated for further incubation, or stored separately for later analysis.
- Each egg should be marked for continual identification.
- Weighing each egg approximately every two days is recommended in order to calculate the weight loss and to be able to adjust the humidity for further brooding.
- Nearer the hatching date, the eggs should be carefully observed for signs of hatching.

4.3 Artificial incubation

The incubation of great bustard eggs varies slightly between projects from available information (see details in Table 1). Although broadly similar, there are slight differences in the method and equipment used. The ambient temperature of the incubation room is also important. Best results have been achieved in the German project with an ambient room temperature of 22-24℃ with 50% air humidity (Williams 2012). Success rates for German project were 69.7% between 2000 and 2007 (Langgemach 2008) and this had increased to 87.7% in 2011 (Torsten Langgemach pers comm.). Consistently high hatrching success rates have also been recorded in the Russian project (David Waters pers comm.).

In the Great Crane Project, 240-volt Brinsea Polyhatcher still-air incubators are used, each operating at different settings. This is because the weight of the crane eggs is monitored very closely and the eggs are moved between relatively ‘wetter' and ‘dryer' incubators depending on the rate of mass being lost (i.e. if losing too much the eggs will be moved to the ‘wet incubator').

The incubation period is reported as being between 21 and 28 days (Cramp and Simmons 1980). This is assumed to be about 24 days in the German project (Langgemach 2012). In general, as the egg nears the hatching point there is increased calling and movement of the chick in the egg due to internal pipping. At this point in all projects the eggs are moved into hatchers which in general are very slightly cooler and have a higher relative humidity to prevent the egg from drying out during hatching. The settings of the hatchers in each project are described in Table 1. With Cranes, the eggs are placed in a pre-hatcher (approximately 2 days before hatching when chicks may have internally pipped but have not broken the shell), followed by a hatcher (when the chicks externally pip i.e. break the shell). This does not seem necessary for great bustards where eggs are moved to a hatcher on pipping.

Hatching is recorded as taking 18 hours on average (Czifark & Szelenyi 2008), but can be between 20 and 24 hours in total (Williams 2012). Any longer than this is thought to have a negative correlation with the vitality of the chick. If hatching takes longer than 24 hours assisting the process has occurred in the past (Williams 2008). However, this does not always result in a positive outcome, often resulting in a chick that is not viable. In the Hungarian project the navel is disinfected with iodine and the chick is individually measured and weighed (Czifark & Szelenyi 2008).

Conclusions

- A broad range of commercial automatic incubators are available. Force-draught incubators have been suggested as working better in great bustards in some cases than still-air machines, but both have been used successfully. An additional incubator should be available in case one of the others breaks down.
- Eggs that are likely to fail should be moved to a separate incubator.
- Although there are combined incubators/hatchers available, hatching should take place in separate incubators, ideally operating in a separate room.
- The room temperature and air humidity should be constant with good aeration.
- The temperature and humidity of the incubators should be checked and recorded on a daily basis during incubation and hatching. This should be done several times per day regularly.
- Both German and Russian projects follow slightly different incubation and hatching protocols (see Table 1) but both projects have recorded high hatching rates.
- Turning the egg should not be carried out at the hatching stage but the egg should have the ability to roll around relatively easily in order to support the chicks' activities.
- Hatched chicks should stay in the hatchers or be put into a warm box until they are fully dry and fluffed up. They should be allowed to evade direct heat. After drying, chicks should be weighed and have a general health check. Navel disinfection usually is not necessary although insufficiently retracted yolk-sacs might be dabbed with a disinfectant or antibiotic.
- Assisted hatching can be carried out if required. However, this should be carried out with care and by experienced staff.
- Any dead eggs should have a veterinary examination but this must comply with quarantine regulations.

4.4 Anti-imprinting and habituation procedures, feeding regime and diet

The diet and feeding regime used in any reintroduction project is vitally important not only for the general health and physical development of individuals, but also for their behavioural development which ultimately has bearing on the bird's ability to survive in the wild.

Being precocial and nidifugous, bustard chicks appear fairly independent after hatching. However, they have one of the longest periods of maternal care in the bird world and are entirely dependent on the mother for the first week or so of their life. Chicks are initially almost entirely fed directly bill to bill for the first few days (Cramp & Simmons 1980). Initially they require several hours, and sometimes up to a day to be able to walk, after which the female will lead them from the nest and brood them overnight and during the day. She will peck gently at them to draw their attention to food items, or drop items in front of the young in order to show them how to feed themselves. The chicks will then gradually become self feeding although it is unknown how long this will take in the wild. For houbara bustards, live food is offered to the chick bill-to-bill initially, though by two to three days of age the females drop prey on the ground to be retrieved by the chicks, and by days five to six the chicks are feeding independently (Schulz and Seddon 1996). It would seem a vital part of their behavioural development that the birds are given the right amount of support and tuition and the right amount of independence whilst in captivity, especially during the crucial early stages.

The adult diet in the wild consists of mainly plants and invertebrates and occasionally also small vertebrates (Cramp & Simmons 1980). The diet of great bustards in the wild has been shown to be seasonally variable varying from over 40% of invertebrates in August to almost entirely plant material in the winter months (Lane et al 1999). It has been shown that young primarily feed on insects, but gradually take more plant food as they grow and that stones are also taken from the first days of life (Cramp & Simmons 1980). However, some observations and experience seem to contradict the importance of insects in the diet of chicks, and what the young eat may be variable depending on what is available (Waters pers comm).

4.4.1 Anti-imprinting procedures and feeding regime

Various methods and techniques have been used in hand rearing over the years all involving a varying degree of human contact. Puppet- or costume-rearing techniques are often used to reduce imprinting in young birds hand-reared for reintroductions. An experimental test of the effects of rearing social birds (common ravens) with or without a conspecific, parental puppet showed no difference in social behaviour prior to release, dispersal from the release area, or integration with wild birds after release between puppet- and non-puppet reared individuals (Valutis & Marzluff 2001). However, although puppet-reared individuals did show increased post-dispersal survival over individuals reared without a puppet, birds did not remain nearby during the juvenile stage. Valutis and Marzluff (2001) recommend that if it is more important for reintroduced birds to remain closer to the release area than integrate with wild conspecifics, they should not be reared with a puppet.

Work on cranes has shown that conventionally hand-reared birds are often unfit to be released into the wild as they are unafraid of humans, some preferring humans to cranes when under stress, and they adapt poorly to conditions in the wild (Nagendran *et al* 1996). Using costume-rearing, it is possible to hand rear a crane chick, yet allow it to imprint it on its own species. This method has resulted in a far higher rate of post release survival (Nagendran *et al* 1996). In the costume-rearing technique, the caretakers dress in an amorphous, hooded costume, the purpose being to disguise the human form. A realistic looking, model crane-head is used when feeding the birds and chicks have a lot of interaction with this model.

The advantages of rearing with minimal human contact may be species-specific. Although this has been found to be beneficial for cranes and other species, Houbara bustards become less tame when prolonged exposure to humans ceases, suggesting that minimising human contact using models and barriers may be unnecessary (van Heezik *et al* 1999). Nevertheless, experience in the German project suggests reduced or completely avoided contact to humans supports bustard specific behaviour after releasing, and the best way to hand-rear bustards is to adopt completely anonymous feeding and caring (Langgemach 2012). Alternatively, uniformly clothed caretakers with an outfit that is unlikely to be met in the field reduces the likelihood of birds becoming attached to the human form in general eg green smocks are used in this project. In this project a short period of hand rearing is recommended, using tweezers, and water and vitamin B solution is provided using a pipette. Following this the birds are fed in food bowls and later by automatic feeders. Handlers and observers should be kept at a minimum as they may act as an additional stressor (Parker *et al.* 2012).

In Hungary, the chicks are fed six times per day. During early stages, the chicks are imprinted onto the sound of a radio station which is used in conjunction with a visual cue: a white plastic bag held in high in the air on one hand (Ashbrook *et al* 2011). Staff members wear white lab coats and the birds are generally wary of people. There does not seem to be attempts in this project to wear dehumanising suits, but the lab coat and use of a radio is used to allow the birds to associate with, and attach themselves to, the keepers, making feeding and predator training more straightforward. Although uniformly clothed personnel have been used there are concerns that this produces some birds that are extremely tame and have to be recaptured after release. It may be that the human form is not significantly disguised and this would suggest that a more complete dehumanising suit with head and face covered, would be worth the extra effort.

In Germany, chicks are weighed twice per day for the first 15 days, then once per day thereafter. This is to ensure they are gaining weight but also to assist with identifying the sex of chicks, as males show a much faster increase in daily weight, which is apparent after one week (Williams 2012).

Feeding at the Saratov field station in Russia is also carried out with minimum contact to humans (Pereverzina & Waters 2008). For the first few days feeding is carried out by a mechanically operated model of a female great bustard head which is operated from behind a curtain. Any humans coming into sight of the birds (for feeding, cleaning and watering) wear a dehumanising suit which aims to disguise the human form e.g. loose arms, covered legs, masked face, vertically patterned, so that the birds do not become familiar with humans. Equally, when birds are in quarantine in the UK in 2011, personnel wore a yellow poncho as a distinguishing feature. This method was introduced with the intention of gaining trust and it was found that during the soft-release stage and actual release, the birds were considered to be steadier and easier to approach (Williams 2011). Although this may have been seen as advantageous during the rearing process, lack of fearfulness in captive-reared individuals has been suggested to be a significant constraint on reintroduction project success (Seddon *et al.* 2007), possibly increasing the development of abnormal behaviours after release.

In the Russian/UK project, feeding is carried out from 6am until 7pm 7 times per day for the first 10 days, 6 times per day up to day 20, and 5 times per day up to day 30. At one month old the chicks are moved into the brooder room which provides shelter and has an attached aviary. At this age they are feeding themselves and food is provided in a dish put through a small window 3 times per day up to day 45 and thereafter twice a day (Pereverzina & Waters 2008).

Conclusions

- Feeding and caring for the birds should be carried out by experienced carers dressed in dehumanising suits at all times. Any contact with the birds should be limited.
- Physically handling the birds should be restricted and limited to weighing and medical treatment as far as possible and within quarantine compliance to avoid feather damage. A technique for weighing birds without handling them is being developed.
- A short period of about one week for hand-feeding is recommended. However, it is recognised that some birds need shorter periods of hand feeding and others need longer and therefore this will vary depending on observations of the experienced aviculturalists. This will hope to replicate what is known about birds in the wild and will aim to encourage chicks to feed by themselves. This should be followed by feeding in food bowls and later on by automatic feeders.

4.4.2 Diet

The diets used in great bustard projects are shown in Table 2. Although these vary it seems important that the diet does not contain too much protein. The reduction in protein in the diet used in the German project has resulted in increasing success in rearing healthy birds with growth deformities much reduced (Langgemach 2008). This is a problem that has been noted in other species i.e. the Great Crane Project feeds chicks a diet consisting of no more than 24% protein because of this risk (GCP 2010).

There is also a common condition seen in all species of captive bustards known as slipped or ‘angel’ wing. This is cause by rapidly developing primary feathers which causes an overextension of the carpal joint and therefore the outer wing starts to droop. If left untreated the wing twists outward resulting in a permanent deformity (Bailey 2008). This condition can be easily treated by using tape or an elastic band. What causes this condition is not clear although a high protein diet is often thought to be connected. Other factors may also be involved however. In captive reared Australian bustards this condition was eliminated when the brooder temperature was reduced periodically during the day to mimic female brooding behaviour (Bailey 2008). However, the German project previously cooled the eggs every day – and angel wing still occurred. It seems likely that this is a diet related issue, related to the exclusively insectivorous diet used in the early rearing process the early days. The Spanish captive rearing programme has been including vegetable matter in early stages (Torsten Langgemach pers comm.).

Because a definitive cause of angel wing is not known it seems very likely that this condition will manifest itself in the hand reared bustards (this typically occurs at day 10 to 14 (Bailey 2008)). It is therefore important to detect and treat this condition at the earliest opportunity to avoid a permanent deformity.

Conclusions

- During the first 24 hours the chicks should not be fed but may benefit from being given water.
- Within the first two weeks the chicks should be fed with insects including commercially available crickets. It is possible that this initial high protein diet is innappropriate and the birds develop angel wing because of this and so herbs and vegetation should also be included. This will depend on what is available but may include stinging nettle, dill, dandelion, chickweed, alfalfa, plantain, clover etc. The percentage of plants in the diet should increase during the next few weeks.
- From the third week an additional diet for growing birds eg "Lundi", a German product, has proved worthwhile, offered as pellets.
- Feeding is usually carried out as required, in practice that means at the beginning of every hour, decreasing down to twice a day at the age of 8 weeks.
- Water should be freely available.
- Careful monitoring of the occurrence of any defects attributable to excessive protein or other metabolic problems is crucial mainly during the first month.
- Because the optimum diet has not been defined from other projects, detailed records should be kept to further develop good protocols.

4.5 Accommodation of chicks

In Germany the chicks are kept in a warm wooden box with a lid and viewing window for up to 3 days. These boxes are equipped with a heat pad below a layer of protective sheet (nappy liner) with a rough cloth on the top to provide a good surface for the young chicks' feet (Williams 2012). Following this they are kept in small groups in a glass house with infrared heating lamps and a gravel/sand substrate. Food and water dishes are placed inside and there are willow panels on the roof to cool the building during hot days. Chicks are quickly encouraged outside into a 300m^2 enclosure. From the start of the fourth week a larger enclosure (3000m^2) is used and a wooden shed is used for shelter. The enclosures contain grassland vegetation with patches of shorter and taller vegetation. Chicks are identified by individually coloured, temporary plastic leg rings.

In Hungary, from hatching the chicks are moved into boxes in a brooding room with an ambient temperature at 25^{o}C and infrared lamps (35^{o}C under lamps) (Czifark & Szelenyi 2008). Chicks are identified via individually-numbered leg-rings and kept inside a pen in a small room until they are about three weeks old. Chicks may be taken to the outside enclosure during the first week if temperature is above 30^{o}C. Chicks are transferred to the larger, outside rearing pens when they are three weeks old. In preparation for the chicks, 30cm of the top-soil is replaced to reduce disease and sown with alfalfa (Ashbrook *et al* 2011). The outdoor rearing pen is a 6m x 10m metal fenced and roofed area. A soft inner pen is created using green netting to prevent birds from damaging themselves on the fencing. A small shed is provided for roosting. When the chicks are 6-8 weeks old and are ready to fly, they are released into an introductory area in the centre of a 400-hectare release pen. This is a small-scale version of the larger pen habitat management, with a mosaic of all the habitat types surrounded by sunflower or maize strips, providing natural fencing.

In Russia, chicks are moved from hatchers into an indoor area with sand substrate which is warmed by heat lamps. They spend the first 4 weeks here, there is an open entrance to an outside pen and the birds are encouraged to go outside as soon as possible. By one month the birds are generally outside in a large outside enclosure, approximately 12m x 5m, that is constructed from a heavy string or rope net suspended from straining wires. There is access to a wooden shed with sand substrate for shelter where they are first placed on moving from the rearing room. However, once the chicks have gone out into the aviary they never go back into the shed. A six-foot high fence surrounds the shed and aviary, and there is wet sawdust soaked in disinfectant in a footbath in the doorway.

It is important to not only think of accommodation in terms of physical needs i.e. warmth and shelter, but also behavioural needs. Consideration should be given to the size of the groups the birds are kept in. Small groups of two or three are recommended initially to replicate the true conditions in the wild (Carl Jones pers comm). However, young birds at the time of release in the UK reintroduction project would still be with their mother in the wild, and it is therefore difficult to recreate these conditions. In addition, releasing small groups of birds over large groups has not been found to improve post-release survival in this project (Burnside *et al.* 2012). One possibility could be to involve older UK captive females (which are ear-marked for captive breeding) in the rearing process. An older female in an adjacent pen may reduce the stress of the rearing process. In other species this has also been shown to assist with learning (Shier & Owings 2007).

Being birds of the open plain, much of the great bustard life cycle is linked to good visual acuity over long distances, being important for detecting mates (Olea et al. 2010), selecting suitable nesting areas to reduce predation risk (Magaña et al. 2010) and flight. Great bustards, like cranes and storks, are particularly subject to high levels of mortality associated with power lines (Janss & Ferrer 2000; Martin & Shaw 2010); ensuring that birds reared in captivity undergo natural visual development can be considered as essential.

Conclusions

- Within the first month of life, it is suggested that the birds should be kept in small groups of similar age to prevent trampling and food bowl dominance.
- Chicks should be kept in warm boxes with a substrate of rough material for the first 1-3 nights. From then on the chicks should spend more and more time in an outdoor enclosure.
- An indoor enclosure with a suitable substrate (eg gravel or sand) is recommended for the nights during roughly the first eight weeks although quarantine restrictions may restrict the possibility of this. Chicks should have access to the outside enclosure through a pop hole - if the weather is bad they may be taken inside (usually they don’t move inside on their own).
- Heating the inside enclosure may be necessary during the first weeks. Infrared lamps can be used if thought necessary to compensate for the lack of the presence of the mother until chicks are able to regulate their body temperature by themselves. How long this heating is required for will depend on the condition of the bird and the weather should be assessed in order to find the right moment to cease additional heating.
- Feeding remains and faeces should be removed at least once a day.
- Predators have to be excluded by a suitable and reliable fence.
- The vegetation within the enclosures can include tough grass and other plant species that are preferred by the bustards and form a mosaic of shorter and taller patches to meet all the requirements that wild chicks have, too (cover, shade, food). Patches of gravel will provide small stones as stomach grit.

4.6 Exercise

Although great bustard chicks are incapable of following their mother immediately after hatching, they may be led up to 100m away from the nest within 24 hours and show a well-developed following response (Cramp and Simmons 1980). Daily walks are an important part of the birds’ development, improving growth and natural behaviour. Having access to larger outdoor enclosures would allow the birds to exercise naturally, although quarantine restrictions may restrict the extent to which this is permitted. Actively encouraging the birds to exercise has been attempted in some projects.

In Hungary, the chicks are led on a walk for 1.5-2 hours per day using the radio and white bag method down a 70-80m fenced corridor (Ashbrook et al 2011).

In the German project, daily walks take place from Day 2. Chicks are placed in a bucket and carried outside twice a day where they are allowed to run in a 1.5m^2 wooden frame which is placed on top of short grass. Later when the chicks are housed in the glass house, birds are taken to a grass area immediately outside for a short walk twice per day. They are also given access to a small fenced enclosure which joins the glass house and has a netted roof (Williams 2012). This involves a person guiding the birds, imitating a communication call to encourage them to follow. The proximity of the suited person becomes increasingly distant as the birds independence grows. This also allows birds to become familiar with their natural surroundings. Walking or exercising birds at one location and releasing them at another does not appear to affect the birds' ability to accept their release site as their natal site; the experience from the German project is that they never return to the rearing site (Williams 2012). It is important to note the birds are not reared at one place and then simply released at another. The rearing continues for a considerable time at the place of release.

In the Great Crane project, chicks are exercised from about 10-12 days old for 10-20 minutes twice a day in their outdoor runs. Here the birds are exposed to soft and natural substrates and to natural food items. This is increased gradually and by age 14 days chicks are exercised and socialised, under supervision, in cohorts of 2-4 in a communal enclosure. As chicks get older and their aggressive tendencies towards each other decrease, more chicks are exercised together. Although exercise is important it is also important not to over-exert chicks, resulting in exhaustion or stress. Excessive exercise may lead to the same leg problems as a lack of exercise (GCP 2010).

Conclusions

- Daily walks of increasing length should be carried out to promote optimal growth, development and behaviour. As in the German project, this could be carried out twice per day from day 2, initially in just a small portable frame for short periods. This can occur first inside, and then outside the enclosure. Birds should be accompanied by a suited carer who should help to guide them. Quarantine restrictions will dictate how this can be done.

4.7 Predator training

With a growing number of reintroduction projects using individuals from captive-rearing programs there is a general concern that their success may be limited by individuals lacking key traits, such as fearfulness, or essential learned behaviours, such as predator recognition (Seddon et al. 2007). A high proportion of translocations and reintroductions have been unsuccessful in establishing viable populations, with mortality through predation being implicated as an important factor in their failure (reviewed by Griffin et al. 2000). Although there are several ways to address this problem, such as eradicating predators and creating predator-proof areas, none of these offer a long-term solution for released birds (Griffin et al. 2000); a growing number of conservation projects are looking to predator awareness training to provide an answer (Shier & Owings 2007; Crane & Mathis 2011; Moseby et al. 2012). As discussed previously, one of the main limitations of the UK great bustard reintroduction project is the loss of individuals early after release by predation (Burnside et al. 2012); the development of effective predator awareness training may reduce this loss.

Little is known about how predator recognition develops under natural conditions, for example, how individuals discriminate predators from other, morphologically similar, innocuous stimuli (Griffin & Evans 2003). In some cases, anti-predator behaviour may be fully expressed on the first encounter, but most depend to some extent on experience (Griffin et al. 2000). Social stimuli, such as alarm calls, and individual experiences, such as being chased and attacked, have been demonstrated to facilitate predator avoidance learning (reviewed by Griffin & Evans 2003; Shier & Owings 2006). However, the pairing of a conditioned stimulus (model or live predator) with an unconditioned stimulus (frightening stimuli) can be effective. The unconditioned stimuli must elicit the same motivational state in the individual as a naturally occurring predatory event. An unpleasant stimulus such as being squirted with water does not mimic a predatory event as effectively as frightening stimulus such as being chased, being exposed to loud noises or looming objects and therefore will be less effective in training (Griffin et al. 2000). However, an using an unpleasant stimulus has been used effectively in some projects when used in conjunction with a frightening stimulus (see crane example below). An additional consideration is that training needs to be performed in an environment where appropriate responses can occur; small enclosures may provide insufficient space for natural escape behaviour and may inadvertently train individuals to flee shorter distances (McLean 1997).

In the Great Crane Project, human predator avoidance training is given to costume-reared chicks so that they develop an aversion to people and mammalian predators.
The first predator aversion training takes place between 10-12 weeks old at the rearing facilities when most of the birds have fledged and are socialising as a group and bonding well (Amy King pers comm.). Costumed handlers remain in the enclosure with the birds and two uncostumed people enter the enclosure at which point the costumed handlers play an alarm call and run across the water channel. The uncostumed people then leave the enclosure and the handlers wait with the birds until they have calmed down. This is carried out again about 1 or 2 weeks later, this time with a dog on a long lead entering the enclosure too. If the birds seem to show little or no reaction then the human only avoidance session is repeated with the people making more noise and coming closer to the birds. Once the birds have been released, dog and people aversion training is again carried out with people approaching the birds and costumed handlers from across the fields. The handlers do an alert pose with the model heads when the people are approaching and once they are too close the alarm call sounds and they run back to the release enclosure and don't stop until they are in the roosting pool. If any birds still choose not to fly off with the others the birds are sprayed with a water bottle and shouted at to reinforce the negative association. This method has been adopted from the regime used by the International Crane Foundation (Nagendran *et al* 1996) and has been shown to work well in this project.

Some restocking initiatives of the Houbara bustard have taken place in Saudi Arabia (race *Chlamydotis undulata macqueenii*) by reintroducing captive bred individuals. Post-release survival in such reintroductions has been low due to predation primarily by the red fox (van Heezik et al 1999). In 1995 predator avoidance trials were carried out using a fox model and later using a live fox. During these trials a hand-reared, muzzled fox on a leash was introduced to the birds in a large enclosure. The fox was allowed to behave naturally watching and stalking the birds and on occasion attacking them. This controversial method does raise some ethical questions as some birds were injured during these training sessions. However, although no benefits were recorded after using the model, post-release survival increased after the captive birds were introduced to the live fox (van Heezik et al 1999).

Predator avoidance training is also carried out in the Hungarian project. The chicks are predator trained in darkness, as this is when they are most vulnerable to foxes. This is done with a fox on a line, which is "thrown" into a group of newly-released birds. A trained dog can be used, but it appears to be more effective with a fox. The claws of the fox are removed beforehand (declawing is illegal in the UK). Foxes are shown for very short intervals and a ranger makes the appropriate bustard alarm call for a ground predator, informing the birds to fly away and the fox is pulled back on the wire. After training the birds are gathered into a group using the radio and bag method. This training is repeated three or four times. The effectiveness of this training has not been scientifically proven (the main cause of mortality would appear to be predation from foxes although as no post release monitoring is carried out this has not been verified).

Predator training was tried by the Great Bustard Group in 2005 (David Waters pers comm.). Half the birds were exposed to a fox-like dog and immediately doused in water from an unseen operator. It was hoped that the birds would flee but they did not react to the dog. There is a risk that this type of operation could result in a bird colliding with a fence or dispersing prematurely. Subsequently there was no difference in the predation rate of "trained birds" and the others and this has not been included in the project since.

Conclusions
There is mixed evidence to suggest that predator awareness training can have a beneficial outcome on how individuals respond to predators; learning may be species-specific and low-risk training may not be effective for some species. Because predation is a significant cause

of mortality, it may be valid to include some form of predator avoidance training. However, with the project undertaking several changes in 2012, the inclusion of this aspect should be carefully considered. If predator avoidance training is to be carried out the following points could be included (Kate Ashbrook pers comm.):

- Chicks could be divided into two groups, with half of the birds undergoing predator awareness training and half not receiving any training. In this way, the effectiveness of the training can be assessed through comparing post-release behaviour and survival.
- Where predator training is performed, birds should experience a negative stimulus if they are unreactive, such as being caught and jostled, until they show a greater response to predator stimuli. The training model used by the Great Crane Project may serve as a good starting point to developing a bustard-specific training model.
- Training should take place early in development in an open environment, reducing the likelihood that birds will damage themselves and allowing sufficient space for birds to flee a safe distance. Later in development, when birds are released into a soft enclosure within the main release pen, training should be repeated to reinforce learning. At this age, it is unlikely that birds will be able to be caught easily; a second negative unconditional stimulus should be substituted for jostling in unreactive birds.
- A bustard alarm call specific for ground predators could be used in conjunction with training, playing the call as the ‘predator’ approaches. By playing this call to captive bustards, it may be possible to learn if birds recognise alarm calls innately, and if so, playing the call as the ‘predator’ is shown may help to reinforce learning.

4.8 Phases of release

Individuals are often held captive at the release site, a so-called ‘soft’ or delayed release as opposed to a ‘hard’ or immediate release; these ‘soft’ releases are often recommended as the release strategy of choice for captive reared animals (Parker et al. 2012). Release methods used in the UK have changed and evolved over the years, with the timing and logistics of this being dictated to some extend by the need for birds to go through a period in quarantine. In some years birds were ‘hard’ released, being moved from quarantine directly into the release pen, and in others they were ‘soft’ released, undergoing a period in a smaller pen within the larger release pen. From 2004 to 2010, there was no difference in the post-release survival of birds between ‘hard’ and ‘soft’ releases (Burnside, pers. comm).

Releasing birds into the wild takes several weeks beginning with the transportation to the release-site and ending with independence from artificial feeding. In 2011, the birds were released using soft release pens so that the birds had a period of adjustment to the surroundings, could adapt visually to the immediate landscape and could see older bustards in the vicinity, with the hope that birds would accept their release site as their natal site (Williams 2011). A new design of soft-release pen was used, different in material and size and location. These were adapted pens used by pheasant breeders (courtesy of GWCT), wooden framed with small gauge wire mesh walls and 30cm boards at the base running the length of each panel. Each enclosure measured $36m^2$ and was built to house 6 birds. The roofs were made of ‘zoomesh’ to avoid injury. Around these release pens the 20ha field was securely fenced using electrified poultry mesh to deter foxes. The pens were on top of growing winter crops preferred by great bustards. An automatic feeder was placed a few meters from the pens and set to distribute pellet food twice per day. In addition, several plastic bustard decoys were situated near to the feeder.

Following quarantine, birds were transported to the soft release enclosures in large animal carriers. Once in the soft-release pens, the birds were provided with water and food, receiving the same food and same proportions that they had received during quarantine, but provisioned only once per day and using a yellow poncho. The birds remained in the soft-release pens for seven days. On release day, the food was scattered outside of the soft-release pens. Three panels were then opened up to allow the birds to leave in their own time.

Birds released in 2011 had on average 66% fully-developed and undamaged primaries, 14% damaged, 8% developing and 12% missing; however, there is no data from previous release years to compare feather condition between releases. Overall, there was no decline in feather condition after one week in soft pens. On the whole the birds were considered to be more steady and manageable, possibly a result of being younger at in age of at import and possibly also due to using the yellow poncho (Williams 2011). Lessons learnt from this year would be to leave pens on site with doors closed after all birds have gone out of them. Pens were removed this year when birds were still in the area and this may have caused premature dispersal. Additionally it would be beneficial to ensure that bare areas are created in the release field for roosting, preening and drying off. Birds were handled when transferred from the quarantine facility to the soft release pens, but after one-week in the soft pens, the doors were opened to allow the birds to move outside without further handling and in their rearing group. In cases where birds were handled prior to release (to activate satellite transmitters), they moved quickly away from the soft release pens, remaining isolated from the rest of the group for some time afterwards (K. Ashbrook, pers. comm). In future releases, monitoring devices should be activated during the final handling event before release to reduce stress and allow greater group cohesion during the release.

In Hungary, at between six and eight weeks when the plumage is full and they are ready for release, they are transported to a 400ha enclosure. For the first two weeks, chicks are guarded during the day from increasing distances; contact frequency is reduced over this time and the birds are fed three times daily. The birds have access to a small shelter where the birds can be led to. Previously birds were herded in but this caused injuries. The shelter now used is dark inside, with only two covered windows to provide low light. The original shelter was lighter inside with a soft roof, but in previous years birds have injured themselves by colliding with the walls and the new design has been much more successful. This is presumably because low light levels will calm the birds and reduce glare which often causes alarm. Lucerne and oil seed rape is cultivated in the surrounding fields for extra foraging. Feeding and guarding is gradually finished in mid-September when the birds become independent. Released birds can stay around this area for up to two months before leaving the pen and joining wild birds (Ashbrook *et al* 2011). The post-release survival in this project, and therefore success of methods used, is not clearly known due to a lack of post-release monitoring.

In Germany, the birds are first released in a 1ha enclosure within a 15ha fenced area (Langgemach 2008). This site is 50-60km from the rearing facilities. A smaller enclosure inside the larger one allows a soft release, allowing the birds to gradually acclimatise to their surroundings and offers a gradual reduction in care and supervision. The small area is opened after a few days to enable the birds to extend their activities. Experience has meant the release method has been adjusted over time to reduce human contact and promote independence. This means that anonymous feeding (eg automatic feeders, or costumed personnel) as long as the birds are in the enclosure is encouraged as this promotes distance behaviour towards human beings after release (Langgemach 2012). However, the caretakers still lead birds out of and back into the enclosure at night but gradually this is reduced. Oil seed rape or other natural foodstuffs are cultivated inside and outside the enclosure. Despite the improved methods of release post release survival has not increased and this remains low. However, the major cause of this is the increasing density of White-tailed eagles (Eisenberg 2008), not an issue for birds in southern England.

Conclusions

The following general considerations should be noted for future releases:

- The release enclosure should be of sufficient size to allow the released birds to exhibit natural behaviour including feeding and defensive roosting. The outer fence should be constructed in a way that there is no access for predatory mammals without becoming a collision hazard for birds.
- A smaller enclosure inside the larger one allows a step-by-step release as well as easier care and supervising at the beginning. The small one is opened after some days to enable the birds to extend their activities after first contact with their wider environment.
- Anonymous feeding as long as the birds are in the enclosure promotes appropriate distance behaviour towards human beings after release. This might be realised by automatic feeding-devices and naturally grown vegetation. Post-release monitoring of

birds will help to provide guidance on when feeders are no longer used by birds and when supplementation should cease.
- Releasing into the wild should take place at around eight weeks old (as soon as the young bustards regulate their body temperature by themselves), although weather conditions may dictate when exactly this should be. Post-release support should continue for several weeks to allow further learning from a costume-wearing individual, which may include guidance on feeding and roosting areas.
- Although generally many people wish to be involved in the handling, transporting and releasing of birds, the welfare of the birds should be the primary concern and those directly involved with the birds should be kept to a minimum.
- Released individuals should have an unimpeded view of suitable habitat and a safe direct dispersal route.

4.9 Post-release monitoring

Post-release monitoring is an essential part of the trial reintroduction project. The need for enhanced monitoring was highlighted in the mid term review process (Burnside et al 2011) and is included as one of the key objectives of the LIFE+ Project.

The project requires an evidence base to inform decisions and actions that will support the re-establishment of great bustards in southern England. However, great bustards are a difficult species to monitor being shy, secretive and often unobtrusive in a large landscape, and have been shown to have a wide and unpredictable pattern of dispersal from the release area. The use of technology is therefore important to the success of the monitoring programme and much thought has gone into consideration of the use of different methods. The favoured method has been to use devices where data can be downloaded remotely (satellite and GPS-GSM devices) but these are quite large and require attachment via harnesses. Harnesses have been used in 5 years but there is considerable debate about the future use of harnesses and whether they cause the birds any problems.

Recent studies have shown that fitting monitoring devices to birds may have negative impacts on their survival (Steenhof *et al.*, 2006; Paton *et al.* 2011), behaviour (Phillips *et al.*, 2003; Saraux *et al.*, 2011) and productivity (Peniche *et al.*, 2011). In addition, harness-mounted transmitters have been implicated to lesions (Peniche *et al.*, 2011), reduced body condition and flight performance (Irvine, Leckie & Redpath, 2007). In grey partridges *Perdix perdix*, both hand-rearing and radio-tagging had adverse effects on flight, with birds carrying tags showing decreased take-off angle and climbing rate to un-tagged birds (Putaala *et al.*, 1997), reducing their ability to avoid predation.

In the most recent analysis of the effect of pre- and post-release factors on mortality, fitting transmitters via backpack harnesses was not found to significantly reduce the survival of released individuals. However, the data collected so far is from a small sample size and it is therefore difficult to ascertain if any negative effects are present. In an analysis of the main factors associated with mortality of birds in the first 165 days following release, harness attachment was not found to be a significant factor. Maximum dispersal distance for released is bi-modal, with most birds moving a maximum of 20 kilometres away from the release site and a smaller proportion travelling 80 – 250 kilometres away. This pattern is shown in birds with and without harnesses, suggesting that movement is not restricted by harnesses. Again this is from a small sample size.

Despite recent evidence to suggest that backpack harnesses can cause lesions in other species (Peniche *et al.* 2011), the veterinary consultant associated with the Great Bustard Reintroduction Project has not found any injuries associated with the present harnesses used (2005 onwards) on recovered birds. However, this does not show if the bird's ability to fly has been compromised.

To date the project has not been registered with the BTO Unconventional Methods Technical Panel UMTP, but the RSPB recommends that this is done at the earliest opportunity and ideally in time to register this year. This panel can advise on the risks and issues associated with different techniques and provide licences as necessary. This application should include full details of tags and harnesses, evidence of safety from other studies, and evidence of the competence and training of the applicant in fitting the harnesses. It is possible for the applicants to propose two options and ask the BTO panel's advice on which is best. Best practice advise can also be sought from WWT who have experience of similar issues for the crane project.

Conclusions

- A precautionary approach should be followed with regard to the use of controversial methods such as harnesses until there is clearer evidence that these will not significant affect the survival rates of birds. Meanwhile lower risk monitoring methods should be used to gather data.
- Expert advice should be sought from the BTO Unconventional Methods Technical Panel to inform decisions on the use of technical equipment.
- Accurate records should be kept of methods used and outcomes, to further inform the use of technical equipment in the future.

4.10 Health and Veterinary Care

Although detailed knowledge of the health and veterinary needs of bustards are beyond the scope of this report, it is recognised that this is a vital aspect of the management of the birds in captivity. Some quarantine screening will be legally required.

Documented disease risk assessments, health protocols, post mortems and analysis of results should be shared between the project partners to better inform project management decisions. A RSPB consultant veterinary advisor will be working with the GBG vet to discuss these issues further and ensure that the project is complying with legal requirements and international guidelines.

5. Summary

Information has been gathered from other projects and from various individuals' experience. However, as rear and release methods have not been fully developed, tested and documented, it is very difficult at this stage to define best practice protocols. It is therefore vital for the advancement of this project, and for the benefit of others, that detailed records on all aspects of the rear and release methods are documented, tested and reviewed.

The following general points are recommended:

1. It is advisable to follow a precautionary approach in this first year of rearing the birds from eggs in the UK (eg strict anonymous feeding), although some techniques could be trialled (eg predator avoidance training).
2. In the absence of a detailed protocol it would be advisable to have dedicated and experienced staff to carry out the rearing of birds so that any problems can be identified and addressed quickly.
3. Detailed records of all aspects of the rear and release should be kept and reported at the end of the year.
4. The establishment of a rear and release technical group including representatives from all project partners would facilitate information exchange and decision making for these often complex and detailed technical issues. This group would carry out the end of year review, address any issues raised and propose new steps to the project steering group.
5. The project partners should aim to document best practice protocols and publish a detailed account of methods, results and lessons learned for wider circulation.

6. ***Appendix***

Table 1. Artificial Incubation - Settings and other information

	Egg incubation				Hatching			
Project	Incubator	Temp.	Humidity	Other info	Hatcher	Temp.	Humidity	Other info
Germany (Langgemach 2008)	Force-draught automatic incubators (thought that these work better than still air machines)	37.4°C	60%	Turned 8-12 times per day (every 180 – 120mins).	one-stage still-air incubators	37.0°C	85%	After hatching the chicks are kept in an inspection box with heat-pad for one day
Hungary (Czifark & Szelenyi 2008)	PL Machine MIDI F90S automatic incubators	37.8°C	65%	Rotation every 180 mins at 180°, ventilation every 20mins and cooling down twice a day to 20°C.		37.5°C	85%	Chick remains in the hatcher for 5 hours.
Russia (Pereverzina & Waters 2008)	Compact Brinsea Octagon 40 incubators	37.2°C	Not humidity controlled, but have fixed air vents and a shallow water trough in the bottom ½ full of water.	Turning (every 90 minutes) and cooling is done automatically by these incubators	Brinsea Polyhatch incubator	36 °C	As incubation	
Kori bustards (AZA Gruiformes TAG 2009)	Grumbach incubator	37.5°C	55%	Eggs are turned every 120mins.	Grumbach incubator	37.4°C	70-75%	Target weight loss is 12% Humidity is adjusted to result in this.

<u>Table 2. Diet used in chick rearing projects.</u>

Project	**Diet**
Germany (Langgemach 2008)	The birds are initially fed only insects, with small bits of herbs being added from about a week old e.g. stinging nettle, dill, dandelion, yarrow, chickweed, alfalfa, plantain, clover. The percentage of plants in the diet increases during the next weeks. Vitamin B complex may be supplemented in weak chicks. The diet may be adapted to the local availability. From the third week they are additionally given a commercially produced low protein foodstuff ('Lundi') in cakes (Lundi pellets ground up, olive oil, white breadcrumbs). Water is supplied *ad libitum*.
Hungary (Czifark & Szelenyi 2008)	The birds are fed soft food (green Lucerne 40%, boiled potato 35%, cottage cheese 6%, boiled beef heart 6%, boiled egg 3%, grained corn 2.5%, grained flax 2.5%, Nutrafort-3 (Ca) 2.5% and AP17 (other minerals) 2.5%) and crickets. From week six crickets are replaced with white mice. To drink, the birds are given camomile tea and then water with vinegar.
Russia (Pereverzina & Waters 2008)	Chicks are fed insects; locusts and grasshoppers (collected from around the field station). Initially (for the first 10 days) the birds are fed protein (lizards, insects, cows heart). Live insects are fed to the birds once they are feeding for themselves. Up to day 30 the diet also includes beef and mince (46% of diet), fresh fish (15%), cottage cheese (11%), and tinned cat food (28%). Wheat bread is also added (10-20%), boiled egg with shells (5%) and green leafy vegetables (increased in quantity and by day 20 birds are given unlimited supplies). From 3 weeks the birds are given a commercially produced crane food beginning with 10% and increasing to 50% by day 45. Vitamin B is added to all water, and minerals (calcium) are sprinkled onto food. At 4-5 days the chicks have access to a small external cage.

7. <u>Acknowledgements</u>

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8. References

Armstrong, D. P., & Seddon, P. J. (2008). Directions in reintroduction biology. Trends in ecology & evolution, 23(1), 20-5.

Ashbrook K, Végvári Z Széll A & Tamás Székely T (2011) Great Bustard Conservation in Dévaványa, Hungary. Internal project report

AZA Gruiformes TAG (2009) Kori Bustard (*Ardeotis kori*) Care Manual. Association of Zoos and Aquariums, Silver Spring, MD. pp.113.

AZA Ratite TAG (2011) Ratite TAG recommended policy on egg transport. Association of Zoos and Aquariums

Bailey, T (2008) Diseases and medical management of Houbara bustards and other *Otididae*. Emirates Printing Press L.L.C, Dubai.

Burnside RJ, Carter I, Dawes A, Waters D, Lock L, Goriup P & Székely T (2012) The UK great bustard *Otis tarda* reintroduction trial: a 5 year progress report. Oryx, Volume 46, Issue 01, pp 112 – 121.

Cramp S & Simmons KEL (1980) The Birds of the Western Palearctic. Volume II: Hawks to Bustards. 659-668. Oxford University Press.

Crane AL & Mathis A (2011) Predator-recognition training: a conservation strategy to increase postrelease survival of hellbenders in head-starting programs. Zoo Biology 30: 611-622.

Czifark G & Szelenyi (2008) Incubation and chick rearing great bustard at the Dévaványa Rescue centre. In Bustard Studies. Volume 7. Great Bustards conservation through nest management and rear and release methods.

Dawes A (2008) Release and monitoring in the UK great bustard reintroduction project. In Bustard Studies. Volume 7. Great Bustards conservation through nest management and rear and release methods.

Eisenberg, A (2008) Post-release monitoring in Germany. In Bustard Studies. Volume 7. Great Bustards conservation through nest management and rear and release methods.

The Great Crane Project (2010) Somerset Reintroduction Project Plan. Section E - Reintroduction protocols. Internal project document.

Griffin AS, Blumstein, DT & Evans, CS (2000) Training captive-bred or translocated animals to avoid predators. Conservation Biology, 14, 1317-1326.

Griffin AS & Evans CS (2003) The role of differential reinforcement in predator avoidance learning. Behavioural Processes. Volume 61, Issues 1–2, 28, Pages 87–94
Janss, G.E.E. & Ferrer, M. (2000) Common Crane and Great Bustard Collision with Power Lines: Collision Rate and Risk. Wildlife Biology Bulletin, 28, 675-680.

Irvine, R. J., Leckie, F., & Redpath, S. M. (2007). Cost of carrying radio transmitters: a test with racing pigeons Columba livia. Wildlife Biology, 13(3), 238-243. doi:10.2981/0909-6396(2007)13

Lane, SJ, Alonso, JC, Alonso, JA, Naveso, MA (1999) Seasonal changes in diet and diet selection of great bustards (*Otis t. tarda*) in north-west Spain. Journal of Zoology Volume 247, Issue 2, pages 201–214.

Langgemach T (2012) Guidelines for reinforcement and reintroduction of the Great Bustard. Prepared for the Memorandum of Understanding on the Conservation and Management of the Middle-European Population of the Great Bustard (*Otis tarda*) under the Convention on Migratory Species (CMS).

Langgemach T (2008) Artificial incubation and rearing methods in the German great bustard conservation programme. In Bustard Studies. Volume 7. Great Bustards conservation through nest management and rear and release methods.

Magaña, M., Alonso, J.C., Martín, C. a., Bautista, L.M. & Martín, B. (2010) Nest-site selection by Great Bustards *Otis tarda* suggests a trade-off between concealment and visibility. Ibis, 152, 77-89.

Martin, G.R. & Shaw, J.M. (2010) Bird collisions with power lines: Failing to see the way ahead? Biological Conservation, 143, 2695-2702.

McLean IG (1997) Conservation and the Ontogeny of Behaviour. In Behavioural approaches to conservation in the wild. Clemmons JR & Buchholz R. Cambridge University Press.

Moseby KE, Cameron A, Crisp HA (2012) Can predator avoidance training improve reintroduction outcomes for the greater bilby in arid Australia? Animal Behaviour 83: 1011-1021

Nagendran, M, R Urbanek, D Ellis (1996) Special Techniques Part D: Reintroduction Techniques. Cranes, Their Biology, Husbandry, and Conservation. DH Ellis, GF Gee, CM Mirande. Washington, National Biological Service**:** 231-252.

Olea, P.P., Casas, F., Redpath, S. & Viñuela, J. (2010) Bottoms up: great bustards use the sun to maximise signal efficacy. Behavioral Ecology and Sociobiology, 64, 927-937.

Palacín, C. & Alonso, J.C. (2008) An updated estimate of the world status and population trends of the Great bustard *Otis tarda*. Ardeola, 55, 13-25.

Paton, P. W. C., Zabel, C. J., Neal, D. L., Steger, G. N., Nancy, G., & Noon, B. R. (2011). Effects of Radio Tags on Spotted Owls. *Sierra*, *55*(4), 617-622.

Parker, K.A., Dickens, M.J., Clarke, R.H., & Lovegrove, T.G. The Theory and Practice of Catching, Holding, Moving and Releasing Animals. In: Ewen, J.G., Armstrong, D.P., Parker, K.A. & Seddon, P.J. Eds. (2012). Reintroduction Biology: Integrating Science and Management (2012). Blackwell Publishing.

Pereverzina T & Waters D (2008) Artificial incubation and rearing of great bustards in the UK-Russia project. In Bustard Studies. Volume 7. Great bustards conservation through nest management and rear and release methods.

Phillips, R. A., Xavier, J. C., Croxall, J. P., & Burger, A. E. (2003). Effects of Satellite Transmitters on Albatrosses and Petrels. The Auk, 120(4), 1082-1090.

Putaala, A., Oksa, J., Rintamäki, H., & Hissa, R. (1997). Effects of Hand-Rearing and Radiotransmitters on Flight of Gray Partridge. *Journal of Wildlife Management*, *61*(4), 1345-1351.

Saraux, C., Le Bohec, C., Durant, J. M., Viblanc, V. a, Gauthier-Clerc, M., Beaune, D., Park, Y.-H., et al. (2011). Reliability of flipper-banded penguins as indicators of climate change. *Nature*, *469*(7329), 203-6. doi:10.1038/nature09630

Schulz, H. and Seddon, P. (1996): Biology and Status of the houbara bustard. In Saint Jalme M. and Van Heezik Y. (eds), Propagation of the houbara bustard. Kegan Paul International, London. pages. 3-14.

Shier DM & Owings DH (2006) Effects of predator training on behavior and post-release survival of captive prairie dogs (*Cynomys ludovicianus*). Biological Conservation. Volume 132, Issue 1, Pages 126–135.

Shier DM & Owings DH (2007) Effects of social learning on predator training and postrelease survival in juvenile black-tailed prairie dogs, *Cynomys ludovicianus*. Animal Behaviour, Volume 73, Issue 4, Pages 567–577.

Seddon PJ, Armstrong DP and Maloney R (2007) Developing the Science of Reintroduction Biology. Conservation Biology, Volume 21, Issue 2, pages 303-312.

Steenhof, K., Bates, K. K., Fuller, M. R., Kochert, M. N., McKinley, J. O., & Lukacs, P. M. (2006). Effects of Radiomarking on Prairie Falcons: Attachment Failures Provide Insights About Survival. *Wildlife Society Bulletin*, *34*(1), 116-126.

Valutis, LL & Marzluff JM. (1999) The Appropriateness of Puppet-Rearing Birds for Reintroduction. Conservation Biology Volume 13, Issue 3, pages 584–591.

van Heezik Y, Seddon PJ & Maloney RF (1999) Helping reintroduced houbara bustards avoid predation: effective anti-predator training and the predictive value of pre-release behaviour. Animal Conservation 2, 155–163.

Williams T (2008) The Great Bustard UK Reintroduction Project – RSPB visits Russia. Internal RSPB report.

Williams T (2011) Great Bustard LIFE+ Project - Quarantine and Release Schedule. Internal project report.

Williams T (2012) Great Bustard LIFE Project, Brandenburg, Germany: Overview of rearing and release. Notes from project visit, Jan 2012.