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Grass field margins and Orthoptera in eastern England

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Synopsis

A recently published study concluded that 6 m wide Countryside Stewardship Scheme (CSS) field margins had positive benefits for Orthoptera in southern England, particularly in landscapes with small (5 ha) and intermediate (9 ha) field sizes. However, research in eastern England, where farmland management can be extremely intensive (e.g. high nitrogen fertiliser input) and field sizes are large, provides evidence that 6 m margins do not necessarily lead to higher Orthoptera densities than intensively managed farmland habitats such as arable fields or improved, fertilised pastures. The low abundance of grasshoppers in field margins in Essex may be partially explained by the annual cutting of the margins in summer (August) leading to direct mortality of adult grasshoppers and dispersal of individuals from the short, cut vegetation (< 10 cm in height) to surrounding tall grassland due to their need for shelter from predation and inclement weather. Shelter from excessively high microclimatic temperatures is also provided by taller vegetation (10–20 cm in height). Botanical composition of the swards may also be important, a predominance of fine-leaved grass species such as *Festuca rubra* leads to a 'warm' (but not too hot) microclimate favourable for grasshopper basking and reproduction, whereas fertilised swards composed entirely of *Lolium perenne* are characterised by tall and dense swards (> 20 cm in height) with a 'cold' microclimate unsuitable for sustained grasshopper activities.

Keywords: grasshoppers, bush-crickets, Acrididae, Tettigoniidae, farmland, field size, fertiliser, Countryside Stewardship Scheme, Environmental Stewardship.

In a recent study published by Marshall, West & Kleijn (2006), the value of Countryside Stewardship Scheme (CSS) 6 m margins for Orthoptera was assessed. These authors concluded that insect diversity and numbers could be increased on agricultural land by the establishment of managed grass margins around arable fields (Table 1). It was suggested that the increases in

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populations of grasshoppers (Orthoptera: Acrididae) reflected the additional habitat resources that these grass strips provide. However, on a landscape scale, it appeared that grass margins were higher in numbers of Orthoptera in landscapes with small (5 ha) or intermediate (9 ha) field sizes compared with landscapes with large (> 10), open fields.

Table 1. Abundance of Orthoptera in boundaries adjacent to 6 m field margins or arable fields in studies by Marshall, West & Kleijn (2006) and in boundaries or arable fields by Gardiner & Hill (2005*a*) and Gardiner (2007); species richness data are shown in brackets after abundance, figures not directly comparable between studies due to different methods of data collection and experimental design.

	Study		
	Marshall, West & Kleijn (2006)	**Gardiner & Hill (2005*b*)**	**Gardiner (2007)**
Habitat			
6 m field margin	5.2 (1.8)*	0.05 (2)	0.02 (3)
Arable field	0.9 (0.6)	0.01 (1)	0.03 (3)
Study characteristics			
Area	Wessex[1]	Essex	Essex
Agri-environment scheme	Countryside Stewardship	Countryside Stewardship	Environmental Stewardship
Mean field size ha (min/max)	9.2 (1.5–50)	7.8 (2.5–14)	13 (2.5–33)
Mean fertiliser input N kg/ha/yr (min/max)	188	174 (150–220)	243 (212–302)
% land use (of farmed area)			
Arable	71	65	98
Grassland	19	35	2

Figures for the study by Marshall, West & Kleijn (2006) are mean nos./plot, for Gardiner & Hill (2005*b*) and Gardiner (2007), density m^{-2} of adult Orthoptera individuals are displayed.
* = significant difference at $P < 0.05$ between abundance on field margins and arable fields.
[1] = Somerset, Dorset, Wiltshire, Gloucestershire.

In recent studies of Orthoptera incidence and diversity conducted at Writtle College (OS grid reference: TL 670070) in eastern England, it was demonstrated that, in contrast to Marshall, West & Kleijn (2006), 6 m margins did not enhance the abundance of three common grassland grasshoppers (*Chorthippus* species) when compared with intensively managed habitats (arable fields or heavily grazed and fertilised pasture) (Gardiner & Hill, 2005*b*; Table 1). The mean field size at Writtle College was small at 7.8 ha in comparison to the overall mean field size in Marshall's study (Table 1) and there were many conservation areas such as hay meadows and field corner woodlands in the locale of the study sites, therefore, the margins should have been favourable for Orthoptera. There was also more grassland habitat on the Writtle College Estate than in the areas studied by Marshall (Table 1).

The main reason for the lack of increase in Orthoptera abundance in margins at Writtle College was that populations of Orthoptera were denuded to such an extent (perhaps due to intensive field management, e.g. insecticide applications) that numbers did not recover over the seven years of the study, even though there was an increase in habitat resources (Gardiner & Hill, 2005*b*). Gardiner, West & Kleijn (2002) and Gardiner & Hill (2003) reported extremely low densities of grasshoppers on arable land at Writtle College, usually lower than 0.5 adult individuals per m^{-2} on farmland sites. Abundances of > 1 adult per m^{-2} were rare in comparison to nearby heathland sites, where densities exceeded 3 adults per m^{-2}. In view of the very low populations on arable land in the study area, margins on intensively managed farmland may be colonised slowly by Orthoptera, thus it may take many years for large populations to occur.

Populations of grasshoppers in footpaths adjacent to 6 m field margins may also be denuded in nearby Boreham (which is only 6 km from Writtle College), where field sizes are generally large (due to historic hedgerow removal) and crop management is intensive (high N fertiliser input) (Table 1). Fertiliser applications increase herbage biomass and may lead to increased grass growth on field margins, with a concomitant decrease in sward temperatures and extinction of light near to the soil surface. Fertiliser input is an important factor in Orthoptera distribution as van Wingerden, van Kreveld & Bongers (1992) suggest that the number of grasshopper species in grassland systems is reduced in such 'cold' grasslands due to slow egg development and delayed hatching. Therefore, a combination of large field size and high fertiliser usage may reduce the effectiveness of field margins in conserving grasshopper populations in the open landscapes of eastern England.

Any land management policy (voluntary or otherwise) that results in increased habitat resources should be applauded. However, implementation of a policy when indicator/target species are limited in abundance may not be as valuable as first supposed by the policy maker. Many factors must be considered when establishing grass margins on arable land, for instance local management practices, soil type and sown sward composition and its influence on microclimatic conditions in the established margin. For example, Gardiner & Hill (2005*b*) demonstrated that field margins at Writtle College located on moist, nutrient rich, alluvial soils promoted the growth of grass species such as *Lolium perenne* L. that dominated in the margins. *Lolium perenne* has been demonstrated to produce swards with unfavourable microclimatic conditions for grasshoppers (van Wingerden, Musters & Maaskamp, 1991). However, in contrast, a disused farm track (which in essence resembled a CSS margin) at the same site, located on well-drained soil, had a short sparse sward of *Agrostis stolonifera* L., leading to a favourable 'warm' microclimate, ideal for sustained grasshopper activity (Gardiner, West & Kleijn, 2002). The margins in Marshall's study were mainly composed of *Dactylis glomerata* L. and *Festuca rubra* L., a combination that may be favourable for grasshoppers such as *Chorthippus parallelus* (Zetterstedt). In feeding and behavioural studies conducted by Gardiner & Hill (2004*b*; 2005*a*), *C. parallelus* ingested both species of grass and may feed in patches of coarse and large-leaved grasses

(*Dactylis*), before returning to the areas of fine-leaved grasses (*Festuca*) for basking and reproduction (Gardiner & Hill, 2004*b*). Marshall (2007) also demonstrated that heterogeneity in vegetation structure due to varying plant composition might be important to Orthoptera.

In the studies conducted in eastern England, a decline in abundance and species richness/diversity of grasshoppers over the first seven years of a CSS agreement was observed at Writtle College. Grasshopper species such as *Chorthippus brunneus* (Thunberg) were notably absent from field margins after seven years of the CSS agreement, reflecting the absence of patches of short, open vegetation in the mature margins (Haes & Harding, 1997). It is suggested that the reduced populations of grasshoppers and lower species richness/diversity in later years of the agreement were due to the annual cutting of the margins for hay in August. This management practice removed the entire grassland habitat in one event, leaving only a very short sward (< 10 cm in height) that is unfavourable for adult grasshoppers (Gardiner, West & Kleijn, 2002). Consequently, after cutting, grasshoppers may have dispersed into the surrounding areas in search of tall vegetation, which provides more shelter from inclement weather and avian predation than the mown field margins that represented a homogenous, 'microclimatically hostile' environment similar to heavily grazed pasture (Gardiner & Hill, 2004*a*). Recently mown margins may also have high temperatures (> 44°C; unshaded air temperature at 10 cm in the sward), which may cause physiological stress to insects such as grasshoppers that overheat without tall grass to provide shade (Gardiner & Hill, 2006*a*; Gardiner & Hassall, 2008). Vigorous escape responses from margins may be exhibited under these conditions (Willott, 1997).

Cutting of the margins in August also leads to increased mortality of large mature grasshopper nymphs and adults that are frequent in mid summer (Wagner, 2004; Gardiner & Hill, 2006*b*), leading to a low abundance of grasshoppers after mowing. Species such as *C. parallelus* may be particularly susceptible to cutting blades which pass through the sward at approximately 10 cm, due to adults spending the majority of their time in the lower sward layers (< 20 cm) resting or basking (Gardiner & Hill, 2005*a*). Proposals to scarify sown margins (Westbury *et al*., 2008) to enhance botanical diversity, while targeted for the winter or spring, may also have adverse effects on Orthoptera.

We agree with the conclusions of Marshall, West & Kleijn (2006) in stating that a case-by-case approach is needed in the prescription of management to enhance taxa such as Orthoptera where their response may differ greatly between different sites and geographical regions in the U.K., as well as between species/families. For example, *Chorthippus* grasshoppers seem to prefer a short, open sward of 10–20 cm in height (Gardiner *et al*., 2002), whereas bush-crickets (Orthoptera: Tettigoniidae) such as *Metrioptera roeselii* (Hagenbach) and *Conocephalus discolor* (Thunberg) are found in field margins with tall, uncut vegetation (Marshall & Haes, 1988). It is interesting to note that bush-crickets such as *C. discolor*, which was first recorded in Essex in 1995 in the extreme west of the county, has since moved eastwards, having been

recorded in a wide range of tall-grass habitats on farmland. Many of these grasslands are CSS grass field margins (2 m and 6 m wide) that have the tall grassland habitat required by this species. Could it be that the climate-driven range expansion of this bush-cricket has been aided by the introduction of grassy field margins on agricultural land usually sparsely populated by Orthoptera (Gardiner & Benton, in press)?

It would seem that 6 m margins established under the new Environmental Stewardship (ES) Scheme (an amalgamation of the CSS with the Environmentally Sensitive Areas Scheme), could incorporate the diversity of approach that may benefit both grasshoppers and bush-crickets on U.K. farmland (Gardiner, 2006) due to the farmer being allowed to cut the 3 m next to the crop edge annually after mid July, whilst only cutting the inner 3 m to control woody growth not more than once in 5 years (RDS, 2005). However, preliminary research on Entry Level Scheme (ELS) margins established as part of the ES Scheme in Boreham suggests that the abundance of Orthoptera in 6 m margins and their adjacent habitats (such as field edge footpaths) may also depend on the location of the grass strips, those on the exposed, windward side of hedgerows may not be particularly favourable whatever the management regime adopted (Gardiner & Dover, 2007). The study by Gardiner & Dover (2007) also showed that the presence of a 2 or 6 m wide grass margin had no significant influence on Orthoptera abundance or species richness in adjacent field edge footpaths (Table 2). Indeed, the abundance of Orthoptera was higher in footpaths that had no field margin adjacent because these sections were located on the sheltered eastern side of hedgerows (Gardiner, 2007; Gardiner & Dover, 2007).

Table 2. Abundance (density of Orthoptera m^{-2}/replicate) and species richness (no. species/100 m/replicate) of Orthoptera in footpaths adjacent to 2 and 6 m wide Entry Level Stewardship field margins in Boreham, Essex.

Margin width (m)	Abundance ± SE	Species richness ± SE
0 (no margin)	2.14 ± 0.43	1.1 ± 0.2
2	0.07 ± 0.01	1.3 ± 0.3
6	0.13 ± 0.03	1.2 ± 0.4

The importance of hedgerow shelter should not be underestimated in open landscapes with large fields; margins should be sited on the sheltered sides of hedgerows where the microclimate is favourable. There is a strong case for re-establishing hedgerows that have been removed in open landscapes where the benefits of field margins may otherwise be minimal. A landscape scale approach needs to be adopted when implementing agri-environment schemes, otherwise environmental payments may not yield the benefits that the policy maker intends. The policy maker should also be aware that the effectiveness of schemes may vary between different geographical regions and landscapes and that higher numbers of grasshoppers in field boundaries may lead to greater food availability for declining farmland birds such as the Skylark, *Alauda arvensis* L., and Cirl Bunting, *Emberiza cirlus* L. (Evans *et al.*, 1997).

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