

**EFFECTS OF SUPPLEMENTARY
FEEDING ON THE BODY
CONDITION AND BREEDING
SUCCESS OF RELEASED
PHEASANTS**

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Abstract

The breeding success of released pheasants (*Phasianus colchicus*) is poor compared with wild ones in Great Britain. Many factors have been cited as possible causes of poor breeding success, including reduced hen condition in the nesting season. The aims of this study were to determine whether reduced body condition due to an inadequate diet contributes to poor breeding success of released pheasants and to demonstrate experimentally the impact of supplementary feeding on their body condition and breeding success. A series of 6 studies of food availability, diet, body condition and breeding success of pheasants was conducted in Britain between 1994 and 2000 to study these questions.

Spring diet and food availability were assessed in a multi-site study. Grains and seeds are important dietary components, but their availability to pheasants and their occurrence in the diet was low on all sites during spring. Grains were only a significant component in the diet on sites where supplementary feeding continued into spring. A spring survey of hen pheasant body condition on 21 sites revealed that fat reserves were higher on sites with spring supplementary feeding compared with sites which ceased feeding at the end of the shooting season (1st February). Further, it was demonstrated experimentally that continuing feeding into spring enabled hens to maintain fat reserves at their winter levels, whereas fat reserves of hens in unsupplemented areas were reduced by up to 50%. Supplementary feeding did not improve survival of hens through the spring, but the pre-breeding density of territorial cocks and hens was increased. Feeding did not significantly influence measured productivity parameters except for aspects of re-nesting ability which were improved by feeding. Overall, the densities of young birds observed during autumn counts were twice as high in plots which had been provided with supplementary grain in the previous spring than in unfed plots.

Although population densities of pheasants were positively influenced by supplementary feeding, breeding success was still lower than that of wild birds. Clearly, there are behavioural and physiological deficiencies which pre-dispose released pheasants to poor performance in the wild. Habitat deficiencies other than adult food availability are likely to be important too; in particular, the quality of brood rearing habitat which influences chick survival. However, the results of this study contribute to our knowledge of the ecology and management of released pheasants and it is recommended that spring feeding should be conducted routinely by game managers to enable released hens to maintain body condition and maximise their breeding potential.

Keywords: captive-rearing, diet, food availability, grain, *Phasianus colchicus*, survival



Photo: Roger Draycott

To my family

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Wickhambrook, October 2002

Roger Draycott

List of original articles

This thesis is based on the following articles, which are referred to in the text by their Roman numerals:

- I Draycott RAH, Butler DA, Nossaman JJ & Carroll JP (1997) Availability of weed seeds and waste cereals to birds on arable fields in spring. 1997 Brighton Crop Protection Conference – Weeds. BCPC, Farnham, p 1155-1160.
- II Draycott RAH, Butler DA & Carroll JP (2000) Spring diet of pheasants in the UK: Implications for the body condition of nesting hens. Hungarian Small Game Bulletin 5: 29-37.
- III Draycott RAH, Hoodless AN, Ludiman MN & Robertson PA (1998) Effects of spring feeding on body condition of captive-reared ring-necked pheasants in Great Britain. J Wildl Manage 62: 557-563.
- IV Hoodless AN, Draycott RAH, Ludiman MN & Robertson PA (1999). Effects of supplementary feeding on territoriality, breeding success and survival of pheasants. J Appl Ecol. 36: 147-156.
- V Draycott RAH, Parish DMB, Woodburn MIA & Carroll JP (2002) Spring body condition of hen pheasants in Great Britain. Wildl Biol 8 (in press).
- VI Draycott RAH, Woodburn MIA, Carroll JP & Sage RB (2002) The impact of supplemental feeding on breeding success of pheasants in Britain. (submitted).

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1 Introduction

1.1 The status of the pheasant as a gamebird in Great Britain

Today, the common pheasant (*Phasianus colchicus*) is the most abundant and widespread gamebird in Great Britain (Tapper 1999). Records show that they were probably introduced to Britain by the Romans, but they were not common until the 15th Century (Hill & Robertson 1988a). Pheasant shooting is an integral component of land management in many agricultural areas and contributes significantly both to the rural environment and economy. For example the shooting industry annually generates over £300 million and sustains 26,500 jobs (Cobham Resource Consultants 1997).

In 1900, pheasants constituted approximately 15% of the annual harvest of gamebirds (Tapper 1999). Due to improvements in rearing technology the numbers of pheasants released in Britain increased dramatically from the 1960's until the 1990's to the extent that in the late 1980's they constituted 55% of the annual harvest (Tapper 1999). Between 1968 and 1988 alone the total biomass of pheasants increased by 2500 tons (Dolton & Brooke 1999). Currently, approximately 20 million pheasants are released each summer in Britain to support an annual harvest of 12 million birds (150 birds/km²) (Tapper 1999). In order to support this elevated pheasant population, the majority of shoots provide game cover crops, and plant and manage substantial areas of woodland (Robertson 1992, Robertson *et al.* 1993a, Short 1994) to provide shelter for birds.

The majority of pheasants in Britain are harvested on 'driven' shoots on private estates, where birds are flushed from cover by a team of beaters over a line of standing guns (Robertson 1997). Typically between 100 and 200 birds are shot each day. To support this level of shooting, estates place artificially reared pheasant poults in woodland release pens at 6 weeks of age during July and August (Game Conservancy 1991). This is a form of 'soft release' whereby birds are allowed time to acclimatise to the natural environment; in contrast to 'hard' releases where birds are released directly into the wild (Westerkov 1953). Birds disperse from the pens over a 3-week period. They are first fed commercial compounded feed pellets and then wheat from hoppers in woodlands and specially planted game cover until the end of the shooting season on 1 February. As well as providing nutrients for the pheasants, the supplementary food also enables birds to be held in specific areas for shooting days. Over-winter mortality of these juvenile released birds is high (Robertson 1988, Robertson & Dowell 1990). However, in some areas large

numbers survive until the breeding season due to the quantity of birds released (Robertson & Dowell 1990, Woodburn 2001). The original aim of pheasant releasing in Britain was to supplement the existing wild stock of birds to facilitate sustainable shooting. However, in order for the harvest to be sustainable, released birds must survive and breed successfully in the wild. In reality, the survival and breeding success of released pheasants is poor compared with wild birds (Hill & Robertson 1988a, 1988b, Brittas *et al.* 1992, Leif 1994), although the productivity of adult released pheasants (birds surviving two winters post-release) is comparable with that of wild birds (Woodburn 1999).

When conducted responsibly, pheasant releasing can benefit wild game in three ways. First it can supplement wild stocks and increase wild production (Robertson 1997), second it encourages the creation and management of habitat which helps wildlife in general (Cox *et al.* 1996, Howard & Carroll 2001) and thirdly, it provides the economic basis for retaining gamekeepers who can control predation on wild stock (Tapper 1999). However, overstocking can suppress wild productivity and can result in negative ecological effects including habitat degradation and increased incidence of disease (Carroll & Robertson 1997).

1.2 Shortcomings of released gamebirds

In order to improve the survival and productivity of juvenile released birds in the wild, it is essential to first determine the differences in biology of wild and released game, and the factors responsible for these differences. Released hen pheasants are more vulnerable to predation during April to August than are wild hens and produce only 25% as many young as wild birds (Hill & Robertson 1988b). Released hens are particularly vulnerable to red fox (*Vulpes vulpes*) predation before and after incubation (Hessler *et al.* 1970, Robertson 1986, 1988). In the United States, spring releases of reared hens result in low production of poults because of high mortality of adults (Kabat *et al.* 1955, Ellis and Anderson 1963, Jarvis and Engbring 1976, Leif 1994). Brittas *et al.* (1992) also recorded reduced chick survival among reared hens.

Many factors have been shown to influence poor performance of reared gamebirds after release. In grey partridges (*Perdix perdix*) poorly developed predator avoidance behaviour due to artificial rearing in the absence of the parent bird has been observed (Dowell 1990, Anttila *et al.* 1995). Increased susceptibility to parasitic infection due to high concentrations of birds after release (Woodburn 1995, Woodburn 1999, Draycott *et al.* 2000) and physiological shortcomings due to rearing in captivity and being fed a highly digestible commercial diet (Putala 1997, Liukkonen-Anttila 2001) can also influence the performance of released gamebirds. The shortcomings of released birds can be exacerbated by the fact that pheasant releasing often occurs in areas with poor breeding habitat (Sage & Robertson 2000), and due to the high concentrations of birds at release points there can be a functional and numerical response of predators to high densities of prey (Kenward 1981, Robertson 1988, Gortázar *et al.* 2000). Poor performance may also be related to body condition in the nesting season. Robertson (1994) noted that released pheasants lost 40% of their April body mass by the time they

reached the brood rearing period. The provision of supplementary grain is common during the winter (Robertson *et al.* 1993a) but this often ceases at the end of the shooting season on the 1st February (Draycott 1998). Removal of this important food source may cause a nutritional deficiency for pheasants in early spring, reducing body condition and impacting on overall performance of the birds.

1.3 Food availability – a nutritional bottleneck for pheasants in spring?

Pheasants are omnivorous and opportunistic feeders and tend to consume energy rich foods (Cramp & Simmons 1980, Johnsgard 1999). In Britain, they feed predominantly in agricultural habitats (Robertson 1997, Hoodless *et al.* 2001) which have been subject to increasingly intensive management over the past few decades (Potts 1980, Potts 1991). This has resulted in the decline in number of several seed-eating farmland bird species during the last 30 years (Tucker & Heath 1994, Fuller *et al.* 1995, Campbell *et al.* 1997, Chamberlain & Fuller 2000, Chamberlain *et al.* 2000). Reduced availability of weed seeds and cereal grains during winter has been cited as a probable cause of some of these declines (Evans 1996, Stoate 1996, Campbell *et al.* 1997, Boatman & Stoate 1999). Several important changes in land use and practice have caused this reduction in seed availability. These include the switch from spring to autumn-sown cropping, increased herbicide inputs and use of more efficient machinery resulting in less over-winter stubble, fewer broadleaved weeds and less grain spilt during harvest (Wilson *et al.* 1995, O'Connor & Shrubbs 1986). Consequently, cereal fields now contain low densities of waste grains and seeds, which are an important component of pheasant diet in spring (Pulliainen 1966, Stromborg 1979, Hoodless *et al.* 2001)

Birds must store food to fuel periods when they cannot feed due to the necessary performance of other tasks (Cuthill & Houston 1997). During the nesting period the opportunity for gamebirds to feed is not only greatly reduced, but nutritional requirements actually increase above maintenance levels (Wise 1994). Laying hens must therefore accumulate extra fat before nesting. Fat reserves of pheasants are at their highest levels in the pre-breeding period (Anderson 1972). Breitenbach and Meyer (1959) demonstrated that healthy penned pheasants may lose 80% of their body fat during first 20 days of incubation.

It is possible that released birds cannot accumulate sufficient fat reserves when their primary food source is removed at the end of the shooting season. These reduced fat reserves could occur because of one or a combination of three factors: reduced competence at finding natural foods, a poorly developed digestive system, or low availability of energy rich foods on intensively managed modern farmland. In winter, it has been shown that supplementary feeding can maintain or improve body condition in a number of gamebird species including pheasants (Bogenschutz *et al.* 1995), bobwhite quail (*Colinus virginianus*) (Robel 1972, Doerr 1988) and black grouse (*Tetrao tetrix*) (Valkeajärvi & Ijäs 1989). However, little research has been published on the effects supplementary feeding or food limitation on reproductive success of pheasants or other

game species, which is surprising considering food supply often limits some aspects of reproduction and occasionally survival in birds (Martin 1987). There is evidence however that egg quality and brood size in some grouse species are related to maternal nutrition (Moss *et al.* 1975, Beckerton & Middleton 1982, Moss & Watson 1984).

2 Natural history of the common pheasant

The common (or ring-necked) pheasant is a member of the order Galliformes, a globally distributed group (Johnsgard 1999). This order also includes groups such as partridges, quail, grouse, turkeys and guinea fowl. In Britain, the pheasant is predominantly a bird of woodland edge, agricultural and shrubby-wetland habitats (Hill & Robertson 1988a, Johnsgard 1999). It has a wide distribution throughout Great Britain (Tapper 1999). Pheasants are sexually dimorphic with an unusual form of polygynous mating, based on defence of harems of females by territorial males with the exclusion of non-territorial males (Oring 1992). Pheasants exhibit seasonal variation in habitat use (Robertson *et al.* 1993a). In winter, woodlands, ditches and dykes provide a major habitat for pheasants in Britain (Robertson *et al.* 1993a). In the USA wetlands, scrub and tall grasses are used in areas where there is no woodland (Guthery & Whiteside 1984, Gatti *et al.* 1989, Perkins *et al.* 1997, Gabbert *et al.* 1999). Pheasants prefer woodlands with a high proportion of shrubby cover (Robertson 1985, Robertson *et al.* 1993a), with structural diversity being more important than species diversity (Lachlan & Bray 1976, Robertson *et al.* 1993a). Shrubby cover provides shelter, concealment and ease of movement at ground level (Robertson *et al.* 1993a).

During early spring pheasants move out of their wintering areas in woodlands (Robertson *et al.* 1993a) and males compete to establish exclusive territories in February and March (Robertson *et al.* 1993b). Some males are unable to establish territories and remain non-territorial throughout the breeding season and are often seen in loose flocks in open ground (Hill & Robertson 1988a). Females form into small flocks and visit the territories of a number of males before settling to breed within a territory (Ridley & Hill 1987, Robertson *et al.* 1993b). In Britain, territories are usually established along woodland edges or other types of permanent cover bordering open ground, particularly fields of arable crops, stubble or set-aside (Lachlan & Bray 1976, Robertson *et al.* 1993b). Females feed in the presence of the territorial male for up to six weeks, during which time they build up fat reserves in preparation for nesting. Whilst the hen is feeding the male remains vigilant over the females, alerting them to predators and protecting them from harassment from other males, enabling them to maximise their energy input while minimising energy output (Ridley & Hill 1987, Woodburn & Robertson 2000). Hen pheasants nest from April – August. They nest close to, but often not in, the territory of the cock they mated with (Woodburn & Robertson 2000). Early nests tend to be in

areas of standing vegetation left over from the previous year, typically long grass, weedy patches or woodland while later nests are often found in new season growth, especially arable crops (Robertson 1997, Bence 2001). Mean clutch size is 11.4 eggs (Robertson 1991) and incubation lasts 25 days (Cramp & Simmons 1980, Hill & Robertson 1988a). After hatch, the brood is led away from the nest by the hen. Chicks are dependent on insect foods for survival in the first two weeks after hatch (Hill 1985, Whitmore *et al.* 1986, Robertson 1997) and preferred brood rearing habitats include weedy arable crops (Hill 1985, Robertson 1997), set-aside (Robertson 1997, Bence 2001) and tall grass fields (Riley *et al.* 1998).

The proportion of wild birds in the annual harvest is unclear, but is unlikely to be much greater than 10% (Tapper 1999, Woodburn 1999). Due to the large number of birds released each year, it is difficult to estimate accurately the status of the national population of wild pheasants. However, good stable populations of wild birds exist in some arable areas of the UK, particularly in East Anglia, central southern England, north east England and areas of the Scottish lowlands (Tapper 1999).

3 Aims of research

The aims of the research were:

1. To test the hypothesis that reduced body condition due to an inadequate diet, contributes to the poor breeding success of released pheasants.
2. To determine experimentally the impact of supplementary feeding on the body condition and breeding success of released pheasants.

The purpose of the work described in Article I was to assess food availability and that in Article II, the diet of pheasants in spring. The purpose of Article III was to determine experimentally the effect of supplementary feeding on body condition of nesting hens. The study described in Article IV investigated by radio-telemetry the impact of supplementary feeding on survival and breeding success of hen pheasants. The aim of Article V was to investigate the importance of supplementary feeding on body condition of pheasants on a national scale. Finally, in Article VI the effects of supplementary feeding on breeding success of released pheasants were investigated on a multi-site field scale study.

4 Methods

4.1 Study sites

Fieldwork described in Articles I & II was conducted on 16 study sites in England and carried out during 1996-97 (Figure 1). All sites were lowland arable farms growing predominantly cereals and oil-seeds. Active pheasant management took place on all sites, though the type and intensity varied considerably. On some sites management was concerned solely with the wild stock of pheasants, whereas on others management concentrated on released birds. Releasing density varied considerably among those sites that released birds (range: 36 – 1500 per km²). Habitat quality, in terms of natural habitats and provision of specially planted game cover crops also varied widely between sites.

Experiments described in Articles III and IV concerning effects of supplementary feeding on body condition and breeding success of pheasants was conducted at Clarendon Park Estate, Wiltshire, England, (51°04'N, 1°44'W) during 1994 and 1995 (Figure 1). The estate covered approximately 20 km², the central 12 km² of which constituted the main study area, and was dominated by arable farming. Major crops were autumn-sown cereals, oilseed rape, and beans, with occasional spring-sown crops of oilseed rape, beans, and ley grass. There was a single large block (360 ha) of mixed woodland in the centre of the estate. Naturalised pheasants, (birds surviving 2 shooting seasons following release) constituted approximately 10% of the population. There were few truly wild pheasants on the study area. Red foxes and corvids were controlled, although there was considerable immigration of these species from neighbouring farms where there was no predator control. Narrow strips (≤ 20 m) of winter cover crops were provided for pheasants, but specialist brood-rearing cover was not incorporated into the farming system. Six 1-km² plots were selected that were ≥ 350 m from each other. Supplementary food in the form of whole wheat grain was provided in randomly assigned plots whereby there were 3 supplemented and 3 unsupplemented plots. In the second year, the treatment and control plots were switched to compensate for habitat and food availability differences between plots and years.



Fig. 1. The location of pheasant study sites in Great Britain described in I-VI. The large dot represents the location of Clarendon Park Estate (III & IV).

Whole-wheat grains in 25 litre slit-hoppers were provided, with 48-58 hoppers placed at 50 m intervals along woodland edges and hedgerows in each of the 3 supplemented plots. Hoppers were not placed within 50 m of the plot edges. Hoppers were opened during the first week of March and checked and refilled them at 14-26 day intervals until mid-June. Wheat was used because it is the food that released pheasants are typically fed during winter in Britain (Carroll *et al.* 1997, Draycott 2002). Unlike commercial compounded feeds, wheat does not become compacted in hoppers when wet. Wheat also provides a more practical option for game managers because it can easily be obtained from local farms. Wheat is a good energy source for pheasants, but lacks certain amino

acids and calcium, which are essential during spring (Hoodless and Draycott 1995). It was expected that pheasants would supplement their wheat intake with other types of seeds, green shoots and insects.

Pheasants collected in Article V for the survey of body condition and parasite burden were collected from the same 16 study sites described in Article I and II except that a further 5 similar sites were sampled in Scotland (Figure 1). Research in Article VI was conducted on seven privately managed driven pheasant shoots between 1997 and 2000. Four in SW England (2 in 1997 & 1998 and 2 in 1999 & 2000), and two in the N England and one in the E England which were studied in all 4 years (Figure 1). All sites were mixed arable and pastureland farms with varying proportions of woodland on each site. The primary pheasant management objective on all sites was for captive-reared released birds. However, all sites wished to increase the breeding potential of these birds to reduce the reliance of their hunting on released birds. The experimental layout and feeding regime in this experiment was similar to that described in III and IV except that instead of six plots there were two independent 1 km² plots on each site.

4.2 Determination of food availability and diet of pheasants in spring

Fieldwork to assess food availability (I) was conducted in a pre-selected 1 km² plot on each of the study sites. Soil samples were taken from all arable fields in each plot. On average, 10 samples were collected from each site in each year. Sampling involved randomly throwing a 0.25 m² quadrat within 20 m of the field boundary which is the area most often used by feeding pheasants, (Hoodless *et al.* 2001) and scraping the top 1 cm of soil and seed bearing vegetation into a plastic bag (Klute *et al.*, 1997).

Pheasant diet (II) was determined by faecal analysis. Samples were collected by walking 1 km transects within each plot in March and late April during 1996 and 1997. Samples were analysed using the methodology described in Hoodless *et al.* (2001). Insect and other animal matter was not included in the analyses as they comprised <2% of all faecal fragments. This method was used to provide information on the change in the diet of pheasants when cereal grain was freely available, rather than providing an absolute estimate of the proportions of different food items ingested (Hoodless *et al.* 2001).

4.3 Pheasant body condition in relation to spring feeding

During February 1994 and 1995, funnel traps were used to capture a sample of 4-6 hen pheasants from each 1 km² plot (III). They were dispatched humanely under licence from English Nature, the statutory government agency. In February, birds were feeding on grain remaining in hoppers at winter feed sites. During the last week of April, between 4 and 6 birds in each plot were shot to determine pre-incubation fat reserves. Total dissectable fat was determined to provide an index of body condition (Wise 1994). With

the exception of breast muscles, hens were dissected according to Wise (1994), to determine muscle mass and gizzard mass. Small intestine and caecal length were measured according to Leopold (1953).

To assess the body condition of pheasants on the extensive study sites (V) a sample of between 5 and 18 hen pheasants were killed on each site under licence from English Nature and Scottish Natural Heritage at the end of April in 1996 or 1997. Hens were killed at the end of April just prior to the start of incubation. Hens were shot opportunistically with a rifle while foraging in open fields shortly after dawn.

In V carcasses were dissected in the same method as III, except that cloacal fat rather than total body fat was used as an indicator of body condition. The mass of the *major pectoralis* muscle mass (breast muscle) from one side of the hen was measured to provide an indication of total body protein, (Brittas & Marcström 1982, Tompkins *et al.* 2000). Pheasants were examined for the presence of the caecal nematode *Heterakis gallinarum* using the method outlined in Draycott *et al.* (2000). Pheasants were also examined for the presence of the tracheal worm *Syngamus trachea* and thread worms *Capillaria* sp.

4.4 Survival and breeding success of radiotagged pheasants

In February and March 1994 and 1995 between 14 and 19 hens were caught in each of six 1 km² study plots (III & IV). The birds were fitted with 17 g necklace radio-transmitters (Biotrack, Dorset, UK) and located with TR2 receivers (Telonics, Arizona, USA) and three-element Yagi antennas. Radiotransmitters were attached to a total of 201 hen pheasants. A sample of 3 to 5 birds per plot were located intensively through March and April each year. The remaining birds were located between 28-30th March and then twice a week during the nesting season (26th April – 15th August). Analyses of the number of nesting attempts and of nesting success were based on the number of hens alive on the 30th April. Broods were located daily and brood size was determined when chicks were 10 and 20 days old.

4.5 Pheasant population counts

Data collection in Article VI was based solely on pre- and post-breeding pheasant population counts. On each site two 1 km² plots were selected that were > 250 m from each other. Game managers at each site provided supplementary wheat grain in one of the plots via hoppers in breeding territories of pheasants, using the method outlined in III & IV except that feeding commenced in mid-February and terminated in mid-May. The treatment and control plots were switched in alternate years over a four year period to compensate for habitat and food availability differences between plots and years.

It was assumed that movement of pheasants between plots was minimal as released pheasants move only short distances (approx. 250 m) in spring once they have settled in cock breeding territories (Robertson 1986, Woodburn & Robertson 2000). Cock pheasant

territories, non-territorial males and hens were counted in each plot during three visits to each estate in April following the method of Robertson *et al.* (1993b). This involved observing all hedgelines, woodland edges, woodland rides and open fields shortly after dawn or before dusk and marking on a map all territorial males, non-territorial males and hens. After 3 counts had been conducted, a summary map of all territories was produced. In late August or September, after harvest of arable crops, counts of all adult and juvenile pheasants were conducted again using the counting method outlined in Robertson *et al.* (1993b), except that in late summer, cock pheasants are no longer holding territories and as crops had been harvested, it was possible to drive over fields as well.

5 Results and discussion

5.1 Food availability and diet in spring

Naturally regenerated set-aside fields (in the form of over-winter stubbles) contained many more grains and weed seeds than autumn and spring sown crops (I). Over-winter stubbles are one of the most important foraging habitat of seed eating birds (Wilson *et al.* 1996, Aebischer 1997, Evans 1997). The numbers of seeds and grains found in autumn and spring sown crops appeared to be very low (I). However, due to the absence of a comprehensive long term monitoring scheme of arable plant abundance and diversity (Campbell *et al.* 1997), it is not possible confirm that there has been a decline in seed abundance and availability in these crops. There is evidence however, that there have been major changes in the relative abundance of a wide range of individual species, and arable fields now contain fewer species than they used to (Campbell *et al.* 1997, Firbank & Smart 2002). For example, in a recent re-survey of arable land, Firbank and Smart (2002) found that *Polygonum aviculare* has declined significantly in the last 25 years. Of the seeds that were found in Article I, *Polygonum spp.* and *Chenopodium spp.* were the most common weed seed species on all field types (I). These species are present and in most cases important in the diet of many granivorous birds including grey partridge (*Perdix perdix*), tree sparrow (*Passer montanus*), greenfinch (*Carduelis chloris*), red-legged partridge (*Alectoris rufa*), pheasant and bullfinch (*Pyrrhula pyrrhula*), (Campbell *et al.* 1997). Also, considering that there are now fewer over-winter stubbles compared with 40 years ago (O'Connor & Shrub 1986) and that less grain is spilt during harvesting operations (Wilson *et al.* 1995, O'Connor & Shrub 1986) it is likely that overall natural food availability for pheasants in early spring has declined significantly.

Analysis of pheasant diet (II) revealed that grains and seeds comprised approximately 20% of the vegetative component of the diet in March. However, when the data was split between sites that provided supplementary grain for pheasants compared to sites where birds foraged solely on natural foods, the proportion of grain in the diet was 23% on fed sites and 3% on unfed sites. Unfortunately, there are no historic published data on spring diet of pheasants on arable farmland in Britain with which to compare. Previous studies of spring pheasant diet, conducted in countries in periods when arable farming was much less intensive than in this study, showed that grain was an important dietary component.

For example, grain constituted the following proportions of spring pheasant diet: Finland 82% (Pulliainen 1966), USA 76% (Stromborg 1979) Hungary 15% (Havasi 1992).

The most important dietary fragment found in both fed and unfed sites was that of green shoots, mainly of growing cereals and grass. These have a relatively high protein content 178g/kg, but have a low metabolizable energy content (5.82 MJ/kg) (McDonald *et al.* 1994). In comparison, wheat grain which has a relatively high metabolizable content (12.2MJ/kg), but a lower protein content (104g/kg (McDonald *et al.* 1994). The results in (II) indicate that it was the energy component of the diet that was deficient. Clearly, a diet based solely on green shoots or cereal grains would not be adequate. However, on fed sites, although birds were provided with supplementary grain *ad libitum* through March, only a quarter of the dietary fragments comprised cereal grain or seeds. Therefore, pheasants did not simply gorge themselves on grain, but foraged on wild foods as well, in order to obtain a balanced diet. Indeed, Hoodless *et al.* (2001) also found that supplementary fed pheasants made up a large proportion of their diet with wild foods. Denbow (2000) reported that several studies have confirmed birds can regulate both their protein and energy intake when given a choice between high energy and high protein diets. The proportion of seeds of early seeding weed species increased between March and April, probably due to a combination increased availability and reduced availability of wheat grain as supplementary feeding ceased on some fed sites at beginning of April. Hoodless *et al.* (2001) found that supplementary feeding continued into May, grain constituted up to 50% of faecal fragments. Game feeders have been shown to be important food sources for several species of songbirds in winter including the corn bunting (*Miliaria calandra*) (Brickle 1997) and the yellowhammer (*Emberiza citrinella*) (Stoate 1999) though there have been no studies on the use or importance of game feeders to songbirds in spring. I suggest, considering the results in I and II, that this is an area requiring investigation.

5.2 Body condition and morphology of nesting hen pheasants

5.2.1 Effects of supplementary feeding on body condition

Data presented in III and V show that hen pheasants which were provided supplementary grain through spring had significantly larger fat reserves than hens in areas where feeding had ceased at the end of the shooting season. These are the first published studies demonstrating the effects of spring supplementary feeding on fat reserves of free-living pheasants, though improved winter body condition through supplementary feeding has been shown by Bogenschutz *et al.* (1995). Many of the hens collected from unfed plots and sites had negligible fat reserves. The levels of fat reserves of hens on fed sites in April (III & V) were comparable to fat reserves typically found in hen pheasants in winter (Carroll *et al.* 1997, Draycott 2002), when supplementary feeding is common (Robertson *et al.* 1993a, III). In the absence of spring supplementary feeding, fat reserves were reduced by 40% to 50% of their winter levels (III, V). Leif & Smith (1993) showed

that bobwhite quail (*Colinus virginianus*) which consumed low energy foods were also unable to accumulate as much body fat as bobwhites which consumed high energy foods. Given that nutrient requirements increase during the pre-nesting period (Wise 1994) and that pheasants use up most of their existing fat reserves during incubation (Breitenbach & Meyer 1959), it is likely that many of the unsupplemented birds were under nutrient stress going into the nesting period. The body mass of both fed and unfed birds increased significantly between February and April, (III). Therefore, body mass measurements alone, would provide an inaccurate estimation of hen body condition in spring. The increase in mass was due primarily to the presence of eggs in the body cavity (III).

Fat reserves were higher on wild sites than on released bird sites (V). This could be due to habitat differences between these types of sites. For example, on sites where there is an emphasis on wild bird management, there is likely to be a higher level of natural food availability due to better quality habitat provision as these sites are reliant on the productivity of the wild population. Without this positive management, natural availability of grains and seeds in spring on modern farms is very low, (Campbell *et al.* 1997, I). It is also possible that differences in fat reserves between wild and released birds was due to morphological and physiological factors caused by rearing birds on commercial foods (Putala & Hissa 1995, Liukkonen-Anttila *et al.* 2000). Breast muscle mass was not influenced by supplementary feeding (III,V). Breast muscle mass is often used by researchers as an indicator of total body protein which is an indicator of body condition (Brittas & Marcström 1982, Tompkins *et al.* 2000). The fact that there were differences in fat levels, but no differences in muscle protein levels between sites is indicative of a diet deficient in high energy foods rather than a deficiency in high protein foods, confirming the findings in I and II. There was a reduction in breast muscle of hens in supplemented and unsupplemented plots between February and April (III) possibly because of physiological changes caused by season or reproductive state. Previous authors have noted losses in carcass protein during egg laying in other species including American coot *Fulica americana* (Alisauskas & Ankney 1985) and lesser black-backed gulls *Larus fuscus* (Houston *et al.* 1983).

5.2.2 Parasites

It has been postulated that supplementary feeding via hoppers may lead to increased incidence of parasites and disease due to the concentrating effect of feed sites (Lehmann 1984, Guthery 1986, Landers & Mueller 1986). Pennycott *et al.* (1998) provided evidence that supplementary feeding of passerines in winter may increase their vulnerability to infectious diseases. In Britain, spring parasite burdens in pheasants are often high (Draycott *et al.* 2000). Burdens of the nematode parasite *Heterakis gallinarum* of hens collected in April were high (V) compared with winter burdens (Robertson & Hillgarth 1993). However, there were no negative effects of *H. gallinarum*, *S. trachea* or *Capillaria* sp. on fat or muscle mass (V) implying that parasites did not adversely affect body condition. The concentration of birds at feed hoppers did not pre-dispose birds to more disease as there were no differences in parasite burdens between birds collected

from sites where supplementary feeding continued into spring and sites where feeding ceased after the shooting season (V). Indeed, siting hoppers 50-75 m apart so there is sufficient for one hopper per cock territory (III, IV & VI), should help reduce concentration of birds at each hopper to just the territorial cock and his harem of hens.

5.2.3 Effects of supplementary feeding on digestive tract morphology

Breitenbach *et al.* (1963) noted that during long periods of adverse nutrition, hen pheasants became more efficient at digesting food because they increased their gut length and decreased alimentary motility. There was no difference in gizzard mass or caecal length between hens in fed and unfed plots (III). However, there was an increase in size of gut structures between February and April (III), revealing the elasticity of intestinal organs and how quickly they respond to changes in diet. An increase in gizzard mass and intestinal length is a common response of birds feeding on a bulky and fibrous diet (Thomas 1986), and has been shown in several game species including red grouse (*Lagopus lagopus scoticus*) (Moss 1972), Japanese quail (*Coturnix coturnix japonica*) (Savory & Gentle 1976), rock partridge (*Alectoris graeca*) (Paganin & Meneguz 1992) and capercaillie (*Tetrao urogallus*) (Liukkonen-Anttila *et al.* 2000). Captive rearing normally requires birds to be fed a commercially produced pelleted food which has a much lower fibre content than natural food (Liukkonen-Anttila *et al.* 1999). Feeding pelleted food can result in smaller gizzards and shorter intestines and caeca in grey partridges (Putala & Hissa 1995). The abrupt change from a commercial to a natural diet after release can affect the ability to utilise nutrients from foods available in the wild for several weeks (Duke *et al.* 1984, Liukkonen-Anttila *et al.* 1999). However, the pheasants analysed in III had already spent at least 6 months in the wild before food supplementation had ceased and should have at least partially adapted to a wild diet. Similarly, the fact that the birds were also foraging on natural foods (II) with a higher fibre content probably ensured that their gut structure had to some extent already adapted to a wild diet. Therefore, the data in III suggest there is a natural change in the morphology of the gut during spring due to changes in diet. Indeed, more wild seeds and less grain were present in April compared to March (II). Seasonal changes in length of digestive tract have been noted in other game species including spruce grouse (*Dendragapus Canadensis*) (Pendergast & Boag 1973) and willow grouse (*Lagopus lagopus*) (Pulliainen & Tunkkari 1983). The cessation of supplementary feeding at the end of January probably initiated an increase in digestive efficiency by pheasants, but this increase may not have been sufficient for fat reserves to be maintained when availability of energy rich food groups were low (I & II).

5.3 Effects of supplementary feeding on reproductive biology

5.3.1 *Spring breeding densities*

In the experimental trials described in Articles IV and VI, the density of territorial males was higher when supplementary food was provided. The presence of feed hoppers affected the location of male territories. A higher proportion of the males were territorial when supplementary grain was provided (IV), although this difference was not detected in VI. The presence of feeders are also known to increase territory density in male red-winged blackbirds (*Agelaius phoeniceus*) (Ewald & Rohwer 1982). There was no difference in harem acquisition by cocks, or in the number of hens under supplemented and un-supplemented conditions (IV). Consequently, harem size was lower when supplementary grain was provided. The results suggest that male quality was more important than territory quality or availability of nesting cover, in agreement with previous studies on mate choice of hen pheasants (Ridley 1983, Ridley & Hill 1987, Göransson *et al.* 1990, Grahn *et al.* 1993a,b, Robertson 1996). Conversely, in VI, both territorial male and hen density were increased by supplementary feeding, implying that supplementary feeding influenced the behaviour of hens. To account for the differences in hen density between treatments, feeding either reduced post-winter dispersal of hens and/or attracted hens from surrounding unfed areas. Dispersal distances of hens once they are in established breeding territories are short (up to 250 m) (Robertson 1986, Woodburn & Robertson 2000), but during seasonal shifts pheasants can move up to, though rarely more than, between 1.6 and 3km (Gates & Hale 1974, Dumke & Pils 1979). Dispersal distances of pheasants are influenced by the quality of their immediate environment, which if adequate, will result in only minimal movements Leopold *et al.* 1938, Wilson *et al.* 1992). It appears that food availability and/or supplementary feeding may influence dispersal of hens from their winter flocks.

5.3.2 *Hen survival*

Supplementary feeding may help preserve energy reserves and increase predator avoidance by decreasing foraging activities (Johnson & Gaines 1990). Studies of non-game species have demonstrated a positive effect of supplementary feeding on winter survival in birds including willow tit (*Parus montanus*) (Orell 1989, Lahti 1997), great tit (*Parus major*) (Van Balen 1980), and black capped chickadees (*Parus atricapillus*) (Brittingham & Temple 1988). In Britain, variation in the annual survival rates of many declining farmland passerine species (Siriwardena *et al.* 1998a, Siriwardena & Robinson 2002) is considered to be the main factor driving the downward trend in populations which have taken over the last 25 years (Siriwardena *et al.* 1998b, Chamberlain *et al.* 2000). Reduced availability of grains and weed seeds on arable farmland in winter is generally agreed to be an important factor influencing over winter survival (Campbell *et al.* 1997, Wilson *et al.* 1999, Robinson & Sutherland 2002), though experiments

investigating the effects of winter food supplementation for songbirds on farmland have only been recently initiated (Hart *et al.* 2002, Perkins & Anderson 2002).

In game species, Townsend *et al.* (1999) demonstrated a positive effect of supplemental feeding on winter survival in bobwhite quail, and Gabbert *et al.* (1999) reported higher survival of pheasants that used corn food plots. The consensus in these studies was that survival was improved through nutritional benefits provided by supplementary feeding during times of severe winter stress, typically extremely low ambient temperatures and reduced availability of food due to snow cover. Conversely, Valkeajärvi and Ijäs (1994) found that spring feeding had a negative effect on black grouse (*Tetrao tetrix*) survival due to increased susceptibility to raptor predation at feed hoppers. There was no difference in spring to summer survival of hens between fed [31%, (IV) and 37% (VI)] and unfed plots [24% (IV), 48% (VI)]. Hen pheasants are particularly vulnerable to red fox predation during the breeding season (Hessler *et al.* 1970, Robertson 1986, 1988, Brittas *et al.* 1992, Schmitz & Clark 1999, Riley & Schulz 2001). Indeed, in IV, 89% of all deaths were attributed to predation by foxes. Putaala (1997) postulated that when physiologically and behaviourally mal-adapted released birds are forced to forage for natural foods to maintain a positive energy and nutrient balance, then less time is spent on other activities such as predator avoidance. It is perhaps not surprising that supplementary feeding did not have either positive or negative impacts on hen survival. This is because the main environmental factors responsible for improved survival in the winter studies cited above were not present in IV and VI, *i.e.* extremely low temperatures and reduced food availability due to snow cover. In addition, pheasants were not predisposed to goshawk predation at feed hoppers, which has been cited as a problem with spring supplementary feeding black grouse in Finland (Valkeajärvi & Ijäs 1994), as the current British goshawk population is relatively low (Tapper 1999).

5.3.3 Effects of supplementary feeding on nesting biology

Energy availability can affect clutch size and time of breeding in birds (Yom-Tov & Hilborn 1981) and there is good evidence for earlier laying in a range of bird species when provided supplementary food (Boutin 1990). In experimental feeding trials supplementary feeding has been shown to induce earlier nesting in Florida scrub jays (*Aphelocoma coerulescens*) (Schoech 1996) and alpine accentors (*Prunella collaris*) (Nakamura 1995). It has also been demonstrated experimentally that restricted diets can delay the onset of egg laying in pheasants (Breitenbach *et al.* 1963, Gates & Woehler 1968, Barrett & Bailey 1972). These authors found that egg laying did not commence until birds had built up large fat reserves. In contrast, the mean start date of incubation by hen pheasants was not significantly influenced by supplementary feeding (IV), even though fat reserves were greater in birds provided supplementary grain (III & V). However, the time taken to re-nest in the event of nest loss was shorter in the supplementary fed group (IV). There were also (although not significantly), more re-nesting attempts in the fed group (IV). All birds had access to supplementary grain in

winter, and it appears that this provided sufficient energy reserves for the control group to successfully lay a first clutch. The results in IV suggest that under unsupplemented conditions hens may not have sufficient energy reserves to re-nest successfully after they have depleted their fat reserves during their first nesting attempt.

Radio-telemetry revealed that there were no differences in clutch size, hatchability or nesting success between supplementary fed and unfed groups with only 18.0% of nests hatching in the un-supplemented group and 24.6% in the supplemented group (IV). This is low compared to other estimates of nesting success of pheasants in Britain: 50.7% and 38.7% (Robertson 1991), 52% (Bence 2001) and was due primarily to high levels of nest predation by foxes and corvids which are important nest predators of pheasants (Robertson 1991, Bence 2001, IV). Fox and corvid predation accounted for most nest losses (38% and 30%, respectively IV). The proportion of failed nests did not differ between treatments, and similarly, there were no differences in rates of nest desertion (fed 13.6%, unfed 17.2%, IV). Consequently, due to the high levels of nest predation, recruitment of chicks to the autumn population was very low (IV). Due to the high levels of mortality and nest loss encountered in IV, it is possible that any subtle effects of supplementary feeding on nesting biology may have been 'masked' and therefore difficult to measure due to the relatively higher importance of the effect of predation. For example, it is surprising that nest survival was not improved by supplementary feeding, as one would expect that hens in the unsupplemented group would spend more time off the nest feeding and hence leave the eggs exposed for longer periods, rendering them more prone to corvid predation. This is an area of research currently being investigated by the author. Indeed, Hoodless *et al.* (2001) found that hen pheasants provided supplementary grain in spring spent less time foraging than unsupplemented group of hens.

5.3.4 Post breeding pheasant densities

The results in VI showed that the provision of supplementary grain led to increases in the density of young pheasants in the fed plots. Almost twice as many juveniles were observed under fed conditions compared to when feeding ceased at the end of the shooting season [fed: 11 young/km², unfed: 6 young/km², (VI)]. However, it is not clear from the data in VI exactly which mechanism was responsible for the higher levels of recruitment when supplementary grain was provided. It is likely to be due in part to the higher density of hens in spring under fed conditions and a combination of a difference in the proportion of hens with broods, and brood size (VI). The higher densities in fed plots provide a strong case for reduced emigration from and perhaps immigration into fed plots. Although the differences in the proportion of hens with broods and brood size between fed and unfed conditions were not significant, (VI), it is suggestive that improved body condition of hens in fed plots (III & V) may have been important too. Poor body condition in red grouse (*Lagopus lagopus scoticus*) can reduce the ability of the hen to brood chicks successfully resulting in smaller brood sizes (Hudson 1992, Newborn 2001). The strong re-nesting capabilities of ring-necked pheasants are

important in determining overall breeding success (Johnsgard 1999). The increase in the proportion of hens with broods [67% when supplemented compared with 52% when unsupplemented (VI)] though not significant, perhaps provides further evidence of an improved ability to re-nest when provided with supplementary grain (IV).

Although the results show that feeding led to increased densities of young pheasants in fed plots, supplementary feeding alone is not sufficient to increase productivity to comparable levels of wild birds. In Britain, wild populations managed for sustainable shooting typically have a young:hen ratio of around 3:1, mean brood sizes of 3.8 and 4, resulting in between 80 and 100 young/km² (Boatman 2000, Sage 2000).

The sites used for study (VI) were not ideal for pheasant reproduction in the wild. They were chosen as they were representative of pheasant management on sites where pheasants are released. Therefore, the observed differences are perhaps not as large as they might have been had the work been conducted on sites more conducive to pheasant reproduction. These sites do exist in Britain but they are in the minority. The work in VI attempted to test the response of released pheasants in the real situation. There would be scientific value in conducting further research on sites where deficiencies in habitat and predation control were not such limiting factors.

6 Conclusions

The results presented in this thesis are among the first to show how positive management can improve aspects of the breeding performance of released pheasants in the wild. They show that the availability of natural grains and seeds on modern arable farmland is not sufficient for hen pheasants to maintain their body condition during nesting. However, by providing supplementary wheat grain in breeding territories the body condition of hens can be maintained and this has positive effect on pre- and post-breeding densities of pheasants. Therefore, it is recommended that spring supplementary feeding should be carried out as standard procedure by game managers, not just to help improve breeding success, but is justified alone on animal welfare grounds to ensure birds have sufficient food resources. Ideally, spring supplementary feeding should be conducted in conjunction with efficient predation control and provision of adequate brood-rearing habitat to maximise the benefit to pheasants.

Clearly, there are important behavioural and physiological short-comings with released pheasants which pre-dispose them to poor performance after release. These factors, along with a proper understanding of the impact of released pheasants on wild populations and the environment need to be addressed before pheasant releasing at its current level can be justified as a sustainable long-term game management strategy. Finally, many granivorous farmland bird species have experienced serious population declines and range contractions in Britain in recent decades. The reduction in winter food resources has been cited as a causative factor in their decline. However, the impact of food availability on body condition and breeding success of these birds has not yet been the focus of research. Results presented in this thesis suggest that this in an area of farmland bird ecology requiring attention.

7 References

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