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Swards and structure: the interactions between farming practices and bird food resources in lowland grasslands

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The ideal grassland to encourage plants and invertebrates suitable as food for farmland birds contains a mixture of grasses and broad-leaved plants with a range of vegetation heights and structures. However, as a result of agricultural intensification the majority of lowland grasslands in the UK now lack botanical and structural complexity. Plants within intensively managed swards are allowed little capacity to set seed, and the majority of invertebrates within these grasslands are either too small to be utilized by birds or inaccessible because of dense vegetation or impenetrable soils. Further research is required into the impact of different grassland management practices on the abundance and accessibility of bird food resources at both the field and the landscape level. The major challenge will be to identify changes to grassland management practices that provide significant biodiversity benefits and yet allow productive livestock farming systems to continue.

Grassland accounts for 67% (i.e. about 12.4 million ha) of the total agricultural land area in the United Kingdom. Excluding rough grazing (both sole right and common), permanent (> 5 years old) and temporary (< 5 years old) grassland comprises 19, 38, 64 and 79% of the total agricultural land area in Scotland, England, Wales and Northern Ireland, respectively (Defra 2002). Lowland grassland is particularly concentrated in the west of the UK. For example, a sample of 20 × 20-km areas in east Devon in 2000 (J.R. Tallowin *et al.* unpubl. data) indicated that approximately 75% of the agricultural land in these areas was under either permanent or temporary grass. In addition, individual farms frequently had all of their agricultural land under grassland.

Lowland grasslands can be utilized by a range of insectivorous, granivorous and herbivorous bird species (e.g. Atkinson *et al.* 2004, Robinson *et al.* 2004, Wilson *et al.* 2004). Moist grassland soils are especially important for waders such as Lapwing *Vanellus vanellus*, Snipe *Gallinago gallinago*, Curlew *Numenius arquata* and Redshank *Tringa totanus* (Beintema *et al.* 1990, Wilson *et al.* 2004) and passerines such as Starling *Sturnus vulgaris* (Olsson *et al.* 2002). These rely on invertebrates such as earthworms and leatherjackets in the soil, beetle adults and larvae on the soil-surface and sawfly larvae and plant bugs on the vegetation (e.g. Barker 2004, Holland 2004). In addition, grass seeds are utilized by a number of bird species (such as Starling, House Sparrow *Passer domesticus* and Yellowhammer *Emberiza citrinella*) while the seeds of broad-leaved plants in the sward are consumed by the adults of other species (such as Skylark *Alauda arvensis*, Greenfinch *Carduelis chloris* and Linnet *C. cannabina*).

Bird foraging and handling time is reduced, and thus energy intake per volume of food item increased, when birds feed on larger items as compared with a similar overall volume of smaller items (Beintema 1991). Hence, the abundance and size of food items occurring within a grassland can influence the potential attractiveness of that sward to foraging birds (McCracken & Bignal 1998, McCracken *et al.* 2004). For a range of invertebrate groups, it has also been shown that larger species occur only in swards experiencing very low levels of grazing or mowing management intensity and that the size distribution of invertebrates within intensively managed grasslands makes such swards of limited value to foraging birds

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(e.g. Siepel 1990, Blake *et al.* 1994). However, the potentially valuable food items within extensively managed grasslands are actually likely to be inaccessible to most grassland birds because of the relatively uniform and dense nature of such swards. Grasslands under moderately intensive management are therefore more likely to provide optimum foraging opportunities for birds, because the resulting diversity of vegetation types and structures serves both to increase the range of potential food items present in these swards and to ensure that these are accessible to foraging birds.

There is now strong evidence that habitat quality for farmland birds has declined markedly throughout grassland-dominated landscapes (Robinson *et al.* 2001, Chamberlain & Fuller 2001). Changes in the populations of farmland birds appear to be linked to large-scale temporal changes in invertebrate numbers and seed resources (Wilson *et al.* 1999, Benton *et al.* 2002, Barker 2004, Holland 2004) and especially the loss of ecological heterogeneity at multiple spatial and temporal scales caused by agricultural intensification (Benton *et al.* 2003). The extent to which grassland management has changed over the past 50 years is considered by Vickery *et al.* (2001). The impacts on vegetation are considered in detail within that paper and within Smith (1994), while the impacts on invertebrates have been well documented by Curry (1994) and Morris (2000). The aim of this paper is to provide an overview of the mechanisms by which the abundance and accessibility of bird food resources are affected by grassland management practices and to suggest where further research could to help reverse the decline in the value of lowland grasslands for birds.

IMPACTS OF FARMING PRACTICES ON BIRD FOOD RESOURCES

Different farm management practices are generally used together in close combination, but for ease of explanation the potential impacts on vegetation and invertebrates within grasslands are summarized in terms of the main management practices involved.

Drainage. The widespread installation and improvement of field drainage has increased markedly the ability of soils to dry out earlier in the spring (Robinson & Armstrong 1988). This provides an advantage to competitive grass species, but disadvantages moisture-requiring species (such as *Carex* spp., *Juncus* spp., *Polygonum* spp., *Rumex* spp.) and reduces both grazing opportunities for wildfowl and the range of seed resources available for use by granivorous birds (Wilson *et al.* 2004). Many soil-dwelling and surface-active invertebrates (especially those that spend a long time as larvae in the soil) can be adversely affected by prolonged waterlogging of soils but also by desiccation if the soil dries out quickly at a vulnerable stage in their life-cycle (McCracken *et al.* 1995). Drainage of wet soils improves soil conditions for some invertebrates such as earthworms, but it can also reduce soil penetrability for probing birds and more vigorous grass growth in spring may reduce access by birds to the soil surface at this critical time for breeding (Ausden *et al.* 2001).

Ploughing and reseeding. Many grasslands on intensive livestock farms have been ploughed and reseeded with high-yielding plant species (Hopkins *et al.* 1985). These grasslands are generally very species-poor *Lolium perenne* leys (MG7) (Rodwell 1992). Permanent grassland is commonly the *Lolium perenne–Cynosurus cristatus* (MG6) community (Rodwell 1992), which are also dominated by grasses (*Poaceae*) adapted to survive frequent defoliation/disturbance under moderate to fertile soil conditions. Few broad-leaved higher plant species (forbs) occur within these swards and those that do rarely achieve cover values of > 25% (Rodwell 1992). The resulting low plant species diversity and associated intensive grazing and cutting of such swards (see below) means that invertebrate diversity is limited (Morris 2000) and the frequent defoliation severely reduces the possibility of seed production. Although the open nature of the swards may make soil and surface-active invertebrates more accessible to birds in the establishment phase immediately after reseeding, the subsequent growth and intensive management of these swards mean that feeding opportunities for birds are limited.

Use of fertilizer. Inorganic fertilizers encourage the rapid growth of competitive species, which combined with frequent defoliation, advantages a small number of grass species. J.R. Tallowin *et al.* (unpubl. data) found that the average number of forb species in grasslands on livestock farms where nitrogen inputs exceeded 75 kg/ha was just three. High forb diversity was only found in grasslands receiving < 15 kg N/ha/yr. Intensive use of fertilizer, whether inorganic or organic forms such as animal slurries, reduce plant species richness. It is also likely that the use of fertilizer has exacerbated the adverse impact of low soil moisture level deficits caused by drainage, because increased availability of nitrogen for plant uptake increases evapotranspiration (Garwood 1988). The addition of fertilizer can benefit some herbivorous birds such as geese species that prefer grass with a high nutrient content (Hassall & Lane 2001, Hassall *et al*. 2001). However, in general the use of fertilizer not only reduces the range of potential invertebrate prey present in the sward (through a reduction in the diversity of plant species) but in addition the resulting tall and dense vegetation limits access by birds into these swards. The fact that fertilizer application to grassland coincides with the start of the bird breeding season may also mean that access to potential food resources becomes limited at an especially critical period for birds and their young.

Cutting. Lowland grasslands are now dominated by grass species and are generally poor habitats for granivorous birds because most intensive grassland management practices aim to achieve high levels of utilization of the crop and thereby limit opportunities for the grasses to set seed (Parsons & Chapman 2000). With the exception of late-cut hay, cutting is timed to occur prior to flowering so that the nutritional quality of the forage for livestock is not severely compromised (Beever *et al*. 2000) and hence any floral apices above about 5 cm are removed by the mower blade. In addition, multiple cuts per season is common in many silage fields. This not only reduces the number of seed heads and flowering plants (and hence the number and type of invertebrates attracted to these swards, Morris 2000) but also serves to remove the vegetative food resource for plant-feeding insects (such as sawflies and plant bugs). This limits the ability of these plants and invertebrates to complete their life-cycles within any one field and so decreases the range and abundance of potential food items present in the swards. The encouragement of rapid regrowth of the sward immediately after cutting also means that the period in which these food items are accessible to birds is very short lived.

Grazing. Grazing animals generally encourage a greater diversity of vegetation structures in the sward through their trampling and dunging and by expression of preferences for some plant species. Plant species-richness is increased by levels of grazing that keep the sward open and free of excess litter, creating gaps in which seedlings (especially of forbs) can establish and open areas that surface-active invertebrates can exploit. Low levels of grazing lead to patches of tall rank vegetation and the accumulation of dead vegetation and litter, where regeneration niches for herbaceous plant species are very limited or non-existent. Although such swards contain a greater variety of invertebrates such as spiders (e.g. Curry 1994, Cole *et al*. in press), the density of the sward and litter layer means that these invertebrates are generally not readily accessible to foraging birds (e.g. Perkins *et al*. 2000). Conversely, heavy grazing produces short dense swards that generate little in the way of seed resource and offer limited foraging and shelter opportunities for many invertebrates (Morris 2000).

Use of pesticides. The use of crop protection chemicals is not as intensive on grasslands as it is on arable crops (Vickery *et al*. 2001). Herbicides may be used to control broad-leaved weeds and this has the effect of maintaining low plant species-richness (and hence low bird food resource value). In addition, insecticides may be directed against soil-dwelling leatherjacket larvae, which although a pest of grassland can also form an important prey item for a range of farmland birds (McCracken *et al*. 1995). However, the most widespread use of chemicals is through the application of anthelmintics to control internal parasites of grazing animals, and particular concern has been expressed over the potential insecticidal effects of residues excreted in the dung of treated animals (McCracken 1993). However, although residues certainly reduce dung-associated insects within individual dung pats (McCracken 1993), the wider impacts of this (whether on the population of such insects within a field or on birds foraging on dung insects) has yet to be assessed fully. The potential for using mixed grazing systems, closed herds and/or plants with anthelminthic properties (Aerts *et al*. 1999, Molan *et al*. 1999) to reduce the parasite burden and the use of insecticides needs to be explored further.

ENHANCING THE POTENTIAL VALUE OF GRASSLANDS FOR BIRDS

The relationships between grassland birds, their prey items and farm management practices are complex, and simply knowing what types of food birds require at any particular time of the year is only part of the process. Hence it is essential to understand the fine detail of how grassland management affects the utilization of such food (e.g. McCracken & Bignal 1998, Perkins *et al.* 2000) and especially how interactions between type, timing and intensity of management practices influence abundance and accessibility of bird food resources.

Improving seed resources for granivorous birds

Studies by Buckingham *et al.* (2004) indicate that seed of *L. perenne* can be a valuable winter food resource for species such as Yellowhammer. Despite the agronomic aim to maintain the state of intensively managed grasslands at an optimum for cutting or grazing by livestock, there are situations where flowering and seed production by *L. perenne* do occur (e.g. beside dung pats in pastures grazed by cattle or around the edges of silage fields where the grass has been left untouched by the harvesting machinery). However, in practice any such increase in grass seed resources is generally reduced or eliminated in fields where autumn and winter sheep grazing occurs. Avoidance of winter sheep grazing on fields containing patches of seeding grasses could therefore offer potential benefits for granivorous bird species. However, the economic impacts of cessation of winter sheep grazing and any consequent deterioration of pasture quality will need to be assessed before any such approach can be recommended.

Current Defra-funded research is examining benefits for granivorous bird species of delaying cutting or complete cessation of any management on grassland for 1 year (or more) or the establishment of spring-sown mixtures of cereals and other species, such as linseed and quinoa, to provide abundant seed resources on field margins of agricultural grassland. In the case of delaying or complete cessation of management on previously intensively managed grassland, any benefits for seed production and invertebrate diversity/abundance will have to be weighed against the risk of pernicious weed populations developing. In addition, before any major effort is put into actions of this nature, it will be essential to evaluate the extent to which grass seed resources satisfy the food requirements of granivorous birds.

Ruderal plant species such as *Stellaria media* and *Polygonum aviculare* are known to be important seed resources for birds (Wilson *et al.* 1999). These species maintain ubiquitous and persistent seed banks within agricultural land (Grime *et al.* 1996). Encouraging growth of these and other important non-grass seed resources requires cultivation or at least disturbance of the grass sward to create patches of bare soil. However, the abundance of these ruderal species in the soil seed bank and thus the amount of seed resources that will be produced by simply cultivating and then fallowing areas of land within grass-dominated landscapes is unpredictable and needs further study. Compared with sowing a crop species that has been selected for high seed yield, any unsown fallow option is likely to require substantially more land to achieve similar amounts of preferred seed resources for birds.

Improving invertebrate resources for insectivorous birds

The abundance and diversity of invertebrate prey items will generally be enhanced in situations where the sward contains a mixture of grasses and broad-leaved plants together with a range of vegetation heights and structures (from short open swards with patches of bare soil to tussocks of tall vegetation). Such a varied vegetation structure is also essential to allow birds access to the potential food items present within the sward. However, although such a diversity of sward composition and structure can be achieved by reducing the intensity of grazing or mowing management that the field is subjected to, trying to extensify or alter the timing of the management practised over the whole of a field may not always be practical or economic for the farmers concerned. To this end, the concept of allowing farmers to combine normal practice in main field areas with wildlife management at field edges has been developed in arable situations (see Holland 2004 for an overview). These arable conservation headlands (cereal crop edges that are not treated with insecticides in the summer and which receive only selective herbicides and fungicides) allow beneficial weeds and insects utilized by chicks to survive at field edges and have improved the breeding success of gamebirds in arable landscapes by improving chick nutrition. Such conservation headlands have also been shown to benefit other wildlife groups such as arable wildflowers, surface-active invertebrates and butterflies (Holland 2004).

The possibility of transferring this approach into intensive grassland situations has been investigated in southern Scotland through the establishment of grassland conservation headlands (e.g. Buckingham *et al.* 2004, Haysom *et al.* 2004). These consist of 6–10-m-wide strips established along the edge of intensively managed grassland fields in which the grassland vegetation is not cut or grazed during spring and summer. At the time of establishment, narrow strips within each headland are also treated with a one-off application of broad-spectrum herbicide in order to provide room for other plants (especially broad-leaved species) to exploit and create 'pathways' to allow ground-active birds easier access into the sward. Both small-plot and field-scale studies have shown that abundance of potential bird invertebrate food resources such as slugs, sawflies and Homopteran bugs increases markedly within such grassland conservation headlands. However, despite this enhanced prey abundance and the potential routes of access into the sward, few birds have been observed foraging in these headlands (D. Parish *et al.* unpubl. data). Much more intensive and detailed observations are therefore required in order to establish whether the increased abundance of invertebrates occurring within grassland conservation headlands is actually attractive and accessible to birds. This may, however, be difficult to achieve in practice within intensively managed grassland landscapes given that bird occurrence within such situations is so low. Indeed, any effective assessment of the impact of grassland conservation headlands (or any other manipulation of management) may only be possible once a far greater proportion of the grassland within any area is under the proposed management regime than is possible in experimental situations.

THE IMPORTANCE OF LANDSCAPE SCALE

The biodiversity value of any one field is also strongly influenced by its surroundings, and conversely changes within any individual field can impact on the biodiversity value of its surroundings (e.g. McCracken *et al.* 2000, Weibull *et al.* 2000). Hence any assessment of the potential biodiversity impact of changes to an agricultural production system needs to be based not only on a consideration of the impact at a field scale but must also take into account what changes in the type and distribution of land covers will occur in the agricultural landscape. There is therefore a need for a greater understanding of the ecological processes and drivers influencing bird utilization of grassland landscapes at a scale (such as a whole farm or suite of farms) much greater than an individual field. Such an understanding would also help in judging the likely impact of broad land-use changes and the choice of best locations to target agri-environment actions aimed at enhancing grassland biodiversity.

To date, most agri-environment actions have been targeted at individual taxa at the level of an individual field (or smaller) and/or have been targeted solely at individual farming practices (e.g. grazing, cutting, drainage) or components in the landscape (e.g. arable, grassland, woodland, hedges, field margins) considered in isolation. The danger of such a restricted approach is that it can also inadvertently encourage uniformity of land-use and result in a decrease in habitat heterogeneity with consequent negative effects on farmland biodiversity. For example, within the Argyll Islands Environmentally Sensitive Area in southwest Scotland, prescriptions aimed at restoring the number of Corncrake *Crex crex* have resulted in a monoculture of tall grass in silage fields over most of the summer. This has the potential to have negative effects on families of Chough *Pyrrhocorax pyrrhocorax* that fledge in early June and rely on foraging in mown-grass aftermaths for a short period during the summer (Bignal *et al.* 2001). The importance of the wider landscape therefore has to be taken into account much more within the development of agri-environment schemes. In addition, it will be essential to move away from the perception that grassland birds can only be influenced by management changes directed at grassland habitats. The importance of interactions between (and contributions arising from) other farmed and non-farmed habitats needs to be taken into account much more when seeking to enhance the value and attractiveness of intensively managed grasslands to farmland birds.

CONCLUSIONS

We currently have poor understanding of scales of landscape elements, in terms of patch size, type and position (both temporal and spatial) that would be required for enhancing farmland biodiversity. Use of past landscapes as models on which to base future landscape reconstruction is seductive, but could be misleading as the context of historical landscapes was different from that of today in terms of overall farming intensity. It is nevertheless clear that greater spatial and structural heterogeneity is required within our farmed landscapes (Siriwardena *et al.* 2000, Benton *et al.* 2003) and that changes are required within grassland management systems *per se* in order to achieve enhanced habitat quality for farmland birds at a landscape scale (Perkins *et al.* 2000).

There are currently two main options to increase the heterogeneity of habitats and structures (and hence plant and invertebrate food resources for farmland birds) on grassland-dominated farms:

(1) To introduce at a farm and landscape level more of a mixture of grass types (e.g. both intensively and less intensively managed) together with more spring-sown arable crops and the occurrence of stubbles overwinter. Although such an approach would require marked changes to current management practices at the farm level, it has the potential to benefit a wide range of both breeding and wintering bird species (especially those with preferences for foraging across the open expanse of agricultural fields). The fact that such an approach would result in large-scale changes would also increase that the likelihood that changes to range of insectivorous and granivorous birds utilizing these areas would be more marked and visible in any one area.

(2) To concentrate less on any one field as a whole and more on mitigating the effects of intensively managed grasslands, e.g. by establishing grassland conservation headlands at the edges of fields and increasing non-farmed habitats around the farm. Such an approach would be easier to implement within existing farming systems, but would only be likely to benefit a limited range of bird species (especially those with preferences for foraging within field margins, hedges and woodland edge). In addition, careful consideration would need to be given to the extent to which such measures were established on individual farms to ensure sufficient habitat was created to enable any increase in these bird populations.

Ideally elements of both approaches should be taken on individual farms. However, for most intensive and moderately intensive livestock farms the first approach is practically and economically unattractive and unless there is a strong production benefit from introducing a greater variety of crop types onto the farm this will not happen at a field scale. Therefore, for many intensively managed grassland farms the second approach may currently be the only possible option. However, not only must the real value to birds of such approaches be proven, but it must also be remembered that to stand any chance of success, the choice of where to locate such measures on the farm is just as important as the decision to implement them.

We therefore face two challenges in trying to redress the declines in farmland bird utilization of grasslands. The first is to identify practical management strategies that will enable food resources to be more readily available to farmland birds at the patch and field scale in grassland-dominated landscapes. The second is to model, and test, ways of integrating such management practices into economically viable farming systems at a landscape scale.

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