An Irish population of the little-known planthopper *Paraliburnia clypealis* (Hom., Delphacidae) in a very unexpected habitat

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The little-known planthopper *Paraliburnia clypealis* is described from experimental field margin strips within a dairy grassland. Suction samples were taken in 2004 and 2005. The number of individuals was greater in the field margins than control grazed areas. The vegetation of the field margin experiment was recorded, giving a detailed description of the habitat. The substantial population of *P. clypealis* found in the field margins indicates that in Ireland this species is not restricted to the wetland habitats and food plants previously described.

Paraliburnia clypealis (J. Sahlberg, 1871) is a relatively little-known species of planthopper (Homoptera: Delphacidae). In the UK it has been classified as 'insufficiently known' (Red Data Book category K), and for many years was only known to occur at Wicken Fen, Cambridgeshire, but has now been found in a number of other localities (Kirby 1992). It occurs in various parts of northern Europe including, the Czech Republic, Finland, Germany, the Netherlands, Russia, Sweden and Ireland (Ossiannilsson 1978, Kirby 1992, Nickel 2003). There are few Irish records of this species, the first of which was a single specimen from the Burren region of Co Clare in 1970 (Morris 1974). Although apparently relatively widespread within northern Europe, its distribution is probably rather patchy and it is also likely to be under-recorded (Kirby 1992, Nickel 2003). Its habitat has been described consistently to be various types of wetland such as bog, fen and wet meadows, and its only known food plant is the purple small-reed *Calamagrostis canescens*, although it has also been found associated with *Rhynchospora* and *Eriophorum* (Ossiannilsson 1978, Kirby 1992, Nickel 2003). In this study, a population of *P. clypealis* is described from a most unexpected habitat, namely experimental field margin strips within an intensively managed dairy grassland. Plant nomenclature is according to Stace (1997).

Methods

Field site

A randomized split-plot field margin experiment was established on the dairy farm at the Teagasc Research Centre in Johnstown Castle, Co Wexford (T026166), in 2002. The purpose of this experiment was to investigate the effect of field margin establishment method on subsequent floral and invertebrate faunal diversity. All internal hedgerows had been removed from the site during the 1970s and 1980s as part of the overall intensification process at the centre. Swards principally consisted of a mid-season yielding variety of *Lolium perenne* and were delineated with electric fences. The field margin experiment was made up of nine 90m long strips of existing grassland which were fenced off from the surrounding paddocks. One of three widths, *i.e.* 1.5m (width recommended within the Irish Rural Environment Protection Scheme), 2.5m and 3.5m were randomly assigned to each strip. Each strip was then divided into three 30m long plots and one of three field margin establishment methods was randomly applied to each of these plots. Establishment methods were:

1. Fenced, *i.e.* existing areas of grassland were fenced off from the surrounding paddocks;
2. Rotavated, *i.e.* these plots were rotavated and then allowed to regenerate naturally;

Table 1. Number, sex and wing development of *Paraliburnia clypealis* found in the Johnstown Castle field margin experiment.

Year	Wing development		Sex		Total
			Female	Male	
2004	Brachypterous		8	14	22
	Macropterous		8	3	11
		Total	16	17	33
2005	Brachypterous		70	32	102
	Macropterous		3	2	5
		Total	73	34	107

3. Reseeded, *i.e.* plots were rotavated and reseeded with a grass and wild flower seed mixture.

There were three replicates of each combination of width and field margin establishment method. Subsequently half of each plot was reverted to grazing in 2003, resulting in plot length of 15m. No external inputs, including fertilizer, were applied to any of the plots over the duration of the experiment. Plots were managed by cutting on an annual basis. Further details of the experimental design are provided in Sheridan (2005) and Sheridan *et al.* (2003).

Insect sampling

Sampling was carried out on 14 June 2004 and 14 June 2005 within the 15m field margin plots. Control samples were taken from randomly chosen areas of the dairy grassland beside each of the nine margin blocks. In 2004 control samples were taken immediately adjacent to the margins (Control 1). This was repeated in 2005 but, due to the possibility of localized movement of insects from the margins into the main paddock, an additional control sample (Control 2) was taken 16m away from the edge of the margin plots, corresponding to the centre of the paddocks. One suction sample, consisting of ten randomly-placed sub-samples of ten second duration, was taken from each field margin replicate and control location, using a Vortis suction sampler (Arnold 1994). In 2004 sweep net samples were also taken in each of the margin replicates but not at the control locations. Each sample consisted of eight figure-of-eight sweeps using a 46cm diameter sweep net. *P. clypealis* was identified using Le Quesne (1960) and Holzinger *et al.* (2003).

The insect data were analyzed using Chi-squared and with analysis of variance of log transformed (log+1) values using the R statistical package (Version 1.7.1) (Ihaka and Gentleman 1996). Analysis of variance was used to analyze the number of individuals in different treatments and margin widths. Data were analyzed using a split plot model with an error structure of treatment nested within width, and individual treatment means were compared with treatment contrasts.

Results

2004

A total of 33 *P. clypealis* was recorded within the field margin experiment (Table 1), which corresponded to 19 per cent of the 159 delphacids of all species collected. Analysis of variance, incorporating samples from the margin treatments and Control 1, indicated that there was no significant difference in the mean number of *P. clypealis* between treatments

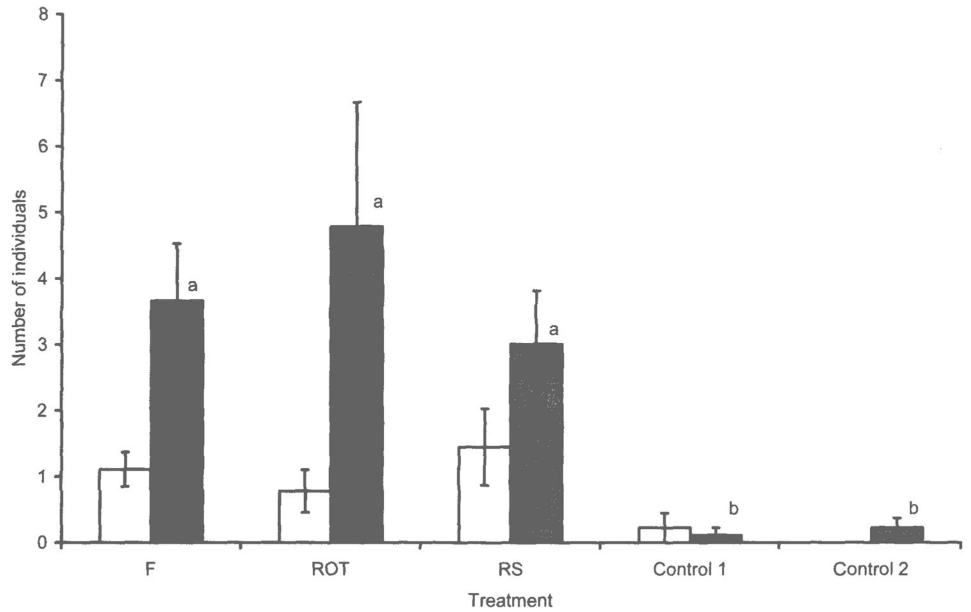

Figure 1. Mean (±SE) abundance of *Paraliburnia clypealis* in field margin treatments in 2004 (white bars) and 2005 (shaded bars). Letters above shaded bars indicate significance of analysis of variance contrasts: same letter, not significant; letters different, p<0.001. (F, fenced; ROT, rotavated; RS, reseeded).

($F_{3,6}$ = 2.47), width ($F_{2,3}$ = 0.51) or with width-treatment interaction ($F_{6,24}$ = 0.90) (Fig. 1). The analysis was then repeated but treating all margins as one treatment to enable a margin-control comparison. This analysis indicated that significantly more *P. clypealis* were recorded within the margin plots than in the grazed control areas ($F_{1,2}$ = 150.76, $p < 0.01$) and there was no significant width effect ($F_{2,1}$ = 0.205) or width-treatment interaction ($F_{2,30}$ = 0.04) (Fig. 1).

At least one individual was found within each of the nine experimental blocks, indicating the species was widely distributed within the experiment. Within the field margins the mean density of *P. clypealis* recorded was 3.4m^{-2} (SD = 3.8).

Of the 33 individuals found in the margins only one was collected using the sweep net, with all others in the suction samples. Thus the difference between sweep net and suction catches was highly significant (χ^2 = 31.3, d.f. = 1, $p < 0.001$).

Characterization of the sample population indicated that the sex ratio was exactly balanced with 16 of each sex, and that males were more likely to be brachypterous than macropterous (χ^2 = 7.12, d.f. = 1, $p < 0.01$) while the number of brachypterous and macropterous females was exactly the same at 8 of each (Table 1).

2005

One hundred and seven *P. clypealis* were collected in June 2005 (Table 1), with a significantly larger mean number per margin sample than in 2004 (One way ANOVA,

Table 2. Plant species recorded (+) within each of the field margin establishment treatmer 2004 (C, control; F, fenced; ROT, rotavated; RS, reseeded).

Latin name	Common name	C	F	ROT	RS
Achillea millefolium	Yarrow	0	0	0	+
Agrostis spp	Bent grass	+	+	+	+
Alopecurus geniculatus	Marsh foxtail	+	+	+	+
Alopecurus pratensis	Meadow foxtail	+	0	0	+
Angelica sylvestris	Wild angelica	0	0	0	+
Anthoxanthum odoratum	Sweet vernal	0	0	0	+
Arctium minus	Lesser burdock	0	0	0	+
Arrhenatherum elatius	False oat-grass	0	0	0	+
Cardamine flexuosa	Wavy bitter-cress	0	0	+	0
Centaurea nigra	Common knapweed	0	0	0	+
Cerastium fontanum	Common mouse-ear	+	+	+	+
Cirsium arvense	Creeping thistle	+	+	+	+
Cynosurus cristatus	Crested dog's-tail	0	0	+	+
Dactylis glomerata	Cocksfoot	+	+	+	+
Daucus carota	Wild carrot	+	0	0	+
Digitalis purpurea	Foxglove	0	0	0	+
Epilobium montanum	Broad-leaved willowherb	+	0	0	0
*Epilobium*sp	Willowherb	0	0	+	+
Festuca rubra	Red fescue	0	0	+	+
Filipendula ulmaria	Meadowsweet	0	0	0	+
Holcus lanatus	Yorkshire-fog	+	+	+	+
Holcus mollis	Creeping soft-grass	+	+	+	+
Juncus effusus	Soft rush	0	0	+	+
Leucanthemum vulgare	Oxeye daisy	0	0	0	+
Lolium perenne	Perennial rye-grass	+	+	+	+
Lychnis flos-cuculi	Ragged Robin	0	0	0	+
Plantago lanceolata	Ribwort plantain	0	0	0	+
Poa pratensis	Smooth meadow-grass	0	0	+	+
Poa trivialis	Rough meadow-grass	+	0	0	0
Primula vulgaris	Primrose	0	0	0	+
Ranunculus acris	Meadow buttercup	0	0	0	+
Ranunculus repens	Creeping buttercup	0	0	+	+
Rumex acetosa	Common sorrel	+	0	+	+
Rumex acetosella	Sheep's sorrel	0	0	+	0
Rumex obtusifolius	Broad-leaved dock	+	+	+	+
Senecio jacobaea	Common ragwort	+	+	+	+
Stellaria media	Common chickweed	+	0	+	+
Taraxacum officinale	Common dandelion	+	0	+	+
Trifolium pratense	Red clover	0	0	0	+
Trifolium repens	White clover	0	0	+	+
Urtica dioica	Common nettle	0	0	+	0

$F_{1,52}$ = 16.31 p < 0.001) (Fig. 1). Mean density of individuals in the margins was 20.1 m^{-2} (SD = 20.0). In total 191 delphacids of all species were collected, meaning that *P. clypealis* accounted for 56 per cent of the total. A split-plot analysis of variance model, with number of *P. clypealis* as the response variable, indicated that there were significant treatment effects ($F_{4,8}$ = 14.59 p < 0.001) with treatment contrasts indicating no differences between margin treatments but significantly more individuals in all margin treatments than in either Control 1 or Control 2 (Fig. 1).

Unlike in 2004, the sex-ratio of the sample was significantly female biased (χ^2 = 20.55, d.f. = 1, p < 0.001), and there were significantly more brachypterous individuals than macropterous in both males (χ^2 = 29.12, d.f. = 1, p < 0.001) and females (χ^2 = 61.49, d.f. = 1, p < 0.001).

Other records of P. clypealis

In addition to the *P. clypealis* recorded at the experimental field margin site, several other individuals were recorded at other locations. Two were found elsewhere at Johnstown Castle. One brachypterous male was collected on 15 May 2004 in a nearby cattle-grazed paddock (T016173) and in a nearby plant biodiversity experiment (T016173) a macropterous male was found on 18 May 2004 and a macropterous female on 14 June 2005. One macropterous male was found in a hillside sheep field at Lyons Estate, Co Kildare (N976283) on 27 August 2002, and two brachypterous individuals, one male and one female, in a dry field margin at Teagasc Grange, Co Meath (N884530) on 17 June 2003.

Plants

A total of 42 plant species, consisting of 13 grasses, one species of rush and 28 other herbs was recorded within the experimental field margins in 2004. A list of species and the treatments within which they were recorded is presented in Table 2.

Seventeen species were recorded within the control areas in 2004. Of these, *L. perenne* was the most abundant while *Agrostis* spp and *Holcus lanatus* ranked in second and third positions in terms of abundance. Dicotyledonous species such as *Cirsium arvense* and *Rumex obtusifolius* were also recorded within control quadrats but at very low levels of abundance. Within the fenced plots, *Agrostis* spp (principally *A. stolonifera*) was found to be the most abundant species. However, few other changes in species composition between the fenced and control plots were observed. Rotavated and reseeded plots were found to be considerably more species rich than either the control or fenced areas, with 25 and 37 species recorded within these, respectively. As can be seen from Table 2, these plots contained many monocotyledonous and dicotyledonous species which were not recorded within either the control or fenced areas *e.g. Achillea millefolium*, *Alopecurus pratensis*, *Anthoxanthum odoratum*, *Arrhenatherum elatius* and *Festuca rubra*. Further details of the botanical composition of the plots is provided in Sheridan (2005).

Discussion

The population of *P. clypealis* described here was found in an unexpected habitat quite unlike the wetland locations previously associated with this species (Ossiannilsson 1978, Kirby 1992, Nickel 2003). Following the discovery of a species in an unexpected habitat or location, it is important to address the question of whether the individuals could be considered residents or are more likely to be vagrants. There are several characteristics of the Johnstown Castle population that indicate that it is resident. Firstly, a relatively large number of individuals were recorded. Vagrants would generally be expected to be found in very low numbers. In this population *P. clypealis* made up a substantial proportion of the total adult delphacids collected (in 2004, 33 of 159; in 2005, 107 of 191). Secondly, given the limited dispersal ability of brachypterous delphacids (Denno and Roderick 1990), that a large proportion of both the males and females sampled were brachypterous (Table 1), and that the margins were isolated from other similar habitat by surrounding grazing paddocks, it is highly likely that most, if not all, of the individuals completed their larval development within the field margins. Ideally, when considering residence status it would be preferable if reproduction could be demonstrated by identifying eggs or larval forms within the habitat. Unfortunately this was not possible as large numbers of immature delphacids were collected which could not all be specifically related to one of the eight other delphacid species (*Conomelus* anceps (Germar), *Dicranotropis hamata* (Boheman), *Javesella dubia* (Kirschbaum), *Javesella obscurella* (Boheman), *Javesella pellucida* (Fabricius), *Megamelodes quadrimaulatus* (Signoret), *Muellerianella fairmairei* (Perris), and *Oncodelphax pullulus* (Boheman)) recorded so far at the site.

The significant difference in numbers of *P. clypealis* caught in margin treatments versus grazed controls (Fig. 1) could be related to one or more of several factors including the presence of or diversity of plant species, exclusion of external nutrients and other inputs, disturbance, micro-climate and vegetation structure.

Botanical records from the treatment plots in 2004 (Table 2) revealed considerable variation in plant species richness between margin treatments but there were no corresponding differences in *P. clypealis* numbers. Also while there were few differences in plant composition between control and fenced plots the number of *P. clypealis* were significantly higher in fenced areas. Thus there is little evidence to suggest plant diversity has any effect. The presence of particular plant species may be a more likely explanation, given the herbivorous nature of this species. However, none of the margins or control areas contained any of the previously-recorded food plants for *P. clypealis*, namely *Calamagrostis canescens, Rhynchospora* and *Eriophorum*. *C. canescens* has not been recorded in Ireland and all of these plants are characteristic of marshes, bogs and flushes (Stace 1997). The very different habitat type and associated lack of these plants in the margins, as well as the large numbers of *P. clypealis* found, would all suggest that the previously-recognized host plants cannot explain the presence of a population of this insect species at this site.

It is highly likely that *P. clypealis* has been feeding on one or more other species that have previously been unrecognized as food plants. *Calamagrostis canescens* belongs to the Poaceae while *Rhynchospora* and *Eriophorum* are both in the Cyperaceae so it would seem likely that the new host plant or plants belong to one or other of these families. No Cyperaceae were recorded but the Poaceae were abundant in all areas with *Agrostis* spp, *Holcus lanatus* and *Lolium perenne* being the most common, and with a number of other grass species present in smaller quantities (Table 2). Given the large number of *P. clypealis* found in the fenced treatment, the least botanically rich margin treatment, it is perhaps likely that the new host plant is one or more of the following species present there: *Agrostis* sp, *Alopecurus geniculatus*, *Dactylis glomerata*, *Holcus lanatus*, *Holcus mollis* and *Lolium perenne*. Many grassland Auchenorrhyncha do not have strong plant host preferences feeding on a number of grass species, and respond more strongly to plant nitrogen levels than plant species (Prestidge and McNeill 1983). Thus plant species may also not be the most important factor in explaining the presence of *P. clypealis*.

Of the other possible factors the margins have: low nutrient inputs, as unlike the grazing paddocks they are not fertilized; much reduced disturbance being cut once a year rather than the regular grazing in the control areas; and as a consequence of the reduced management, a much higher and more complex three-dimensional structure. Sheridan *et al.* (2003) found that nitrogen levels were lower in vegetation samples taken from the margin strips than in those taken from control areas. However, given that the more expected habitat for *P. clypealis* is in wet, usually acidic and peaty sites, where nitrogen levels would be expected to be even lower than the margins, nutrient levels would seem an unlikely explanation.

The lack of disturbance may play an important role in facilitating the presence of *P. clypealis*. The infrequent cutting results in a complex sward structure including the formation of a vegetation understorey. Sward structure may be important in providing a greater level of heterogeneity in refuges, feeding and oviposition sites and microclimatic conditions (Andrzejewska 1965, Waloff and Solomon 1973), some of which would be suitable for this species.

Comparison of suction and sweep net samples enabled some measure of vertical distribution of this species to be assessed. This is possible because sweep nets sample the middle and upper parts of the vegetation only, while suction sampling can collect insects from the lower parts of the vegetation as well (Stewart 2002). Only one individual was caught using a sweep net, indicating that *P. clypealis* showed a strong preference for the lower strata of the vegetation. Previous work has shown that within grassland Auchenorrhyncha communities, vertical stratification results from species having preferences for different layers (Andrzejewska 1965). As these preferences are influenced by temporally variable factors such as life-cycle stage, plant growth and micro-climate, the classification of *P. clypealis* as lower vegetation species cannot be unequivocally stated but this may help to explain why it is relatively little-known and probably under-recorded (Ossiannilsson 1978, Kirby 1992, Nickel 2003).

Evidence presented in this paper shows the existence of a substantial population of the planthopper *Paraliburnia clypealis* in experimental field margin strips within intensive dairy grassland. Its presence within this very unexpected habitat, which did not contain any of its previously reported food plants, together with records of individuals from similar habitats elsewhere, indicate that in Ireland *P. clypealis* is not restricted to the wetland habitats previously reported for this species.

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