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Authors: Gardiner, Tim, Pye, Michelle, Field, Robin, and Hill, Julian

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The influence of sward height and vegetation composition in determining the habitat preferences of three *Chorthippus* species (Orthoptera: Acrididae) in Chelmsford, Essex, UK

TIM GARDINER, MICHELLE PYE, ROBIN FIELD AND JULIAN HILL

Centre for Environment & Rural Affairs (CERA), Writtle College, Lordship Road, Writtle, Chelmsford, Essex, UK, CM1 3RR.
(TG) Email: tg@writtle.ac.uk

Abstract

This paper investigates the habitat preferences of *Chorthippus albomarginatus*, *Chorthippus brunneus* and *Chorthippus parallelus* in relation to sward height and vegetation composition. Using 2 X 2-m quadrats, the grasshopper fauna of 15 sites was surveyed in July and August of 2000 and 2001. The results obtained highlight the importance of sward height and vegetation composition in determining grasshopper abundance. The three *Chorthippus* species were found to favor sward heights between 100 to 200 mm. *C. brunneus* and *C. parallelus* in particular, were positively associated with fine-leaved grass species such as *Agrostis* spp. or *Festuca* spp. ($p < 0.05$) and negatively associated with *Lolium perenne* L. and *Poa trivialis* L. ($p < 0.01$).

Both *C. parallelus* and *C. brunneus* were found to be in significantly higher abundance at heathland sites than in agricultural habitats. This may have been because the farmland sites were dominated by *L. perenne*, which may not be a suitable food resource for grasshoppers, whereas heathland swards tended to be composed of fine-leaved grass species such as *Agrostis capillaris*, which might be more favorable for adult feeding. The lack of suitable swards on agricultural land may severely restrict the occurrence of these grasshopper species. This could have important conservation implications for rare farmland bird species, such as *Emberiza cirlus* which utilise grasshoppers as a food source.

Key words

Grasshoppers, habitat, sward height, vegetation, farmland

Introduction

Vegetation structure has been suggested as an important factor for grassland fauna (Duffey *et al*. 1974, Morris 2000), in particular for British grasshoppers. Clarke (1948), for instance, notes that vegetation height and density are the most important habitat factors for grasshoppers, as a result of their influence on sward microclimate. Dense and tall vegetation is not readily warmed by the sun or cooled by free circulation of air. In contrast, sparse vegetation provides better environmental conditions for diurnal activity and egg development (Clark 1948, van Wingerden *et al*. 1991). Dense vegetation with a high percentage cover, however, provides abundant food sources. Therefore, grasshoppers may be abundant in habitats which possess both dense vegetation and patches of sparse vegetation. Local differentiation of vegetation structure may thus be important in the distribution of Orthoptera in improved grasslands (Clarke 1948).

Vegetation height and density is also related to the growth form of component species, properties of the soil and the type of sward management applied. Grasslands dominated by *Arrhenatherum elatius* and *Dactylis glomerata*, which form very tall and dense cover on fertile soils, are probably unsuitable for the majority of grasshopper species. However, grasslands on less fertile soils, often dominated by species such as *Festuca ovina* and *Agrostis capillaris*, form sparse, less dense swards which are more favorable for grasshoppers (Clarke 1948). The majority of grasslands recreated on agricultural land as a result of agri-environmental policies are composed of grass species that may be unsuitable for grasshoppers.

Grazing and trampling are also important influences upon vegetation height and density. Grazing by cattle and sheep on fertile soils can produce a short, dense sward of neutral grassland species such as *Lolium perenne*, which may be unsuitable for many species of grasshoppers. However, Clarke (1948) suggests that excessive grazing by rabbits on chalk grassland and heathland promotes sparse vegetation, comprised of less vigorous species such as *F. ovina*, which is consequently more favorable to grasshoppers.

However, in studies examining populations of *Chorthippus brunneus* Thunberg on a heavily rabbit-grazed calcareous grassland, the greatest abundance was within an exclosure area which was not grazed (Grayson & Hassall 1985). It was suggested that the longer vegetation in the exclosure provided better cover from vertebrate predators, more suitable microclimate and better quality food resources for grasshopper nymphs than the shorter, grazed vegetation.

The primary aim of this paper is to examine the importance of sward height and vegetation composition in determining the habitat preferences of 3 grasshopper species in the UK: *C. albomarginatus* De Geer, *C. brunneus* and *C. parallelus* Zetterstedt.

Methods

Fifteen study sites were surveyed, encompassing a wide variety of habitats ranging from grazed pastures, hay meadows to heathland. Ten of the study sites were located on agricultural land at Writtle College (TL 670070), Chelmsford, in Essex (Fig. 1). The approximate size of the estate is 210 ha, mainly comprised of farmland and horticultural areas, with some designated conservation sites. The other 5 study sites were located throughout the Chelmsford area of Essex (Fig. 2). The main characteristics of the 15 sites are shown in Table 1.

Fig. 1. Location of the study plots on the Writtle College Estate.

Sampling method for grasshopper populations.— In this study the method used for surveying grasshoppers was adapted from Ausden (1996) and Gardiner & Pye (2001). The size of the quadrats used in the survey was $4m^2$ (2 X 2 m). Ten quadrats were positioned using random co-ordinates in a 100-m^2 plot at each study site. The corners of each quadrat were marked using poles, without disturbing the grasshoppers within by casting shadows. Two types of plot were used: a standard 10 X 10-m plot and a linear plot of 5 X 20 m for grasslands such as roadside verges, where it was impossible to accommodate the former plot. Each plot at the study sites was surveyed to ascertain grasshopper abundance once in July and once in August, in both 2000 and 2001. Surveys were conducted in these months as adult grasshoppers are most abundant in midsummer. Only adult grasshoppers were recorded in this study because during this life stage identification can be confirmed without the capture of individuals (Richards & Waloff 1954).

The number of adult individuals of each species were recorded by visual sighting in each quadrat. The vegetation of each quadrat was brushed with a pole to cause any grasshoppers present to jump (Richards & Waloff 1954). This 'flushing' of grasshoppers was conducted in a standardized method, ensuring coverage of the whole quadrat by moving from one edge to the other, sweeping the vegetation in a 180° arc. Only grasshoppers within the quadrat at the start of the sweep were recorded. It was felt that adults could be accurately identified on sight without the need for physical capturing. One observer conducted all of the grasshopper surveys to minimize any recording error. The surveys were undertaken between 1045 and 1545 h, if the air temperature was 17°C or over (Marshall & Haes 1988, Pollard & Yates 1993). Total and individual species densities (adults per m^2) were calculated for each site by combining the data collected in both years.

In each quadrat in July in both 2000 and 2001 the following vegetation data were recorded: height in millimetres obtained using the Boorman Drop Disc (Waring 1992), and percentage cover of each plant species estimated by eye. Four height measurements were obtained for each quadrat in the July survey. A mean sward height for each site was obtained using the 80 height measurements taken with the Boorman Drop Disc. A mean sward height was also calculated for each quadrat in the July survey, enabling the frequency of grasshoppers at different sward height categories to be determined. Visual estimates of percentage cover were conducted by only one observer, therefore minimizing the error associated with this type of subjective vegetation surveying. The percentage cover values for each of the plant species at all of the sites were converted to the Domin scale (Kent & Coker 1992). The median Domin value was calculated for every plant species at each site.

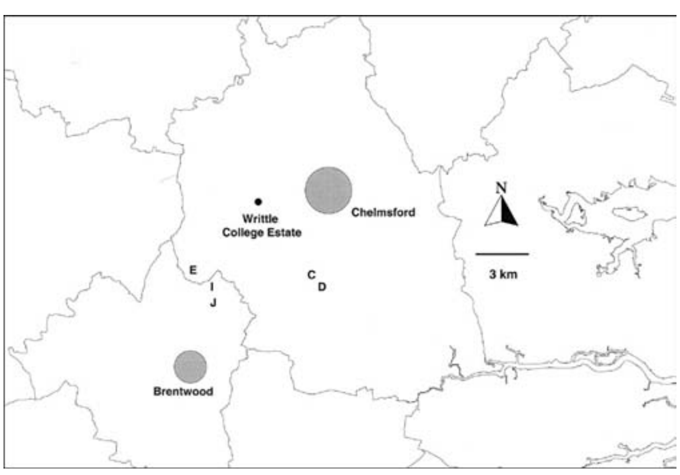

Fig. 2. Location of Writtle College Estate and other study sites in Essex.

Statistical analysis.— An association analysis between the 3 grasshopper species and 5 different grass species was conducted using chi-square (χ^2) association coefficient in a contingency table (Fowler *et al.* 1998). The authors also wanted to determine the 'optimum' sward height for the 3 *Chorthippus* species. Therefore, the numbers of adult individuals of each *Chorthippus* species were pooled into 3 sward-height categories: < 100 mm, 100-200 mm and > 200 mm for 2000 and 2001. The frequency of each species between 100 to 200 mm was then compared with short vegetation (< 100 mm) and tall vegetation (> 200 mm) using a chi-square analysis (χ^2). As there was only one degree of freedom, Yates correction for continuity was included in the calculation (Fowler *et al.* 1998).

Relationships between the densities of each of the three *Chorthippus* species at each of the 15 sites were tested using the Kruskal-Wallis multiple comparison statistic (Heath 1995) to investigate habitat preferences. For ease of analysis, abundance data for each site were pooled for 2000 and 2001. Dunn's non-parametric pro-

Table 1. Main characteristics of the study sites.

Site	Plot	Grid reference	Habitat type	Area (m^2)
A	S	TL669070	Arable field	100500
B	L	TL680073	6 m CSS grass field margin	4500
C	S	TL703028	Grassy heathland	20000
D	S	TL703028	Dense *Pteridium aquilinum* stand	500
E	S	TL625031	Set-aside grassland	40000
F	S	TL664067	Lightly grazed horse pasture	3750
G	L	TL688071	6 m CSS grass field margin	4320
H	S	TL674068	Heavily grazed cattle pasture	10600
I	S	TL637013	Dry heathland	15000
J	S	TL637013	Wet heathland	5000
K	L	TL666071	Roadside verge	500
L	L	TL672069	Hay meadow	11250
M	S	TL675069	Set-aside grassland	30000
N	S	TL663068	Heavily grazed sheep pasture	10100
O	L	TL663073	Disused farm track	750

S = standard plot (10 X 10 m)
L = linear plot (5 X 20 m)
CSS = Countryside Stewardship Scheme

cedure (Gardiner 1997) was used to determine between which sites the significant differences in grasshopper density occurred.

To determine whether sward height or vegetation composition was related to the density of the 3 grasshopper species, we used Spearman's Rank Correlation (R_s) (Heath 1995). Mean sward height and median Domin value of *Agrostis* spp. and *L. perenne* were correlated with density of the 3 *Chorthippus* species. All statistical analyses were performed using SPSS Version 10 (SPSS 1999).

Results

Total number of grasshoppers.— The most common species in the survey was *C. parallelus*, which formed approximately 64% of all sightings. *C. albomarginatus* and *C. brunneus* were less common, with 27% and 9% of all observations respectively.

Vegetation height.—Vegetation height had an important influence on grasshopper abundance in both years. Figure 3 shows the proportion of the 3 *Chorthippus* species in 3 different sward height categories in 2000 and 2001. *C. albomarginatus* and *C. parallelus* were most abundant in sward heights of 100 to 200 mm in both years, being much less numerous in very short vegetation (< 100 mm) and in tall swards (> 200 mm).

To define 'optimum' sward height, a chi-square analysis (χ^2) was conducted between the frequencies of the 3 grasshopper species in sward heights of 100 to 200 mm and in short (< 100 mm) and tall vegetation (> 200 mm) (Table 2). All 3 *Chorthippus* species were significantly more numerous in sward heights of 100 to 200 mm than in very short vegetation in both years ($p < 0.01$). Both *C. albomarginatus* and *C. parallelus* were also significantly more frequent in sward heights of 100 to 200 mm than in taller swards (> 200 mm) in both 2000 and 2001 ($p < 0.01$). *C. brunneus,* was significantly more numerous in sward heights of 100 to 200 mm than in tall vegetation in 2000 ($p < 0.05$). However, this same significant relationship was not detected in 2001.

Vegetation composition and grasshopper occurrence.— Table 3 displays associations between the 3 *Chorthippus* species and 5 grass species in 2000 and 2001. In both years, *C. brunneus* and *C. parallelus* were positively associated ($p < 0.01$) with *Agrostis* spp. and *Festuca* spp., negatively associated ($p < 0.01$) with *L. perenne*. *C. brunneus* and *C. parallelus* were negatively associated with *Poa trivialis* L. in 2000 ($p < 0.01$), however, in 2001, only the former grasshopper species was negatively associated with *P. trivialis* ($p < 0.05$). In 2000 and 2001, *C. albomarginatus* was significantly positively associated with *Agrostis* spp. and *P. trivialis*.

Sward heights at each site.— Having determined that vegetation height has a significant influence on grasshopper abundance (Fig. 3, Table 2), the mean sward heights at each of the sites were calculated (Table 4). Sward heights varied considerably on agricultural land, with intensive management often creating either very tall or short swards. Mean sward height in a heavily grazed pasture (site N) was extremely low over the study period, whereas the sward of a more lightly grazed pasture (site F) was higher. In the lightly grazed pasture, mean sward height was between 100-200 mm which is more favorable for grasshoppers (Fig. 3, Table 2). The sward heights of the two set-aside grasslands (sites E and M) were substantially different, with the latter sward being very tall.

Sward height also varied considerably on the three heathland sites, with short dry heath (site I) having an ideal sward height for grasshoppers of between 100-200 mm, whereas tall wet heath (site J) and *Pteridium aquilinum* L. covered areas (site D) had much higher mean sward heights. However, there was no significant correlation detected between the density per m^2 of the three *Chorthippus* species and mean sward height at each site (Table 5).

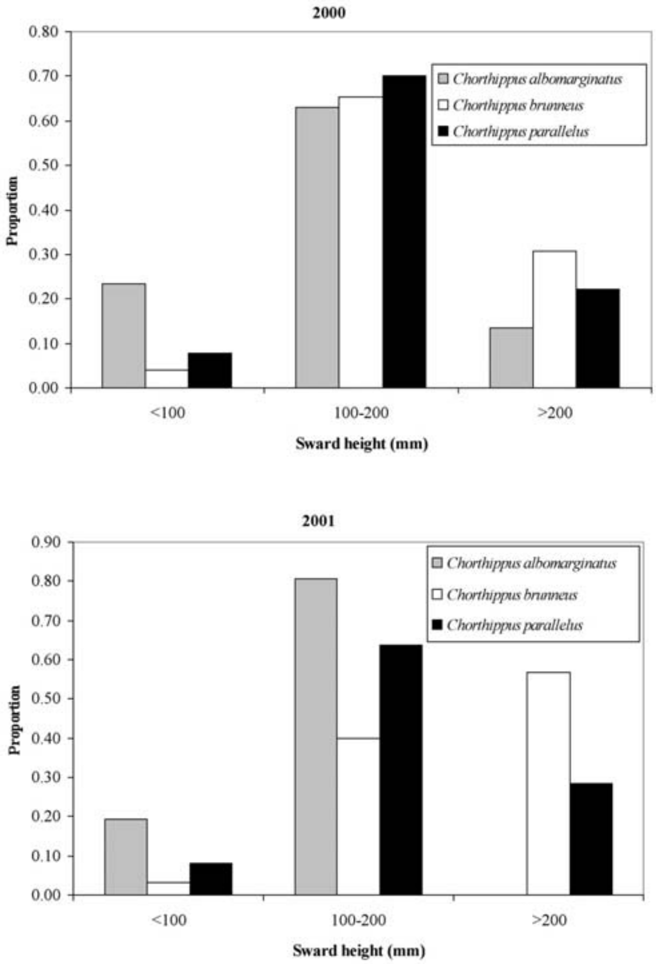

Fig. 3. Proportion of the total number of each grasshopper species in 3 sward-height categories in 2000 and 2001.

Vegetation composition of the sites.— The heathland grasslands were mainly comprised of fine-leaved grass species (Table 4). At these sites (C, D, I and J), *A. capillaris* was the most abundant grass species. In contrast to these grasslands, many of the agricultural sites (B, G, F, H and N) were dominated by *L. perenne.* Site O was the only agricultural grassland where the fine-leaved grass species *Agrostis stolonifera* L. was dominant. Site E was dominated by *P. trivialis.* The median Domin value of *Agrostis* spp. and *L. perenne* was correlated with density per m^2 of the three *Chorthippus* species (Table 5). There were significant positive correlations between the densities of *C. brunneus, C. parallelus* and the abundance of *Agrostis* spp., but a negative correlation between *L. perenne* and the two *Chorthippus* species.

Habitat preferences of grasshoppers.— Vegetation height (Fig. 3, Table 2) and composition (Tables 3, 5) has a significant influence on grasshopper occurrence. These factors vary in accordance with habitat type and management practices.

C. albomarginatus was significantly more numerous on set-aside grassland (site E) and a disused farm track (site O) than on any other survey sites ($p < 0.05$) (Table 4). This species was not recorded on dry heathland (site I), wet heathland (J) or intensively managed agricultural habitats such as arable fields (site A) or heavily grazed pasture (site N). *C. albomarginatus* was recorded in very low abundance on the two grass field margins which were established in an effort to enhance farmland biodiversity in the area under the UK Government's Countryside Stewardship Scheme (CSS). However, densities of this species were not significantly different on these two field margins than in the intensively managed agricultural habitats such as sites A and N. *C. albomarginatus* was significantly more abundant in a lightly grazed horse pasture (site F) than in either of the heavily grazed pastures (sites H and N), which had much shorter vegetation.

Both *C. brunneus* and *C. parallelus* were extremely rare on agricultural land during the study period, with the former species absent from most farmland sites (Table 4). *C. parallelus* was significantly more abundant on dry heathland (site I) and wet heathland (site J) than on all other sites ($p < 0.05$). Densities of this species were particularly low in intensively managed agricultural habitats such as sites A and N which were also not favored by *C. albomarginatus* or *C. brunneus*. Similarly to *C. albomarginatus*, densities of *C. parallelus* were not statistically different on the two CSS grass field margins than in the more intensively managed farmland sites such as heavily grazed pasture (sites H and N) or arable fields (site A). In the more lightly grazed horse pasture (site F), densities of *C. parallelus* were significantly higher than the heavily grazed pastures.

Densities of *C. brunneus* were significantly higher at the four heathland sites (sites C, D, I and J) than at any of the agricultural habitats ($p < 0.05$) (Table 4). At eight farmland survey sites this species was absent, which included intensively managed pastures (sites H and N) and CSS grass field margins (sites B and G).

Discussion

This survey suggests that *C. albomarginatus* is a common insect in some farmland habitats, often being the most numerous grasshopper on set-aside and other nonintensive agricultural areas where *A. stolonifera* and *P. trivialis* predominate (Table 4). Wake (1997) states that in Essex, *C. albomarginatus* is mainly found in coastal habitats such as seawalls and salt marshes, although in recent years this species has shown a tendency to increase its range to more inland habitats in the county. *C. albomarginatus* is perhaps benefiting from the increased provision of grassland areas within agricultural land such as 'set-aside grassland' which may facilitate their dispersal to new inland habitats. The low abundance on farmland of *C. brunneus* and *C. parallelus* (Table 4), two common species in Britain (Haes & Harding 1997), is of particular concern, especially as they may be an important food source for rare farmland bird species such as *Emberiza cirlus* L. (Peach *et al*. 2001).

Table 2. Chi- square analysis (χ^2) of the frequency of each grasshopper species at 100 to 200 mm with short (< 100 mm) vs tall (> 200 mm) vegetation.

Year	Sward height (mm)	*C. albomarginatus*	*C. brunneus*	*C. parallelus*
2000	< 100	20.18**	26.50**	188.48**
	> 200	35.60**	6.17*	93.11**
2001	< 100	36.74**	9.39**	181.97**
	> 200	79.02**	0.90	49.37**

* = significant at $p < 0.05$
** = significant at $p < 0.01$

Table 3. Associations (χ^2) between the three *Chorthippus* species and selected grass species in 2000 and 2001.

Year	Grass species	*C. albomarginatus*	*C. parallelus*	*C. brunneus*
2000	*Agrostis* spp.	5.00*	9.67**	42.83**
	Arrhenatherum elatius	2.72	0.22	2.23
	Festuca spp.	0.05	24.99**	14.89**
	Lolium perenne	5.13*	13.11**	35.13**
	Poa trivialis	26.79**	13.22**	11.87**
2001	*Agrostis* spp.	9.12**	17.37**	19.46**
	A. elatius	2.80	1.66	0.47
	Festuca spp.	1.06	29.58**	12.06**
	L. perenne	0.13	41.45**	28.28**
	P. trivialis	30.43**	1.22	5.73*

* = significant at $p < 0.05$

** = significant at $p < 0.01$

Table 4. Grasshopper density per m^2, mean sward height and dominant vegetation species for each site (data for 2000 and 2001 is pooled).

Total Density	*C. albomarginatus*	*C. brunneus*	*C. parallelus*	Mean sward height (mm)	$S_{\bar{x}}$	Dominant vegetation species	**Median Domin**	Site
3.36	0.00^{d}	0.20^{ab}	3.16^{a}	129.13	± 3.59	*Agrostis capillaris*	9	I*
1.56	0.00^{d}	0.14^{b}	1.42^{a}	252.00	± 8.51	*A. capillaris*	8	J*
1.21	1.08^{a}	0.00^{c}	0.37^{b}	145.00	± 7.16	*A. stolonifera*	8	O
0.78	0.26^{b}	0.15^{b}	0.26^{bc}	191.13	± 7.69	*A. capillaris*	9	C*
0.71	0.63^{a}	0.02^{c}	0.19^{bc}	110.25	± 6.11	*Poa trivialis*	8	E
0.48	0.21^{b}	0.01^{c}	0.13^{cd}	119.25	± 4.16	*Lolium perenne*	10	F
0.39	0.02^{d}	0.31^{a}	0.10^{cde}	255.75	± 9.95	*A. capillaris*	9	D*
0.34	0.12^{c}	0.03^{c}	0.06^{def}	107.50	± 6.87	*Festuca rubra*	9	K
0.13	0.03^{cd}	0.00^{c}	0.06^{def}	131.00	± 7.27	*L. perenne*	8	L
0.06	0.03^{cd}	0.00^{c}	0.03^{ef}	147.91	± 7.37	*L. perenne*	9	B
0.03	0.02^{d}	0.00^{c}	0.01^{f}	119.38	± 3.78	*L. perenne*	10	G
0.01	0.00^{d}	0.00^{c}	0.01^{f}	259.00	± 12.17	*Hordeum* spp.	10	A
0.01	0.01^{d}	0.00^{c}	0.01^{f}	57.75	± 2.73	*L. perenne*	10	H
0.01	0.00^{d}	0.00^{c}	0.00^{f}	428.75	± 15.42	*Phleum pratense*	10	M
0.00	0.00^{d}	0.00^{c}	0.00^{f}	62.50	± 1.98	*L. perenne*	10	N

* = heathland site, all other sites were situated on agricultural land.
Significant differences at $p < 0.05$ between grasshopper densities with different superscripts – Kruskal-Wallis.

Table 5. Spearman's Rank Correlation values (R_s) between density per m^2 of each *Chorthippus* species and mean sward height, median Domin value of *Agrostis* spp. and *Lolium perenne.*

Correlation factor	*C. albomarginatus*	*C. brunneus*	*C. parallelus*
Mean sward height	-0.23	0.12	0.09
Median Domin *Agrostis* spp.	0.10	0.59*	0.70**
Median Domin *L. perenne*	0.01	-0.69**	-0.52*

Spearman's Rank Correlation (R_s)
* = significant at $p < 0.05$
** = significant at $p < 0.01$

From the survey results, the optimum sward height and vegetation composition have been identified. As Clarke (1948) noted, vegetation height has an important influence on the occurrence of grasshoppers. Vegetation height is mainly determined by the growth form of the component plant species (Clarke 1948). All three *Chorthippus* species were most numerous between vegetation heights of 100 to 200 mm (Fig. 3, Table 2). However, there was no significant correlation between the density of each *Chorthippus* species and mean sward height (Table 5).

Heathland sites which supported high densities of *C. brunneus* and *C. parallelus* did not necessarily have the 'optimum' sward height of 100 to 200 mm. For example, site J had a mean sward height exceeding 200 mm (Table 4), yet was favored by *C. brunneus* and *C. parallelus* over many other sites. Therefore, it is likely that local differentiation in vegetation structure within a grassland sward may be more important, with grasshoppers being recorded in high abundance within patches of vegetation having the 'optimum' sward conditions. It may be that grasshoppers were in highest abundance between 100 to 200 mm because they favored swards composed of species such as *Agrostis* spp. (Tables 3, 5), which,, on poor acidic soils, form a sward of this height.

C. brunneus and *C. parallelus*, in particular, favored grasslands dominated by fine-leaved grass species, such as *Agrostis* spp. and *Festuca* spp., and were in low densities at sites with an abundance of *L. perenne* (Tables 3, 5). The heathland swards that supported high densities of both *C. brunneus* and *C. parallelus* (Table 4) tended to be predominantly composed of these fine-leaved grass species, which may be preferentially selected as a food source by grasshoppers. The food preferences of *C. brunneus* and *C. parallelus* have been examined in some depth by Clarke (1948), Richards & Waloff (1954) and Bernays & Chapman (1970a, 1970b). While Clarke (1948) and Richards & Waloff (1954) state that the availability of suitable food may not be a limiting factor for British grasshoppers, Bernays & Chapman (1970b) found that grasses such as *Agrostis* species and *Festuca* species were often selected in preference to *Holcus lanatus*, *Cynosurus cristatus* and *D. glomerata* by *C. parallelus*.

Other factors that were not considered in this study may also have an important influence in determining the habitat preferences of grasshoppers. For example, the availability of bare earth varied between the study sites. Choudhuri (1958) investigated the oviposition habits of *C. brunneus* and *C. parallelus,* concluding that *C. parallelus* preferred to oviposit in moist sand, whilst *C. brunneus* mostly laid eggs into dry sand. Exposed soil may also offer other benefits for grasshoppers by providing sites where they can bask (Key 2000), as exposed soil is often much warmer than surrounding vegetation.

The agricultural grasslands were often dominated by *L. perenne* or *Phleum pratense* and were less favorable for grasshoppers. The former grass species is very competitive and forms a dense sward to the exclusion of fine-leaved grass species on heavily fertilized farmland sites. Grasshoppers were absent or in very low densities in the heavily grazed pastures (Table 4), which were dominated by *L. perenne* and characterized by very short swards. These pastures provided limited cover from adverse weather and predators, and poor quality food resources. However, in a pasture which was grazed less intensively by horses, *C. albomarginatus* and *C. parallelus* were significantly more abundant, perhaps preferring the taller sward, which provided cover. This paper presents some evidence which confirms the view stated in Peach *et al*. (2001) that lightly grazed pastures have the potential to support a rich source of invertebrates such as Orthoptera.

Chorthippus species are particularly sensitive to insecticide sprays (Natural Environment Research Council 1972) and consequently are not found in intensively managed arable fields. However, set-aside grassland and to a lesser extent grass field margins, provide areas where grasshoppers can sustain populations on farmland.

The two grass field margins in this study were established with funding from the UK Government's Countryside Stewardship Scheme (CSS). The aim of the CSS is to maintain and enhance wildlife and other landscape features (Peach *et al*. 2001). Uncultivated grass field margins have been created over large parts of Britain under such agri-environmental schemes. However, this study provides some evidence that grasshopper populations in these margins are no higher than in the surrounding intensively managed agricultural land. This may be due to the dominance of unsuitable grass species such as *L. perenne* in these margins. The authors suggest that newly created agricultural habitats such as field margins should include fine-leaved grass species such as *A. capillaris* or *Festuca rubra* L. which would provide a short, sparse sward which may be more favorable to all 3 *Chorthippus* species.

Grasshoppers are an important component of grassland ecosystems, providing a food source for many declining farmland bird species including *Alauda arvensis* L. and *Perdix perdix* L. The dearth of grasshoppers on agricultural land, due to the lack of suitable habitats, must then limit the food supply of these predators. Thus further research is needed to investigate the effect of different agricultural management regimes on the abundance of the 3 *Chorthippus* species.

Conclusion

This study highlights the influence of vegetation height and composition in determining the habitat preferences of common British grasshoppers. The three *Chorthippus* species were most numerous at sward heights between 100-200 mm, which may provide adequate cover from inclement weather and predation. Extremely short (< 100 mm) or tall vegetation (> 200 mm) was less favored by grasshoppers.

C. brunneus and *C. parallelus,* in particular, tended to be observed in the highest densities in heathland swards which were dominated by fine-leaved grass species such as *A. capillaris*. *C. brunneus* and *C. parallelus* were infrequently recorded within sites on farmland because intensive agricultural management practices such as heavy grazing often produced short swards composed mainly of *L. perenne* that were not favorable for grasshoppers. Further research is required on enhancing the abundance of grasshoppers on farmland in lowland England.

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