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A Review of Gray Partridge Restocking in the UK and its Implications for the UK Biodiversity Action Plan

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The gray partridge *Perdix perdix* has been the subject of many re-introduction projects throughout the world. In earlier attempts many releases simply aimed to increase the number of individuals for harvesting. This is very different from a conservation project aiming to establish a self-sustaining population. In recent decades, the gray partridge has declined severely in abundance and it is a species of conservation concern throughout Western Europe. Until now, gray partridge releasing projects have mainly focused on releasing large numbers of captive-reared individuals, of which few survive because of heavy predation and low breeding success. We reviewed the scientific and gamekeepering literature, and found that nevertheless a number of traditional methods for rearing and releasing gray partridges exist. Although these have primarily been developed to supplement existing wild stocks to produce shootable resources, some can be re-used today for conservation purposes. The most promising system for producing birds for re-introduction and supplementation purposes is to obtain eggs from a reliable source, hatch and rear the chicks under bantams to eight weeks of age, then foster to failed pairs of wild gray partridges. A less labour-intensive alternative is to hatch and raise chicks under artificial heat and foster these to unsuccessful wild pairs. Obviously these two systems are dependent on the presence of local free-living wild birds. If no pairs of wild gray partridges are present it is necessary to establish a founder population first. We see two methods to achieve this goal, the release of coveys in autumn or of pairs in spring. An important pre-requisite to any restocking scheme is appropriate management including the provision of suitable habitat for feeding and nesting and the control of predators, otherwise restocking is unlikely to lead to long-term establishment.

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Introduction

Prior to the Second World War, the rearing and releasing of gray partridges was not commonly undertaken within the partridge's natural range. Good partridge management, which primarily concentrated on controlling predators, was sufficient to ensure that enough birds survived to provide a shootable resource. The farmed environment at the time was ideal for gray partridges, providing a range of naturally occurring nesting sites and good food availability. Consequently, gray partridges were one of the most common and widespread farmland birds (Potts 1986). In the UK, a number of methods for rearing and releasing were developed to ensure that this resource was even larger than it would be if left to nature, and imported ("Hungarian") eggs and birds were used solely to introduce new blood.

In the UK, agricultural intensification from the 1950s and a reduction in predation control resulted in huge declines in wild gray partridge numbers (Potts 1980, 1986) of 89% over the last 30 years accompanied by a 25% contraction in range during the same period (Gibbons et al. 1993, Baillie et al. 2005). As a result, the species has been recognised by the UK government as a Biodiversity Action Plan (BAP) species and as such has specific targets relating to increases in population size that must be met by 2010 (Anonymous 1995). During this decline phase, a number of estates tried rearing and releasing gray partridges on a large scale, whilst most oth-

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ers switched to the easier and more cost-effective releasing of pheasants and red-legged partridges and ceased active gray partridge management. Having identified the causes of the decline in the UK (Potts 1980, 1986), research sought to produce management options targeted at reducing the damaging effects of modern agriculture (Rands 1986, 1987, Sotherton et al. 1988). Many of these options are now part of government-funded agri-environmental schemes. Consequently, not only do we know what is needed to restore the fortunes of the gray partridge, but government has largely provided the means to do so.

A number of estates have adopted partridge-friendly agri-environmental options, but owing to the absence or low numbers of gray partridges occurring in the wild, the birds have not responded. How then to establish partridges in a sustainable fashion that will contribute to achieving the aims and targets of the species' action plan?

In this review of traditional and current rearing and releasing systems, which could potentially be used to contribute towards reaching the BAP targets, we seek to identify which method or combination of methods would be most suitable to answer this question.

The review was conducted by searching through old game management books, the scientific literature, and through formal and informal interviews and discussions with gamekeepers (see the References and Acknowledgements sections for the publications and people consulted).

Traditional rearing and releasing methods

Traditionally most gamekeepers left their gray partridges to take care of themselves. Only estates that used farming methods that resulted in large nest losses, for example hay and silage cutting or heavy grazing by stock, intervened and interfered with the natural breeding of the partridges. Where this happened, most techniques for rearing and releasing were variations of one of the four systems outlined below.

The Euston System

This system was developed to overcome the problem of hen and nest losses during the incubation period (through predation, disturbance, trampling, etc.), to spread the date of hatching and to increase genetic heterogeneity. As many gray partridge nests as possible were found and mapped. Nests that were regarded as truly safe were left to hatch naturally. For other nests, once they contained 5 eggs, the eggs were removed and replaced with matching wooden eggs. Further natural eggs were then removed on every other day until all natural eggs were removed and replaced with wooden ones. When the female gray partridge started incubating the wooden eggs, the date that incubation started was recorded. For nests that were in unsuitable positions all the eggs were removed and the nest destroyed, in the hope that the female would nest again elsewhere. The removed natural eggs were placed under broody bantams and monitored daily. Once the eggs started chipping, they were carefully replaced under the incubating female gray partridge, after first removing the wooden eggs. Generally it was possible to swap the eggs without disturbing the female, but if she did leave the nest, she was likely to return very quickly. It was believed that chipping eggs could be returned to an incubating female between 14 to 21 days after she started incubation, and the time of returning eggs should coincide with a period of good weather. Some gamekeepers would exchange eggs, prior to starting their incubation, with neighbouring estates to introduce "new blood" to the estate.

This system was successful in maintaining and enhancing gray partridge numbers to produce a shootable resource, but it was not intended to be used for restocking. It has not been used on a large scale in the UK for many decades (at least 60 years) and documented evidence of its success is not available in the modern literature, although a number of historical books state that it was highly successful (e.g. Alington 1910, Wormald 1912, Portal and Collinge 1933). It was very labour-intensive, however, and required a high degree of knowledge about

the nesting behaviour of partridges. To really provide benefit for the shooting estate there needed to be a large resident stock, otherwise the effort involved was not justified. Additionally, this system increased only the number of nests that successfully hatched eggs and provided no additional benefits to the chicks. The key to success for this system was the widespread availability of suitable chick-rearing habitats, with an abundance of good invertebrate food. The system offered no protection against inclement weather, which can have a major impact on chick survival. For these reasons, the use of the Euston system is not really viable today.

The French or Continental System

This system was developed to allow gray partridges to rear their own young within a controlled system that protected them from predation, poor food availability during the first few days after hatching, and to some extent, the weather. Fundamental to the French system was the construction of a suitable partridge enclosure, which consisted of a large central area, maybe as large as 40 m by 60 m, with a number of smaller pens arranged around it. The central enclosure and the side pens contained bushes, fir branches, tussocky grass and a good supply of grit, water and food. Electric fencing and numerous traps was placed around the enclosure to prevent predation. Up to 60 true pairs (i.e. equal numbers of males and females) were introduced into the central enclosure, usually in November. Traditionally these were "Hungarian" birds, these being hand-reared birds usually imported from Hungary, but not exclusively. When introduced into the central enclosure each bird would have had one wing tied, or "brailed", to prevent the bird from flying and damaging itself. A gamekeeper would watch the birds and as soon as pairing was observed he would quietly drive the pair into one of the side pens where it would be left to produce eggs and hatch young. Pairs were never forced as it was felt that an "unnatural marriage" would never work. Any unpaired birds were released from the central enclosure into the wild, or retained as stock birds. Each female was permitted to lay up to 25 eggs. Any surplus was removed and incubated under broody bantams; the resulting chicks were either released when fully grown, or reintroduced to the penned birds to make up a brood. The penned pair meanwhile was left to incubate its clutch, kept within the pens until the chicks were 3-4 days old, then the adults and brood were released onto the estate. During bad weather, the adults and their chicks would be held in captivity until it improved.

Compared with the Euston System, this system provided assistance to gray partridge chicks during the first few days after hatching, when they are most susceptible to poor weather and limited food supply. Additionally it provided an opportunity to rapidly increase stock over a relatively short period, and as such provided an opportunity to restock as well as provide a shootable resource. Again it is difficult to find documented evidence of this system's success, but one gamekeeper reports that to produce a large stock this system is the best (Portal and Collinge 1933). Like the Euston System, this system was also very labour-intensive and required a dedicated gamekeeper to produce the pairs and a lot of knowledge to induce them to breed successfully.

The Montebello System

The French System required the construction of a large purpose-made enclosure and a gamekeeper to watch for paired birds. The Montebello System overcame the need for a specially constructed enclosure and the commitment of a gamekeeper's time, by forcing the pairing of a male and female. At the start of the rearing process, a forced pair was put into a small breeding enclosure, with the hope that they would accept each other and settle down to breed. Traditionally, the system would use either wild-caught pairs or a combination of a wild-caught bird and one from reared stock. The pen contained all of the requirements for partridge breeding, including food, water, grit, vegetative cover and a suitable nesting area. The pair of partridges was left to undertake egg laying and incubation. Once the

chicks were 3-4 days old, they were released with the adults into suitable habitat close by.

This system was very similar to the Continental System, but overcame the problems of requiring a large, specially constructed pen and a dedicated gamekeeper. It still required the holding of birds in pens, with its associated problems of preventing predation, and was dependent on the ability of captive-held partridges to produce eggs, undertake incubation and rear young. This ability to act as suitable parents whilst in captivity is something that is dubious today (see later).

Traditional hand-rearing of partridges

Historically gray partridges were not reared and released in the sense that we would regard the rearing of pheasants and red-legged partridges today. Generally, a gamekeeper would acquire a few eggs from badly sited or predated nests, from friends, as a result of surpluses from the Euston or French System or as bought-in "Hungarian eggs". Foremost in the gamekeeper's mind was cleanliness and disease prevention. All equipment associated with rearing was scrupulously cleaned, including broody boxes, coops, feeders and drinkers prior to the start of the breeding season. Broody hens and bantams were all treated for scaly leg and were dusted with insect powder. Each hen or bantam was given up to 30 partridge eggs to hatch, with some being removed for the Euston System or some other purpose, ultimately leaving the hen with 18 eggs. Once the eggs were hatched and whilst the chicks were between 12-24 hours old, the hen and 16 chicks were moved to a rearing field and placed in a coop (i.e. a box that contained the hen, but allowed the chicks to move freely in and out of the box via wooden slats or bars). Excess chicks were divided between broods to make numbers up to 16. Coops were positioned about 80 m apart and had fir branches positioned near them to provide cover. The coops were kept in an open field, which required rigorous predator control especially at night, even though the coops were shut each night. Each coop was moved onto fresh ground daily, when the hen was removed from the coop and allowed to eat and drink whilst being tethered by one leg. The chicks were fed three times a day by scattering an appropriately prepared mixture of egg yolk, scalded biscuit meal and barley flour outside the coop. Ants and their eggs were also offered to the chicks once a day. Once the chicks were 4 days old, chopped onion and boiled rabbit was also added to the feed. Until the age of 8 weeks various other ingredients were added to the food, including maize, rice and egg white. When the chicks were 8 weeks old, the coops were moved to a field edge and arranged in pairs, at about a half mile distance from the next nearest pair of coops. Feeding was reduced to three times a day, coops were still moved daily, but were not shut up at night. At about 9 weeks, one of the hens was removed from the pair of coops and a week later the other hen was removed. The coops were left in place, but were finally removed by mid-September. Usually a barren wild pair would come and adopt the chicks or the chicks would disperse naturally.

This incredibly labour-intensive system would have undoubtedly produced a shootable resource by the start of the shooting season, and obviously the more birds reared the larger the resource. However, what is not known, or recorded, is how successful this system was in supplementing the existing wild stock or in restocking areas where only a small residual wild population remained. It is likely that some of the released birds would have survived over winter and bred the following year, principally because they would have mixed with true wild birds, but how the reared birds would have survived in the absence of a wild source is unknown.

Current rearing and releasing methods

Over the last 10-20 years, very few estates in the UK have used traditional methods to rear and release gray partridges for restocking. However, in East Anglia and a few isolated pockets elsewhere in the country, some estates have developed techniques that are essentially modifications of the traditional methods, but which use improved technology and a

better understanding of gray partridge behaviour.

Modified Montebello System

Over the last 10 years a number of estates in Norfolk (Eastern England) have been using a modified version of the Montebello System. A pair of gray partridges is kept in a small enclosure and allowed to breed, but chicks are retained up to the age of at least six weeks before release (K.A. Blake, unpublished). This sought to overcome the problems of early chick losses associated primarily with limited food availability in modern-day arable habitats. In order to simplify management of the birds, some estates tried keeping the paired pens in close proximity on a rearing field before moving the adults and chicks to suitable areas for release. Pairs apparently spent a lot of time calling to one another and pacing up and down the sides of the pens in an attempt to get together. This seemed to confuse the pairs, which did not settle and in some cases started fighting. To overcome this, pens were then sited in natural habitats away from the other pens so that birds would not call to each other. Although this overcame the problem, occasionally wild single male birds would be attracted to the pens, which resulted in fighting and poor fertility. Pairs were formed by using either reared birds or a mix of wild and reared birds. The problems of fighting within the pairings, poor fertility, and the use of reared birds often meant that birds did not incubate the eggs correctly and produced only small broods of young. To overcome this, some estates exploited the natural instinct of adult gray partridges to adopt young partridges. The young were produced by hatching the eggs produced by the penned birds under bantams or by purchasing day-old chicks from game farms. The young were often adopted immediately after being introduced to the penned partridges. Another modification to the traditional Montebello System arose from the desire to retain the adult partridges as stock birds, for use in future years. To do this the adult partridges were taken away from the chicks at approximately six to eight weeks. The chicks were then moved to small pens sited within the territories of unsuccessful wild pairs, where they were released in the hope that they would be adopted.

Although estates that used the modified Montebello System reported initial successes, the problems outlined above led to the majority of estates moving to the system described in the next section. Brood production of the pairs held under this system varied from about 60% to 100% depending on the origin of the parents (K.A. Blake, unpublished). Pairs that were made up of a wild male and a captive-reared female had the highest rate of brood production, those that were from purely reared stock had the lowest brood production, and the pairs that were made up of purely wild birds were mid-way between. Mean brood size followed a similar pattern and ranged from 2.8 ± 1.0 (SE; $n = 7$) young per pair for reared pairs to 11.0 ± 1.4 (SE, $n = 12$) for mixed pairs.

Fostering to wild barren pairs

One of the most commonly undertaken methods of rearing and releasing young today has been fostering to wild pairs. For this system, eggs or young are reared to the age of about six to eight weeks, taken to the territory of a failed wild pair and released in the expectation that they will be adopted. Sources of eggs include those picked up from the wild, produced by stock birds or occasionally obtained from game farms. These eggs are either hatched and reared by bantams or hatched in an incubator and reared under an electric brooder. Once these chicks are at least six to eight weeks old they are formed into broods of 10-15, placed into small pens and moved into the territory of an unsuccessful wild pair. Some gamekeepers place these pens within a standing crop, whilst others place them in the open. Once the wild pair is seen close to the pens, the young are released and taken away by the wild pair. Occasionally a few of the young are released from the pen, so that those outside call to those inside the pen, thereby potentially increasing the attraction of the young birds to the adults. Usually the released young remain in coveys with the adults, but occasionally coveys have been known to merge.

The survival of these birds after release and their breeding success in subsequent years appears to be very good. This method has been scientifically evaluated in Switzerland and compared to other releasing techniques mentioned above, in the course of a re-introduction scheme. The Swiss scientists compared the monthly survival rates of individuals originating from three different release strategies: 1) translocation of wild adults, 2) releases of captive parent-reared adults and 3) captive parent-reared chicks that were fostered to wild pairs. Locally born offspring (second generation birds) from the established breeding pairs served as a control group. The fostered birds had the highest monthly survival rate (0.86 ± 0.03), followed by the translocated birds (0.82 ± 0.06) and by the adults reared in captivity (0.70 ± 0.06). The high survival rate of fostered birds was most likely due to acquiring knowledge about predator avoidance from their experienced parents (Buner and Schaub 2008). However, because that study was based at a single location with relatively low sample sizes, further research involving larger sample sizes and multiple study sites would be appropriate.

Modern-day rearing and releasing

The two previously discussed modern-day techniques have been primarily aimed at increasing stock levels and not necessarily enhancing the shootable resource. All of these techniques are labour-intensive, requiring some specialist equipment and a degree of knowledge about gray partridge husbandry. Modern-day shooting has relied increasingly on the use of rearing and releasing of large numbers of pheasants and red-legged partridges to produce sufficient numbers of birds for shooting. This approach has also been applied to the rearing and releasing of gray partridges. It is easy to obtain large numbers of gray partridges for release by obtaining eggs from captive-reared stock birds, hatching them in incubators and rearing the chicks under electric brooders. Finnish research into the fate of radio-tagged wild and released birds showed that released birds had lower survival and breeding success compared to wild birds (Putaala and Hissa 1998, Putaala et al. 2001). Many of the released birds starved or were predated, and the work concluded that released birds would contribute little to boosting threatened wild populations (Putaala and Hissa 1998). A Scottish study also found that the majority of released birds were predated shortly after being released (Game Conservancy Trust 2000). This method has been used to re-establish wild gray partridge stocks in an area of Northern Italy, where habitat was suitable and it was likely that the gray partridge had succumbed to overshooting. After curtailing shooting and instigating habitat improvement and predator control, thousands of reared gray partridges were released during autumn. Some of these birds survived over winter and bred in the following year (P. Tout, personal communication). The success of this project seemed to be dependent on the release of very large numbers of birds into a well-managed area.

The Edmonthorpe Method

Eggs taken from the wild are hatched and reared by bantams to produce a captive breeding stock. This breeding stock is held as pairs in captivity and any eggs laid by these birds are removed and hatched, usually in an incubator. At two weeks of age the chicks are fostered back to a pair of birds from the captive stock. If more young are produced than pairs are available, then the young are fostered to a single adult bird. At eight weeks of age the chicks and the foster parents are moved to an area of specially prepared habitat and held in captivity for a few days before release. The area of specially prepared habitat consists of strips of maize, a cereal crop, stubble from the previous year and sown grass. The arrangement of these strips allows a high density of coveys to be released. The captive breeding stock is replaced annually by retaining hatched young or hatching eggs from the wild under broody bantams.

This system seems to provide enough birds to shoot and also contributes to the wild stock of partridges.

The François Hughes Method

Having obtained a breeding stock of birds from the wild, this system maintains the birds in captivity in 16-20-m^2 vegetated pens, of which half is mown on a regular basis, the other half left undisturbed to provide breeding cover. In order to keep the captive stock as wild as possible, wild genes are introduced annually by the collection of over-mown wild clutches. The birds are left to pair naturally, produce and hatch eggs and rear their own young. These family coveys are then available for release as a real family group containing two adults and an average of 13 at least 6-week-old young.

This method has supplied birds for restocking in France mainly, but also in Scotland, Ireland and Switzerland (see above).

Translocation outside the natural range

Numerous attempts to introduce the gray partridge to areas outside its natural range have been undertaken at various sites around the world, primarily to provide hunting opportunities (Long 1981). These releases generally involved the releasing of groups of partridges caught from the wild in Europe. The numbers released ranged from groups of less than 100, to in some cases over 20,000 birds. Although it is not recorded, these birds were probably held in enclosures for a few days to allow acclimatisation, before being released en masse.

During the period from about 1880 to the mid-1900s gray partridges were released at numerous locations throughout the United States of America. Some of these releases were highly successful, and today gray partridges are found throughout much of the Mid-west. In Canada, gray partridges were released from about 1900 to the 1930s, and are established in south central Canada today. Other unsuccessful attempts at introducing gray partridges were undertaken in Hawaii, New Zealand, Australia, Fiji and Chile in the late 1800s and early 1900s.

Discussion

Habitat provision and predation control

Underlying the decline of gray partridges throughout its range has been the degradation of feeding and nesting habitats and the increase in predation pressure. Numerous studies have shown that the provision of the correct habitat features can help, in part, to restore gray partridge numbers and this has now been adopted nationally in the UK within agri-environment schemes. A fundamental pre-requisite to any intended gray partridge reintroduction or supplementation is that suitable partridge habitat must constitute a minimum of 6% of the core release area (e.g. Buner et al. 2005). With respect to predation, a study on Salisbury Plain showed that predator control increased wild gray partridge density 2.5 times over three years (Tapper et al. 1996). No study has looked specifically at the effect of predation on released birds, although it is recognised as one of the main factors affecting the survival of released gray partridges. For example, over 90% of gray partridges were dead within six months of releasing compared with 30-70% of wild birds in the same area of the UK, and the highest single factor causing these losses was predation (Dowell 1990*b*). In Finland, where gray partridges were released in both autumn and spring, the losses to predation were between 60-80% (Putaala et al. 2001). Effective predator control is thus also an important pre-requisite to releasing gray partridges, and should be in place before re-establishment begins.

Egg provision

For restocking, every gamekeeper would, without doubt, prefer to have eggs picked up from the wild. It is generally assumed that wild eggs represent true genetic stock, whereas eggs from game farms are somehow genetically impure. It is possible that some of the instinctive behaviour of the birds, including aspects of breeding, foraging and anti-predator behaviour, may be altered by generations of captive breeding. However, whether this behaviour originates from genetics or is acquired by

learning has not been established.

Some gamekeepers have set up their own stock of breeding birds from gray partridges caught as adult pairs in the wild and held in captivity or from captive-reared birds hatched from wild eggs and held over-winter. In both situations, it is necessary to ensure that the risk of predation and disease is removed. Gamekeepers have reported that birds caught directly from the wild do not adapt well to captivity, are nervous, lay only small clutches of eggs, tend to lay later than wild birds, and probably as a result of increased stress levels are more susceptible to disease. However, better pen construction and provision of cover may improve performance.

Incubation and rearing

There are three principal methods available to hatch gray partridge eggs. Probably the easiest way is to incubate them in an electric incubator. The resultant young are then usually reared under an artificial heat source, either an electric or gas brooder, but it is possible to foster these chicks, as day-olds, to captive gray partridge adults without chicks or a broody bantam. A second popular option for hatching eggs is under a broody bantam, which is usually left to rear the young. It is possible, however, to take the young away from the bantam and foster them to a captive pair of gray partridges without chicks. The third option is to allow eggs laid by captive birds to be incubated by the birds themselves (parent-rearing). Many keepers (and experience on the GWCT rearing field) have reported that such birds lay 30-50 eggs, are poor incubators, frequently produce infertile eggs and consequently produce few to no chicks. Dowell (1990*c*) showed that only one out of nine pairs caught directly from the wild laid and incubated eggs, whereas gray partridges from a game farm could be induced to undertake incubation. The use of bantams and artificial incubators/brooders is relatively straightforward, although subsequent behaviour may be affected. Dowell (1990*a*) showed that, under experimental conditions, gray partridge chicks reared in captivity by gray partridges respond more appropriately to aerial predators and adult warnings than chicks reared by bantams or artificially. After release, all of the captive-reared chicks, irrespective of the rearing method, suffered greatly reduced survival in the short term (25 days) compared to wild-reared birds, and suffered large over-winter losses (90%) in the longer term. Although based on small sample sizes, there was a suggestion that bantam-reared and adopted (after release) broods fared better than gray partridge and artificially reared young. This has recently been supported by releases in Switzerland (Buner and Schaub 2008), see above.

Young provision

In the absence of a supply of eggs or if there is no desire to hatch eggs oneself, it is possible to acquire day-old chicks from game farms. These could be reared under artificial heat or fostered to a broody bantam or a captive pair of gray partridges.

Establishment of free-living adults

One of the most widely used techniques today for stocking gray partridges using traditional methods involves fostering 6-8-week-old gray partridges to failed wild pairs. However, this is dependent on the presence of resident gray partridge pairs onto which young can be fostered. In situations where gray partridges are completely absent or at very low densities, this technique is not applicable. One solution is to establish a free-living founder population of adult birds, which either breed themselves or most likely can act as foster parents. There are three potential options to achieve this: 1) to rear chicks to about 6-8 weeks and release them either in a single large group or as a number of smaller groups. This mirrors the modern rearing and releasing system used to provide birds for shooting. 2) To release a covey consisting of adults and young birds in autumn. The covey would most likely be made up of a pair of adult captive-reared birds with about 10 young fostered to them. In either case, over-winter losses may be high. To overcome this, a third option would be to hold captive-reared gray partridges over winter and release them as pairs in early spring. The birds would then be left to breed and produce

young or, if they failed to breed successfully, to act as foster parents later in the breeding season.

Developing a system for use in gray partridge conservation

A national re-establishment project needs to be cost-effective, relatively easy to undertake and lead to self-sustaining partridge populations. However, sites for re-establishment must be within the species' historical range, and crucially should have at least a minimum of appropriate management in place, including provision of nesting habitat, brood-rearing and over-winter cover, and ideally the presence of a gamekeeper. At least 6% of the core area and 3% of the total area should support habitat suitable for nesting, feeding and cover. There should be no intention to shoot gray partridges until at least 20 birds per 100 ha in the autumn has been achieved and maintained, and measures must be undertaken to ensure that accidental shooting of gray partridges does not occur.

The use of wild-origin birds or eggs for all intended translocations or releases would be ideal. Alternatively, the best system for producing birds for release would use eggs laid in the wild, hatch them under captive gray partridges that would also rear the chicks, then either release the chicks with the adults or foster them to wild gray partridges. However, wild eggs and particularly wild adults are not available in sufficient numbers and it is unlikely that captive-reared gray partridges would make sufficiently good parents to produce enough young. Therefore a compromise is needed to produce a system that is easy, practical and cost-effective, but would produce young gray partridges of sufficient number and quality for re-establishment purposes.

We therefore recommend obtaining eggs from a reliable source, namely a game farm, then hatching the eggs under bantams, which would also rear them to eight weeks. These young would then be fostered to failed wild pairs of gray partridges. A suitable alternative might be to hatch and raise chicks under artificial heat sources and foster these to wild pairs.

If no pairs of wild gray partridges are present it will be necessary first to establish free-living adults. We see two possible methods for doing this, namely release of family groups in autumn or pairs in spring. In order to establish these coveys, gray partridges could be obtained from a game farm in February, held in a large pen and, after pair formation, each pair would be allowed to breed. As it is unlikely that many of these pairs would produce young, day-old chicks would be obtained from a game farm and reared to 4-6 weeks of age. Batches of 13 chicks would be fostered onto each pair to form a covey of 15 birds, for release in late autumn. The second method involves releasing pairs in late March, when the main period of over-winter predation has passed. To establish these pairs, day-old chicks would need to be obtained from a game farm in early summer and held in a large pen until the end of the winter. In early spring these birds would need to be moved into groups of about 50 birds, allowed to form pairs and released shortly after. In both cases, there would need to be a period of acclimatisation to allow them to adapt from pelleted food to natural food such as seed mixtures and grass.

A 2-year research project currently being undertaken by The Game Conservancy Trust will monitor the success of chicks released on 26 study sites in 2 distinct regions of the UK using exactly the techniques outlined above.

Current knowledge gaps and recommendations for future work

This review highlights a number of areas where knowledge is lacking and further research is required. These are highlighted below.

1) It is not known whether young produced from eggs, laid in the wild by truly wild parents, and ones from eggs laid by captive game-farm parents and reared under identical conditions, will behave and survive differently or have different breeding success when released into the wild.

This could be explored by obtaining eggs from the two sources, hatching and rearing them under identical conditions, releasing them into the wild

and monitoring their survival and breeding success following release.

2) It is not known whether there are differences in the behaviour and survival of young hatched and reared by either captive gray partridges, a bantam or an electric heat source, then adopted by wild barren pairs.

This could be explored by hatching and rearing young under the three different systems, then releasing the young reared by these three methods and monitoring their subsequent success.

3) It is not known if the release of coveys in autumn or of pairs in spring is a more effective method of re-establishing free-living adult gray partridges.

This should be investigated by releasing both coveys and pairs of gray partridges and monitoring the success.

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