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Every partridge counts, successful techniques used in the captive conservation breeding programme for wild grey partridge in Ireland.

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Abstract

Every partridge counts, successful techniques used in the captive conservation breeding programme for wild grey partridge in Ireland.— Between 1998 and 2001 the last remaining wild grey partridge (*Perdix perdix*) population in Ireland faced imminent extinction with an estimated spring population of 4–6 pairs, and an autumn population of 22–24 birds. A captive breeding programme began in 2002 with two pairs of grey partridge. In the most successful year in 2010, 39 pairs produced a total of 510 chicks. Average chick survival rate was 65.13%. At 88.9 the highest chick survival rate was achieved in 2011. Chick survival of parent–reared birds in captivity is defined by the number of juveniles surviving at age six weeks: similar to estimations used for wild populations of grey partridge. Family coveys were released in late summer to early autumn. In most instances the entire family cohort was released as one unit. However, in coveys of twenty or above, an average of five parent–reared poults were held back as breeding stock for the following year. In early spring of the following year, birds held back were paired with single males or females trapped from the wild. The techniques we used were traditional and labour intensive but highly effective. We recommend that other grey partridge recovery projects should consider captive breeding using the methods employed in this programme to compliment other game management methods used.

Key words: Grey partridge (*Perdix perdix*), Conservation breeding, Parent–rearing, Breeding success, Chick survival rate, Re–introduction.

Resumen

Cada perdiz cuenta, técnicas utilizadas con éxito en el programa de conservación de cría en cautividad para la perdiz pardilla en Irlanda.— Entre los años 1998 y 2001, los últimos restos de la población salvaje de perdiz pardilla (Perdix perdix) de Irlanda se enfrentaban a una extinción inminente, con una población primaveral estimada de 4–6 parejas, y una población otoñal de 22–24 aves. En el 2002 se inició un programa de cría en cautividad con dos parejas de perdices pardillas. En el año con mayor éxito, 2010, 39 parejas produjeron un total de 510 pollos. La tasa promedio de supervivencia de los pollos era del 65,13%. Se consiguió la mayor tasa de supervivencia de éstos en el 2011, que era del 88,9%. La supervivencia de las crías de los pollos de parejas de progenitores criados en cautividad se define mediante el número de jóvenes que sobreviven hasta la edad de seis semanas: parecida a las estimas utilizadas para las poblaciones salvajes de perdiz pardilla. Se soltaron grupos familiares desde finales del verano a principios del otoño. En la mayoría de los casos se soltaba la cohorte familiar entera como una unidad. Sin embargo, en los grupos de veinte o más, se retenía un promedio de cinco pollos criados por sus padres para formar la población de cría para el año siguiente. Al iniciarse la primavera del año siguiente, las aves retenidas se emparejaban con machos o hembras sueltos que se recogían de la naturaleza mediante trampas. Las técnicas que utilizamos eran las tradicionales y el trabajo intensivo, pero muy efectivo. Recomendamos que otros proyectos de recuperación de la perdiz pardilla consideren la cría en cautividad, utilizando los métodos empleados en este programa, para completar otros métodos de gestión utilizados.

Palabras clave: Perdiz pardilla (*Perdix perdix*), Cría de conservación, Criado por los padres, Éxito reproductivo,

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Introduction

Re–introduction projects attempt to re–establish species within their historical ranges through the release of translocated wild or captive–bred individuals following extirpation or extinction in the wild (IUCN, 1998). Captive breeding of wild animals can be a vital component of re–introduction biology (Seddon et al., 2007). There are, however, a number of concerns regarding the potential success of captive breeding projects such as the reduced ability of individuals to survive in the wild (Snyder et al., 1996), in addition to poor health and condition of captive bred stock (Mathews et al., 2005). Captive breeding projects using individual birds from wild populations are not always guaranteed to succeed, e.g. Laysan Teal *Anas laysanensis*, (IUCN, 2010), and reservations have been expressed regarding the success of parent–rearing methods (Kreger et al., 2005). There is little published information relating to the captive breeding of wild grey partridge *(Perdix perdix*). The only reference on captive breeding was found in Maxwell (1911). Thus the information regarding captive breeding within Maxwell's book formed the basis of the conservation breeding programme for the species in Ireland.

The grey partridge is a farmland species which has declined across Europe (Burfield & Van Bommel, 2004; Kuijper et al., 2009). It is also a red–listed species in the Republic of Ireland and it is the most westerly population of the species in Europe (Lynas et al., 2007). The population has been in steep decline in Ireland since the middle of the 19th century (Ussher & Warren, 1900; Whilde, 1993). Although grey partridge were a popular game species in Ireland, anecdotal evidence suggests that few estates were managed specifically for grey partridge shooting. With little or no motivation to manage for shooting, fluctuations in the Irish population were inextricably linked to changes in agricultural land management.

A population increase was noted from 1933 onwards,perhaps due to successful translocations although no reason is given and grey partridges had colonised areas in the west of Ireland where 20 years before they were unknown (O'Gorman, 2007). However, from the 1950s onwards across most parts of Ireland the grey partridge was still sparsely distributed, with most birds present in County Carlow (Kennedy et al., 1954). The status in the 1960s was similar to that given previously with no indication as to the actual size of the population. Ruttledge (1966) noted that the grey partridge was sparsely distributed and sometimes found in small cultivated fields of desolate agricultural areas (O'Gorman, 2001).

Whilde (1993) described the native grey partridge in Ireland as 'endangered' with less than 200 breeding pairs. This estimation, however, should be considered with some caution as grey partridges were released from game farms in several areas across the country. In areas where no releases had taken place, local extinctions had already occurred decades earlier. For example, a number of release programmes were initiated on farmland in Kildare in 1993 and Wexford in 1994, but neither resulted in the establishment of a successful wild breeding population (Kavanagh, 1998). In 1991, an autumn survey was carried out at the two last known wild partridge populations in the midlands of Ireland, at Boora, County Offaly & Lullymore Kildare, both located in post–industrial cutaway bogs.

An autumn survey of the [illegible] partridge populations was carried out at Boora, co[illegible] Offaly and Lullymore and county Kildare. Both locations are cutaway peat land bogs. Cutaway bog is an open, mostly barren habitat following industrial peat extraction. Re–colonisation by a variety of plant communities formerly found in traditional tillage fields emerged in subsequent years.

From 1992 onwards, a combination of surveys and information on sightings was collated to produce minimum estimates of the total autumn population for these two sites (Kavanagh, 1992, 1998). From 1996 to 2002, no releases of grey partridge had occurred in Boora. This population was monitored by spring and autumn estimations only. In 1993, three grey partridge pairs were radio–tagged in Lullymore (Hearshaw, 1996), initiating the first focused study of the species in Ireland. Nesting sites were chosen in areas of recolonized cutaway bogs, but all were predated (O'Gorman, 2007). In spring 1994, the Lullymore population was estimated at only 3–4 pairs, and by 2000, grey partridge were extinct in Lullymore Thus, after the year 2000, the only wild population left in the Republic of Ireland was at Boora.

In 1996 a conservation project, including predator control and habitat management with concurrent research, was established to prevent the extinction of this very last Irish population. With an increase in the total autumn population from 59 in 1996 to 72 birds in 1997, the initial response of the grey partridge recovery project was encouraging. However, three successive wet and cold summers followed, and together with a further loss of habitat owing to reclamation of the cut–away for grassland and forestry by Bord Na Mona —an Irish semi–state company set up in the mid 1950's to exploit Irish peat lands for fuel— the Boora population declined to 22 birds in autumn 2001. The extinction of the species as a breeding bird in Ireland therefore seemed imminent. Since the re–introduction of captive–bred artificially–reared birds has been shown to be ineffective due to high mortality (Potts, 1986; Rantanen et al., 2010; Buner et al., 2011), the release of game–farm reared grey partridge was not considered. Instead, a behavioural study on the ability of captive grey partridges was carried out in Boora (Kavanagh & Fattbert, 2002) using game–farm reared breeding stock for parent–rearing. This research concluded that the average clutch size of artificially–reared birds (35.5) was almost double the average clutch size of wild birds and hatching success of game farm–reared birds was virtually zero. Any hatched chicks were compromised by the degenerate and maladapted behaviour of their parent birds.

As a result of the difficulties associated with captive–bred artificially–reared birds and their subsequent lack of success in the wild (Rantanen et al., 2010; Buner et al., 2008, 2011), a decision was taken to proceed with a conservation breeding programme using wild–caught grey partridges from Estonia and Boora (see also 'Origin of founder captive stock for parent–rearing'

in Material and methods). This paper reflects on the successful methods used to breed wild grey partridge in captivity in Ireland and the relevance for reintroduction and restocking of the species for conservation purposes. In addition, some recommendations for the successful breeding of wild grey partridges in captivity are outlined.

Materials and methods

Study area

The captive breeding experiment was located in the area of the grey partridge conservation project in Boora, County Offaly, Ireland. The study comprised a 5 km^2 core area. However, a variable number of grey partridge were dispersing 12 km^2 from the core area, particularly to the east and south where the tillage and root crop farming is practised. Outside the core area, non–intensive predator control was also carried out, namely the culling of localised fox populations. This core site was chosen on the basis of logistical prudence and its convenience to the local population of wild grey partridges. In terms of managing the experiment, the site at Boora provided a source of wild grey partridge for trapping. Simultaneously, predators were controlled systematically and suitable habitats were created and managed for grey partridge post–release.

Rearing methods

Origin of founder captive stock for parent–rearing

During the first three years, from 2002–2004, grey partridges used in our captive parent–reared breeding programme were obtained from a similar captive programme in France (Kavanagh, 2001). These birds were the progeny of wild trapped birds. They had not been subjected to successive generations in captivity, unlike those of normal game farm stock.

In 2005, grey partridges used in our captive breeding programme were trapped directly from the wild in Estonia. The population in Ireland shares ancestry with both eastern and western populations of grey partridges in Europe (Liukkonen–Anttila et al., 2002). These birds were paired in captivity with birds from the local Irish population (see below). Estonian birds comprising pure pairs (both individuals from Estonia) or mixed pairs (one local Irish and the other Estonian) proved far more difficult to manage. Thus, in 2005, when we used either pure or mixed pairs, we recorded the lowest chick survival rate. Determined efforts were made to understand why chick survival was so low.

After careful and prolonged observations it was discovered that Estonian adult birds and/or mixed pairs spent a significant amount of time hidden in cover, refusing to bring their chicks to the high protein chick crumb provided. Any journeys that were made by adult birds with their chicks were short lived. Thus an insufficient amount of high protein food was consumed by the chicks. Consequently, chick mortality increased significantly.

Wild–caught adult birds from Boora for parent–rearing

Each year grey partridges from the project area in Boora were trapped from the wild. Trapping did not begin until after wild birds had paired. The reason for this approach was not to interfere with the mating behaviour of the few remaining last wild birds. Trapping for the captive breeding programme focused mainly on un–paired males; single females were only occasionally caught as they normally re–pair very quickly in the wild owing to a male surplus that is typical in wild partridge populations.

Single birds were attracted to a pen containing a live decoy of the opposite sex, which was kept in a small 1 m^2 container within a larger pen in which the trapped bird was visible. The door of the pen was left open to allow the wild bird to enter, triggering the door to shut behind.

Trapped birds were placed in a pentagon shaped pen, each section measuring 2.5 m long by 1.2 m high. These pens were situated on a free–draining grassland and post–glacial bolder clay. Depending on the circumstances, either three domesticated males or females, which were kept in captivity over–winter (see 'Origin of founder captive stock for parent–rearing'), were then introduced to the wild trapped bird to allow for unforced pairing. Mate choice was noted by the keeper based on the behaviour observed, *e.g.* a male and female staying together or the newly formed pair driving other un–paired birds away from them.

Each breeding pair was then given an individual pen, similar to the one described above. The normal breeding process began in captivity, *e.g.* nest construction, egg–laying and incubation. After hatching, chicks were allowed 24 hours to digest their natural egg yolk food supply. Following this period, chicks were caught up, followed by their parent birds, in that order. The family unit was then placed in a brood–rearing box measuring 1.5 m long by 0.6 m high by 0.6 m wide. The box was covered with a dust proof green mesh to prevent injury. A clear sheet of acrylic glass was placed at one end of the box over the top one–third of the unit. The family group was kept in this box for a period of one week to ten days; grey partridge chick starter crumb and water was provided at all times. It was decided to bring the crumb to the chicks instead of attempting to get the chicks to come to the crumb after the learning experience with the Estonian birds described above. Chicks confined in these boxes were effectively trained to the crumb.

The pair and their chicks were checked regularly for short periods of time throughout each day of their confinement. Contact with chicks was kept to an absolute minimum to prevent habituation. Family groups held for longer than one week were first fed on a diet of grey partridge chick starter crumb, followed by mini–pellets and 'finished off' on grower pellets prior to release as an intact family covey. After time periods ranging from one to six weeks, the leg ringed adult pair was released with their chicks into suitable habitat.

Rearing with Bantam chickens

When wild grey partridge pairs were confined to a breeding pen, the majority of their eggs were laid in

Table 1. Captive breeding data from 2002 to 2011 of the Irish grey partridge recovery programme in Boora: – No data.

Tabla 1. Datos de cría en cautividad del 2002 al 2011, en el programa de recuperación de la perdiz pardilla en Boora: – Sin datos.

Year									
2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Number of pairs nesting									
2	5	6	14	18	18	21	35	39	34
Number of pairs incubating eggs									
2	3	6	14	11	–	19	28	32	24
Number of total chicks hatched									
–	33	86	116	127	–	187	281	510	307
Number of chicks surviving to 5 weeks									
10	20	66	12	75	–	139	185	436	273
Chick survival rate (%)									
–	60.6	76.7	10.3	59.1	–	74.3	65.8	85.5	88.9

a scrape. These eggs were covered by the pair with dead vegetation, until incubation commenced.

However, our experience indicated that females were not inclined to lay all their eggs in one nest. Eggs not laid in the nest were usually 'scattered' around the pen. Left unused these eggs represented an unacceptable waste of potential adult birds. Thus, these eggs were 'bled out' until a suitable number was obtained. When approximately 20 eggs were collected they were placed under a mongrel broody Bantam chicken for incubation.

Standard facilities were provided to the Bantams to rear these chicks until they were five weeks old. Juvenile bantam–reared grey partridges were then isolated from their foster mother for a period of one week. These juveniles were leg–ringed and placed in a fostering unit. The fostering unit was then moved to an area where a single adult bird or a barren breeding pair was present in the wild.

These pairs or single birds quickly fostered the juvenile bantam–reared grey partridges as their own as described in detail in Buner & Aebischer (2008). In addition to fostering juvenile birds, grey partridge coveys were removed from their breeding pens and placed into a square 1.5 m x 1.5 m^2 wooden box with a hinged front door. The coveys were then transported to release sites with suitable habitats. A 20 m string was then attached to the door. After a period of 30 minutes the hinged door was opened, allowing the covey to escape un–stressed.

Disease and disease prevention of rearing stock

Throughout the entire period of the captive breeding programme, the grey partridges remained susceptible to disease. Diseases included coccidiosis, septicaemia, lung consolidation causing *Escherichia coli septicaemia,* and gapes (*Syngamus trachea*). These diseases were identified by a veterinary surgeon in post mortems on 28–day old chicks and one adult (Clerkin, 2008). Over the period of the captive breeding programme some mortality occurred in chicks less than one week old. On veterinary advice, a four–day treatment of vitamins and anti–pathogenic medicines including Amoxinsol–50 and water soluble vitamin E was administered. In addition, anti–gape treatment was given to chicks by mixing flubenvet into chick starter crumb, mini pellets and grower pellets. This approach significantly reduced the mortality of chicks and juveniles. To further reduce the incidence of pathogenic and parasitic disease, breeding pens were moved each year onto 'fresh ground' prior to the onset of the breeding season.

Results

Captive breeding data from 2002 to 2011 are summarised in table 1. There was a substantial increase in chick survival rate (CSR) over time. A CSR of 88.9% in 2011 represents the highest chick survival rate ever recorded for the captive breeding programme. The lowest CSR recorded was 10.3% in 2005 which appears to be an outlier as over the 10–year period owing to the reasons explained under 2.2., the average CSR was 65.2%. No data were recorded in 2007 due to a temporary shortage of staff.

Discussion

Captive breeding of wild animals may be a vital com-

ponent of re–introduction biology but success is not a foregone conclusion (Snyder et al., 1996; Mathews et al., 2005). The ability of wild individuals to survive in a captive environment is a major concern.

The balance of maintaining good health and condition in conjunction with fostering a sufficient reproductive breeding success to reintroduce individuals cannot be overstated. In addition, there is an underlying necessity to maintain the innate wild behaviours and instincts of the breeding stock. Where population augmentation is the aim, integration of the most appropriate genetic variation is another consideration.To our knowledge the Irish captive breeding strategy of wild grey partridges is the most successful captive breeding programme aimed at re–establishing a wild population ever recorded,with a CSR of 88.9% in 2011 and an average CSR of 65.2% over the duration of 10 years to date. The most plausible explanation for the success of this programme is the result of numerous factors employed by the personnel involved.

However, the action taken to bring the crumb to the chicks and the attention paid to the prevention of disease is fundamental to the success of the breeding programme in Boora. It would also appear that taking into account the wild behaviour of the partridges in captivity and adjusting the breeding techniques to incorporate this behaviour is paramount to the success of the birds' post–release survival and successful breeding.

Captive breeding widens the scope for the re–introduction of endangered bird species such as the grey partridge in Ireland. This strategy ensures that insofar as possible, each individual bird within an endangered population can make a contribution to the population as a whole. Breeding in captivity in mixed pairings with wild and domesticated individuals can produce high numbers of well–adapted offspring which are ideal for the release into the wild. This is reflected in an overall increase in the wild population. Since the inception of the captive breeding programme the autumn populations of wild grey partridge has increased on average 42.8% over the ten–year period

It can be assumed that our released parent–reared juveniles benefited directly in terms of survival from the local knowledge of their captured wild parent (either male or female in each parent–reared covey released) and that the subsequent breeding success of these offspring is making a major contribution to the wild population. Captive breeding also provides the opportunity to maximise the breeding productivity of wild grey partridges in years when the variables of an Irish summer or indeed the lack of continuity of funding reduce the wild productivity below sustainable levels.

In Ireland the captive breeding programme has not only assisted the recovery of the species in Boora but the success has resulted in facilitating the relocation or re–introduction of coveys of grey partridge into additional farmland habitats formerly occupied by the species. The methods used in this breeding programme can be applied in other translocation, restocking or re–introduction projects throughout Europe in areas where the species used to be present or where critically endangered wild populations would benefit from population augmentation.

However, in Ireland and indeed in other countries, captive breeding of wild grey partridges is not a long–term solution. Captive breeding and release of grey partridges should only be implemented in conjunction with habitat management and predator control. From a European and Irish perspective, the long–term viability of this iconic farmland specialist species is to create agricultural ecosystems which can meet its ecological requirements. It would appear that the most likely vehicle to achieve this is to devise targeted agri–environment schemes.

Although the captive breeding programme has been successful, the long–term viability of the population of grey partridges, as with many farmland specialist birds in Ireland, is more likely to be dependent on agri–environment policy (McMahon, 2007). Captive breeding was used as a conservation tool in Ireland to augment the existing breeding population of grey partridge because without it, this enigmatic species would most likely now be extinct.

Conservation Implications

The success of the breeding programme has enabled recommendations to be devised as a result of the lessons learned: (1) Captive–bred hand–reared grey partridge should never be used as they are behaviourally maladapted and do not breed successfully post release. (2) To maximise survival of released coveys, parent birds should contain at least one wild–caught grey partridge and ideally, the captured bird originates from the release site; as a rule, the caught wild birds bring their survival experiences to the released covey and hence increase post–release survival of the whole group. (3) It is recommended that a wild male is allowed to pair naturally with a domesticated female; 24 hours post hatching, broods of chicks should be placed into brood–rearing boxes with parent birds following in that order. (4) Ready access to crumb for the chicks up until they are at least ten days old is essential. (5) Contact between game keepers and the breeding pairs and their chicks should be kept to an absolute minimum to avoid habituation. (6) Wild grey partridges should not spend more than one year in captivity. (7) Good habitat, supplementary feeding and predation control should be in situ before any releases occur.

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