

Artificial incubation and rearing methods in the German Great Bustard (*Otis tarda*) conservation programme

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Introduction

The first censuses of Great Bustards in Germany were carried out in 1934 and 1939: more than 3,000 individuals were counted in the area of today's State of Brandenburg at that time (LUTZ 1939) making it the most important part of the German bustard population. Since then the population steadily decreased over a period of several decades. The first conservation steps were made only in the mid 1970s – in a period of intensified farming and the political directive of industrialisation of agriculture. Within this framework, there was no scope for habitat management in a bustard friendly way until the late 1980s. The only way of bustard conservation was to rescue all bustard clutches which were found during agricultural work, to incubate them artificially and to release the hand-reared juveniles in a pessimal environment. The first attempts at artificial incubation, hand-rearing and releasing Great Bustard chicks were made during the 1960s in the former nature centre Serrahn (today State of Mecklenburg – Western Pomerania) (PRILL 1969). Beginning in 1973, proven methods were used systematically to supplement the decreasing German population. This started at the Biological Station Steckby (State of Saxony-Anhalt) (DORNBUSCH 1983) and was continued at the Nature Centre Buckow (now Bird Conservation Centre of Brandenburg) from 1979 onwards.

Today, habitat management forms the core part of the German Great Bustard conservation programme. Nevertheless, the artificial rear and release project is still essential, firstly to prevent the German population from extinction and secondly to raise it to a population size great enough for self-sustaining survival under markedly improved environmental conditions. Both habitat management and artificial rearing are carried out together by the Brandenburg State Bird Conservation Centre and the NGO Förderverein Grosstrappenschutz. This paper describes egg collecting, artificial incubation of the eggs and rearing of the

chicks. For marking, release methods and post-release monitoring see EISENBERG (2008).

Study area and methods

Study area

The breeding area of Great Bustards in Germany has been continuously declining over the past decades. Many former territories have been abandoned and there are only three reproductive leks remaining, all west of Berlin and designated Special Protection Areas (SPA) under the Birds Directive: these are the SPAs “Havelländisches Luch”, “Belziger Landschaftswiesen” (Brandenburg) and “Fiener Bruch” (Brandenburg / Saxony-Anhalt). These represent the current study and conservation area whereas data before 1994 include eggs from several other areas where bustards are not present today. The field hatchery building is situated about 50 km west of Berlin in Buckow / Nennhausen. It is part of the Bird Conservation Centre of the State of Brandenburg.

Egg collecting

All eggs within the artificial rear and release project are from the indigenous breeding population and not from another donor population. Up to 1993, eggs came from a lot of parts of Brandenburg and adjacent regions and had to be transported over long distances. Today there are only the above mentioned three areas with fertile populations and regular breeding attempts. The collected eggs result from:

- Broods that are disturbed, usually due to agriculture.
- Clutches without chance of success, *e.g.* Red Fox (*Vulpes vulpes*) den or Common Raven (*Corvus corax*) nest nearby.
- Early clutches from the wild that are searched and collected systematically (see below).
- First clutches from females in captivity.

According to recent monitoring data, reproductive success in the field is currently very low due mainly to high predation pressure (LITZBARSKI & ESCHHOLZ 1999). This is true not only for the Great Bustard but for a lot of ground nesting bird species in large parts of Central Europe (LANGGEMACH & BELLEBAUM 2006). For Great Bustards, particularly early clutches in April and the beginning of May, with low vegetation cover, nearly all were unsuccessful in the 1990s. Therefore, since then, first or “early” clutches have been collected systematically, using intensive observation and roping of meadows and fields.

For several reasons (experience and availability of personnel, landscape features *etc.*) this was done mainly in the SPA “Havelländisches Luch”. The continuously low breeding success in both of the other areas gives evidence that collecting early clutches is no additional risk for the population. Usually, the eggs taken are replaced by wooden dummy eggs to keep the female sitting. If females continue sitting until hatching time, the wooden clutch is exchanged for the original. However, in the majority of cases even wooden eggs get lost. For example they are attractive toys for ravens even though they are not edible. As is typical for ground-nesters, fertile females regularly produce at least one, mostly two or more substitute clutches. Up to eleven eggs per hen per year with nine being fertile are documented (A. EISENBERG & P. BLOCK, unpublished.). Thus, the birds are able to compensate for lost eggs to a certain extent.

So far, nothing is known about a calendar effect in Great Bustards under natural conditions in Central Europe, *i.e.* changing data in egg size, hatching success, rearing success *etc.* in the course of the breeding season. Anyway, this is not relevant for management decisions as long as breeding success in the field is nearly exclusively influenced by predation.

Summarising, there are three ways for handling clutches found in the field and a mix of these creates a fourth:

1. Eggs remain outside
 - extensification scheme works
 - extensification scheme needs to be changed
2. Collection of eggs
 - rescue of threatened eggs
 - taking these without substitution in order to provoke a replacement clutch
3. Exchange of eggs for wooden dummy eggs
 - changing back prior to hatching
 - replacement clutch if wooden eggs get lost
4. Mix of methods – exchange of single egg *etc.*

For details of the management decisions used, see Figure 1. “Enclosure” means five areas, each of 15 – 20 ha, that are fenced in order to provide fox free refuges. These are selected by wild (!) females for breeding, making this approach a successful one for more than ten years in the “Havelländisches Luch”. Positive results have also come from the other areas. The management of the meadows inside the enclosures is easier since there is no pressure for any agricultural use. Additionally, it is easier to observe the females, to find their eggs and to manage the nest sites. So, inside the enclosures 82 % of the dummy eggs are accepted by the females after exchange compared to only 48 % outside – an overall total of 65 %.

Field methods – decision criteria

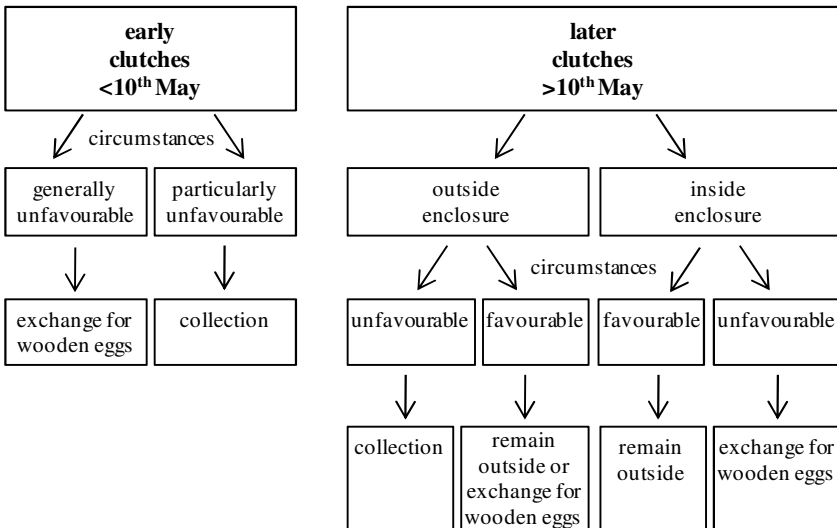


Figure 1: Decision criteria for taking Great Bustard eggs (for more information see text).

Special challenges in nest site management are:

- Finding breeding females in late spring with tall vegetation.
- Pressure of time prior to mowing dates.
- In some years competition with ravens which often take the earlier eggs immediately after laying (also inside the enclosures).
- Considering hens with chicks during agricultural work since they may be very mobile.
- Inflexible EU extensification schemes.

The collected eggs are carried in styro-foam boxes upholstered to minimise vibration. For longer distances (up to 60 km) transport incubators are used, requiring a second person. To avoid any contamination with human microbes the eggs are touched as little as necessary, using clinical gloves or with thoroughly cleaned and disinfected hands. Only stronger contaminated eggs are washed under running water of about 35 °C but not colder in order to avoid influx of water and germs into the eggs (DEEMING 2000).

Incubation

The eggs are incubated at 37.4 °C, 60 % humidity and turned eight times per day, using commercial force-draught automatic incubators, since 2003. The formerly used one-stage still-air incubators of older types are used now as hatchers running at 37.0 °C and 85 % humidity without turning. The eggs are brought into the hatchers one to two days before hatching, the signal being the start of louder calling of the chicks. In both breeding and hatching rooms there is a stringent disinfection scheme based mainly on 70 % alcohol. Each egg is weighed every fifth day. Suspect eggs (*e.g.* slight smell, no movements, no calling before hatching) are incubated separately, and eggs that are sure to be unsuccessful are selected as early as possible. Failed eggs are immediately brought to a veterinary laboratory for investigation – so the results are available within a short time for changing management in the same breeding season if necessary.

Unfortunately, candling is impossible in Great Bustard eggs because of thickness, structure and pigmentation of the egg-shell. So it is difficult to find out if an egg is fertile or not and what age embryos are. X-raying as a possible alternative has not been used so far because of possible risks for the developing gonads of the embryo. The formula of DEEMING (2000) to determine the age of an egg based on the loss of weight does not work in bustard eggs, and the attempt to ascertain a specific Great Bustard constant for this formula by eggs of known age failed because of the wide range of results.

Rearing

After hatching the chicks are moved into a warm box for about one day. From the second day onwards they are kept in groups of similar age in a glass house which provides early contact with con-specifics as well as with their later environment. This glass house is equipped with infrared heating lamps and ground-heating for warming and has a litter of gravel. We try to get the chicks outside as much as possible using an enclosure of about 300 m². From the end of the first week onwards, staying in the glass house is restricted more or less to the nights and phases of bad weather. Beginning with the fourth week a greater run of 3,000 m² is used with a wooden shed for sleeping. The grassland vegetation within the enclosures forms a mosaic of shorter and taller patches to meet all the demands that wild chicks have.

Main objectives for the rearing period are a good health status and bustard specific behaviour after releasing. The latter shall be supported by reduced human contact and an early start of the release-period at the age of six weeks. The few people that care for the chicks are uniformly dressed with pale-green smocks, to reduce the appearance of humans to a very narrow pattern that the birds are unlikely to meet in the field. We try to reduce the contact with the birds to a necessary minimum, *i.e.* mainly the feeding times. Touching is

restricted to weighing and medical treatment if necessary. The birds are weighed twice per day during the first two weeks (morning and evening before feeding), then only in the morning until 25th day and afterwards only twice until release.

The hand-feeding period of the chicks has gradually been shortened during recent years and is now only done for one week. To promote feeding by themselves hand-feeding should be restricted. Within the first two weeks the chicks are fed only insects (commercially available crickets and insects from the field) and little pieces of herbs complemented with vitamins. From the third week onwards they get an additional diet for growing birds called “Lundi”, from a German producer. Important for metabolism and development of the skeleton is a protein content that is not too high. Our bustard diet contains 35 % during the first five to six weeks and 20 % thereafter. For optimal development daily walks are necessary.

The only routine veterinary care is treatment against *Coccidiosis* some days before going to the release-sites.

Personnel

The whole incubation period is managed by two experienced female staff. The rearing staff consists of five people altogether. Nobody else but a veterinarian, if necessary, has access to the rearing facilities. Each group of chicks is fed by one person to avoid any additional contact with humans.

Results

Reproductive status of the donor population

Figure 2 demonstrates the number of eggs collected and insemination rates for each year. The depression in the egg numbers between the late 1980s and the early 1990s marks the decreasing population size but also consequences of this decline: a critical population status with dissolving leks, reduced displaying and mating activities and a greater number of older individuals. The following increase of egg numbers is due to an increase of the population size and the number of reproductive females, respectively, and to more systematic collection of first clutches in the remaining breeding areas. Insemination rates of eggs from the field are steadily increasing over the whole investigation period (the peak around 1990 is based on low egg numbers).

Table 1 shows the averages of three investigation periods with marked differences between them. The present values indicate a good fitness of the population, satisfactory environmental conditions and absence of disturbances inside the conservation areas (cf. LITZBARSKI *et al.* 1987 on reasons for low insemination rates in the past).

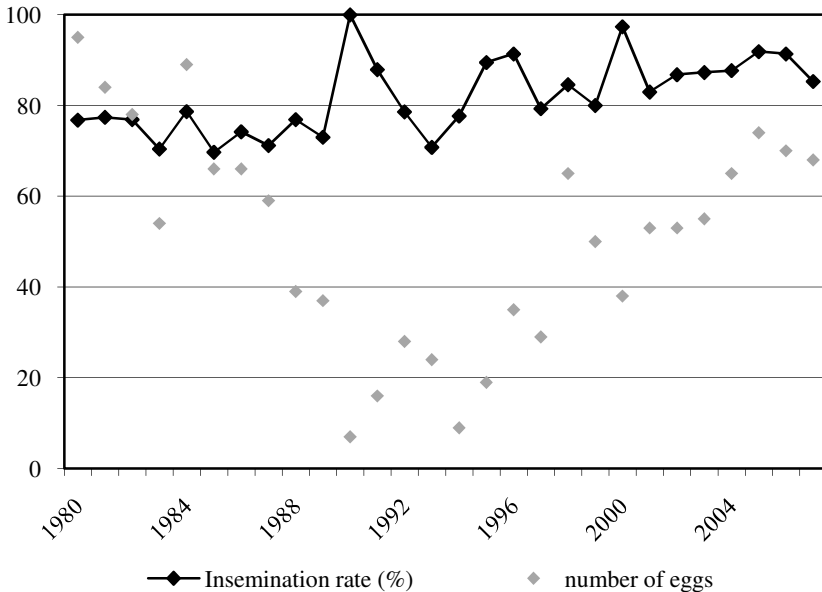


Figure 2: Insemination rates of Great Bustard eggs from the free-living German population and numbers of collected eggs per year between 1980 and 2007 (n=1,448).

Table 1: Insemination rates of Great Bustard eggs from the free-living German population between 1980 and 2007 (n=1,448, after LITZBARSKI & LITZBARSKI 1999, continued).

Year	Insemination rate	Number of eggs
1980–89	73.8 %	707
1990–99	81.9 %	265
2000–07	88.6 %	476

Figure 3 shows that insemination rates remain stable at least until the end of May. Later data rely on a small sample size of only seven eggs. An average insemination rate higher than that in Table 1 is due to the fact that Figure 3 refers only to eggs with a known laying date. However, in infertile eggs the percentage of eggs with known laying date is lower than in fertile eggs. The selection of a higher rate of infertile eggs compared to fertile eggs raises the average insemination rate. Within the sample of 22 selected infertile eggs without exact known laying date there is no evidence for a bias towards later dates.

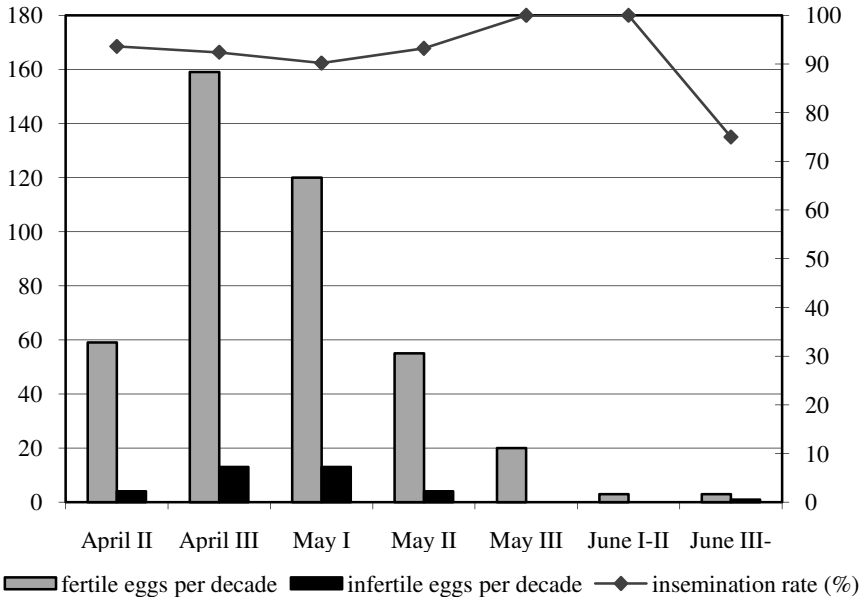


Figure 3: Insemination rates in the course of the breeding period between 2000 and 2007 (n=454).

Compared to a former analysis (LITZBARSKI & LITZBARSKI 1999) there are two remarkable phenomena: Firstly, the breeding period today begins markedly earlier which might be caused by climatic changes; however, the rather early end of the breeding period in Figure 3 is an artefact due to the egg-collecting scheme – observations in the field suggest that there are no differences compared to the past. Secondly, whereas between 1980 and 1989 insemination rates fell over the breeding season they are constant over the main part of the breeding season in recent years.

Incubation period

Between 1980 and 2007, 67.4 % of the fertile eggs produced chicks. Table 2 demonstrates that hatching rates have been slightly increasing over time. In the 1980s, the eggs were often collected by farmers and came only indirectly to the breeding centre, sometimes transported over long distances and not as carefully as they should have been. In the following period decreasing egg numbers and the abandonment of more peripheral sub-populations made it more frequent that eggs were picked up by programme staff using suitable equipment. With increasing predation pressure in the mid 1990s the eggs often disappeared

during the first few days and sometimes immediately after laying. So a decision was made to take all first clutches as soon as possible after laying to make them at least available for artificial incubation. However, the first part of the incubation period is the most sensitive one (DEEMING 2000). Whereas in the past the majority of the eggs had been incubated naturally for the first few days or weeks, nowadays many eggs are artificially incubated from the first day onwards. This could reduce the hatching success to some extent. In all investigation periods there might have been a small percentage of fertile eggs that had died in the field before collecting for artificial incubation.

Table 2: Hatching success of fertile Great Bustard eggs from the free-living German population between 1980 and 2007 (n=1,161, after LITZBARSKI & LITZBARSKI, 1993, corrected and completed with new data).

Year	Hatching rate	Number of fertile eggs
1980–1989	64.7 %	522
1990–2000	69.6 %	217
2000–2007	69.7 %	422

Rearing success

“Rearing success” in the context of the artificial rear and release project means released birds per hatched egg. Table 3 shows the data for three different periods. Differences in numbers of hatched chicks between Table 2 and Table 3 are due to two reasons: Firstly a number of eggs that are counted in Table 2 were replaced (“adopted”) under brooding hens in the field immediately before hatching (see above – *Egg collecting*), and secondly, Table 3 includes hatched chicks from the captive group whose eggs are disregarded in Table 1 and Table 2. Between 1980 and 2007, 497 artificially reared Great Bustards have been released in Germany.

Table 3: Rearing success of hatched Great Bustard chicks between 1980 and 2007 (n=753).

Year	Released birds per hatched egg	number of hatched chicks
1980–1989	53.6 %	338
1990–2000	69.9 %	143
2000–2007	79.4 %	272

Increasing success in rearing reflects increasing experience over the years, eventually leading to a better health status of the growing birds. Long bone deformations and a paresis-like syndrome that occurred sometimes in the past are prevented now by reduced protein in the diet and active training by daily

walks. Early symptoms are treated with low doses of minerals (calcium-phosphate and others) which are successful in most cases. Angel wing that occurs in many chicks at the end of the first week is only a temporary nuisance. It is cured by routinely fixing forearm and hand with little rubber bands for one to two days. The only remaining phenomenon is cases of *prolapsus cloacae* in some of the very young chicks. These chicks are treated with *Buscopan comp.* (0.05 ml/100 g) immediately after noticing the first symptoms. Even if the cause of the problem is still unknown this therapy is successful in most cases after one injection, generally avoiding surgical methods. In some cases, the latter is still necessary but this is a short procedure that usually leads to success after one day.

Discussion

Prior to the rear and release project the Great Bustard had been extinct in the “Havelländisches Luch” area in 1989. Only very few individuals would have survived in the “Belziger Landschaftswiesen” and “Fiener Bruch” but without any chance of an increase or even re-establishing a vital population by themselves. So the project prevented the German Great Bustard population from extinction. Furthermore, as a part of a more comprehensive conservation programme, it has been contributing to a population increase from 57 individuals in 1997 to 110 in 2007. In spring 2007, the breeding population consisted of 60 ringed birds from the artificial rear and release project and 50 individuals without rings representing mainly descendants of the released birds (first and further generations) and a maximum of five individuals which could have survived from the original (not manipulated) population. Since there are regularly single bustards in other areas which are not intensively monitored, there might be some additional birds.

Sometimes the question is discussed whether – even considering that nearly all first clutches would be predated – taking the first clutches could do more harm than help to the population since later clutches could have reduced insemination rates. This is not true, as shown in Figure 3. In most years little chicks are seen up to late July and most of the few chicks that become fledged are from late broods. More relevant for the (potential) hatching success in the field is the distinct overall increase of insemination rates during the last 25 years due to better environmental conditions and reduced disturbances within the conservation areas. This, however, does not occur due to the high predation rate. This is the background that any discussion has to take into account.

Figure 4 shows that the population decline decreased with the start of the artificial breeding programme in the mid 1970s. That, with additional measures, has turned the decline into an increase since 1998. Additionally, Figure 5 shows that the time of intensified egg collecting since the late 1990s is also characterised by more offspring in the wild and greater numbers of released

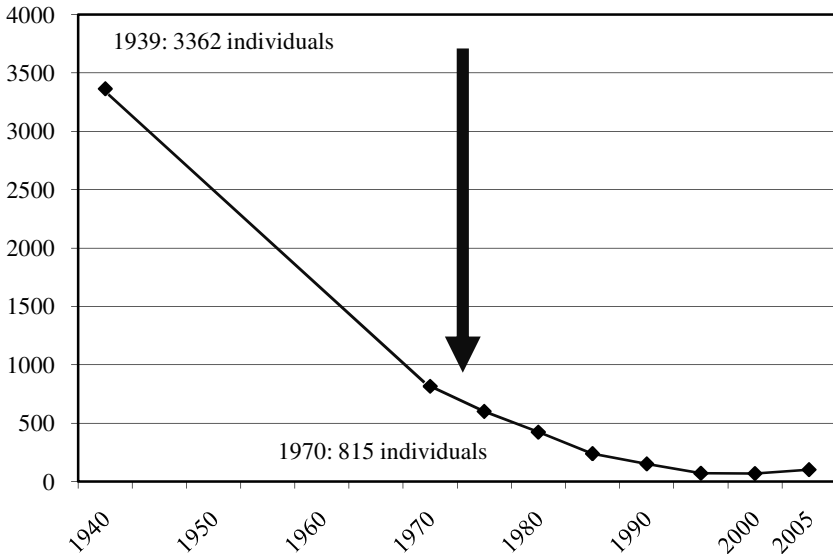


Figure 4: Population trend of the German Great Bustard population. The arrow marks the start of the rear and release project.

birds leading together to a population growth which is the first after at least six decades of decline. One can assume that without intensified management, the negative population trend would have continued from the mid 1990s, eventually leading to extinction.

Unfortunately, the population still depends completely on conservation due to low reproductive success in the wild. The monitoring accompanying all conservation measures demonstrates that high predation pressure on clutches and juveniles rather than unfavourable environmental conditions (such as an insufficient nutritional basis) is responsible for this situation. Red Fox and (at least for early clutches) Common Raven seem to be most significant in this context whereas the role of some other species such as Raccoon (*Procyon lotor*) and Raccoon Dog (*Nyctereutes procyonoides*) is not yet clear. Among several approaches to predation management that have been tested in the past, one way seems to be most promising at the moment: the fencing of areas of at least 15 ha (up to 400 ha as in Hungary) to provide the wild bustards predator-free refuges for reproduction. Attempts to reduce predatory species with hunting measures failed (LITZBARSKI *et al.* 2005). A population analysis in the SPA “Havelländisches Luch” demonstrated that the high reproductive success inside the enclosure raised the survival probability of the population to nearly 100 % (STREICH *et al.* 2000). So, natural offspring additionally contribute to the increasing population trend. In the “Havelländisches Luch” the population

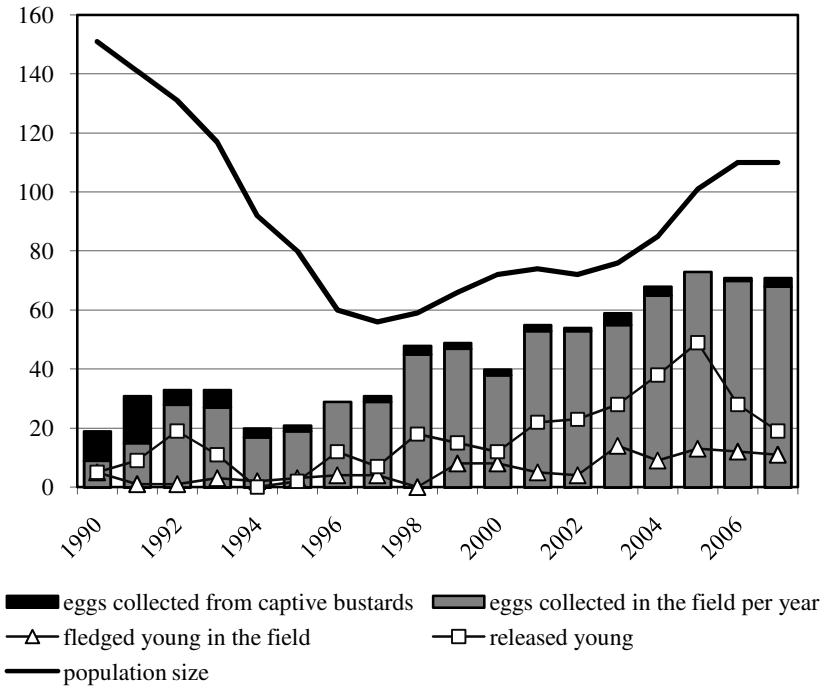


Figure 5: Relationship between management within the framework of the artificial breeding programme, annual offspring (including fenced areas) and population trend of German Great Bustards between 1990 and 2007.

increase during the last decade succeeded nearly without re-stocking with birds from the rear and release project.

There is hope that a further population increase by intensive habitat, population and predation management will lead to a more stable population structure that allows the population to compensate for losses by predation. The main goal is a self-sustaining Great Bustard population in Germany.

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