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Author(s): M. G. Morris

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AUCHENORHYNCHA (HEMIPTERA) OF THE BURREN, WITH SPECIAL REFERENCE TO SPECIES-ASSOCIATIONS OF THE GRASSLANDS

By M. G. Morris

Monks Wood Experimental Station, Abbots Ripton, Huntingdon.

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Abstract

1. Auchenorhyncha were taken in standard samples of 2 m² from Burren grasslands, 15 samples being taken in July and 23 in August-September, 1971.

2. The species and associations of species recorded are discussed and compared with those of similar samples taken from calcareous grasslands in England.

3. The relationship between the structure of the vegetation and the numbers of species, numbers of individual leafhoppers and species-diversity of the samples is examined.

4. An attempt is made to classify the samples by the use of an index of similarity based on the numbers of each species present in the samples.

5. An annotated list is given of Auchenorhyncha collected in the Burren in 1969, 1970 and 1971. 128 species are recorded, of which 30 are new to the Irish fauna.

6. The leafhopper fauna of the Burren is briefly discussed in relation to biogeography, climate and grassland management. Assessment of this fauna is difficult because of the scarcity of information from other parts of Ireland.

Contents

Introduction

The Auchenorhyncha (leafhoppers and froghoppers) are insects which have been neglected until recently, in Great Britain as well as in Ireland. Halbert (1935) summarised what was known of the Irish fauna at the time he wrote and commented on the paucity of records of even common species from the country. Since then very little work has been done. Richards

(1961) recorded four species from a crevice in the limestone pavement of the Burren, and Lansbury (1965) found nine named species, also in the Burren, mainly round the Roughan House area. Le Quesne, in his series of handbooks for the identification of the British species of Auchenorhyncha (1960, 1965, 1969) included records of those species known to occur in Ireland. The biology of most species of Auchenorhyncha is little known, although renewed interest in the group has been shown recently by several workers.

Auchenorhyncha are a numerous and important constituent of the fauna of most grasslands. Following a study of the leafhopper faunas of grazed and ungrazed chalk grassland in Bedfordshire (Morris 1971a) an extensive survey of the Auchenorhyncha faunas of calcareous grasslands was made in 1968–1970 in England (Morris, in preparation). This survey included samples taken from Carboniferous Limestone grasslands in Derbyshire (Peak district) and Somerset (Mendip Hills). The outstanding botanical and zoological features of the Burren semi-karst of County Clare (see, for example, Webb 1962, Ivimey-Cook and Proctor 1966, Morris 1967, Bradley and Pelham-Clinton 1967) suggested that interesting comparisons might be drawn if similar samples were taken from the limestone grasslands of the Burren. In September 1969 and June 1970 expeditions had been made to the Burren and Auchenorhyncha collected from woodland, bogs, fens and other areas as well as grasslands. Thus the samples taken in 1971 could be placed in the context of at least an interim list of Auchenorhyncha of the Burren. The following account consists of two parts: a description and discussion of the associations of Auchenorhyncha found in samples taken from Burren grasslands, and an annotated list of species recorded from the Burren area as defined by Webb (1962). A number of species are recorded as Irish for the first time while doubtful records of some others are confirmed.

Sampling and Collecting Sites

Ten grassland sites were selected for sampling during the period 23rd-27th July, 1971. The sites were chosen to be good examples of the different structural types of grassland in the Burren and to give a fair geographical spread of sites within the region. One limiting factor was that all sites had to be reasonably close to a road, for ease of transport of the sampling apparatus. Although all the sites were grasslands one differed markedly from the others in being a dune grassland site (Fanore). At each site either one or two samples were taken, the second sample, if taken, being collected from a contrasting area of grassland. During the period 29th August – 6th September, 1971, the same sites and areas were sampled again. Two additional grassland sites, not worked in July, were sampled and the number of areas sampled at each site was increased in some cases. Fifteen samples were taken in July and twenty-three in August-September, although the latter total included comparative samples from plant communities dominated by *Calluna vulgaris* and by *Carex* spp. taken at two sites. A synopsis of the samples and the dates on which they were taken is given in Table 1.

TABLE 1. Synopsis of samples of Auchenorhyncha from Burren sites (limestone grassland unless otherwise stated). *S*, number of species represented in sample. *N*, number of individuals. *D*, species diversity. Ht, mean height of vegetation in cm. I.G.R., approximate Irish grid reference to sample site area.

Sites sampled twice

Site			*dates*	*S*	*N*	*D*	*Ht.*	*I.G.R.*
Poulsallagh	1		23 July	8	113	1·51	5	M 084022
			30 August	5	64	1·71	5	
	2		23 July	13	205	2·56	20	M 084022
			30 August	19	276	2·79	25	
Connell's Ford			24 July	13	198	1·80	7	R 296942
			31 August	12	126	2·70	7	
Mullagh More	1		24 July	3	3	0·86	2	R 315943
			4 September	6	12	1·80	5	
	2		24 July	2	4	0·49	5	R 315942
			4 September	5	14	1·59	5	
Corkscrew Hill	1		25 July	11	109	2·19	10	M 206029
			1 September	17	76	3·23	10	
	2		25 July	13	157	2·83	15	M 203031
			1 September	14	161	3·19	15	
Druid's Altar			25 July	14	178	2·79	25	M 260013
			5 September	15	407	2·41	25	
Gleninsheen	1		25 July	5	8	1·46	7	M 224031
			1 September	4	10	1·22	7	
nr. Boston			26 July	4	11	1·25	2	M 370012
			6 September	2	6	0·43	2	
Black Head	1		26 July	8	54	2·05	7	M 157118
			30 August	7	58	2·10	7	
	2		26 July	2	61	0·55	2	M 149117
			30 August	2	3	0·52	2	
Fanore	1	(dune)	27 July	9	138	2·44	15	M 137090
			1 September	7	75	1·83	20	
	2	(dune)	27 July	2	17	0·55	2	M 137090
			1 September	3	10	0·64	2	
Glencolumbkille	1		27 July	14	208	2·30	10	M 325012
			5 September	8	137	1·84	7	

Sites sampled once

Deerpark	1		29 August	14	126	3·07	15	R 239951
	2		29 August	10	116	2·74	35	R 239951
Poulsallagh	3		30 August	2	7	0·40	5	M 083021
Gleninsheen	2	(acid)	1 September	10	104	2·00	20	M 224032
Mullagh More	3	(marsh)	4 September	12	203	2·64	10	R 315941
Noughaval			5 September	18	113	3·06	35	R 213969
Glencolumbkille	2		5 September	16	174	3·25	30	M 336026
	3		5 September	12	56	2·74	50	M 336026

Most Auchenorhyncha are in the adult stage during the period mid-July to end of September. The single-brooded species are usually adult during this period and those which have two generations a year are also present, as adults of the second generation, which is usually the more abundant one. A few species tend to occur earlier in the year, but some of these (e.g. *Criomorphus albomarginatus*) were included in the July sampling. On chalk grassland the number of species of Auchenorhyncha present as adults increases rapidly from about June onwards, reaching a maximum in mid-August, although many species continue to occur until the end of September, or even later (Morris 1971a). In areas where sampling is limited to one or two occasions during the year July, August and September are the months in which most species should be taken. Sampling in the Burren was done, therefore, during this period. By sampling twice at each site it was hoped to include species such as *Criomorphus albomarginatus*, which tend to occur in the first part of this period, and others, such as *Stenocranus minutus* and *Aphrodes flavostriatus*, which appear towards its end. For obvious reasons, however, two samples taken from a site in the course of one year cannot fully record the fauna of the site.

Auchenorhyncha were collected from many sites in the Burren which were not sampled. The aim was to compile as full a list of species as possible in the time available and to achieve a wide geographical range of sites within the confines of the Burren as defined by Webb (1962). Sites are named by reference to the 6-inch to the mile Ordnance Survey plans. This has meant some revision of names of sites included in an earlier paper on the Burren fauna (Morris 1967). Mullagh More 'I' becomes Connell's Ford, Mullagh More being retained for Mullagh More 'II'. Murroogh is properly known as Fanore, or Fanore dunes, as in Ivimey-Cook and Proctor (1966) and Bradley and Pelham-Clinton (1967). Poulavallan 'I' is corrected to Glen of Clab and Poulavallan restricted to Poulavallan 'II' of the earlier paper. It now appears that Ballynalacken Castle lies just within the Burren instead of just outside it. Wherever possible, the names used by Ivimey-Cook and Proctor (1966) and Bradley and Pelham-Clinton (1967) have also been employed in this paper. Figure 1 includes the names of all the sites mentioned in the text.

Methods

The 'D-Vac' vacuum net, described by Dietrick (1961), was used for sampling. The apparatus consists of a two-stroke, petrol-driven engine which drives a fan, producing a partial vacuum in a short length of hose *c.* 20cm in diameter. A sampling head 1 sq ft in area is attached to the hose and a net bag fixed in the hose between the removable sampling head and the fan. Insects and loose plant material are sucked into the net when the sampling head is placed in vegetation. The net containing a sample of insects may be removed from the apparatus and examined, or stored for subsequent examination. In sampling Burren grassland sites a standard sample of 24 × 1 sq ft subsamples (or 'sucks') was collected, as described for other sites by Morris (1971a). The area of grassland sampled corresponds to 2 sq m approximately. The subsamples were taken at about 3–5m intervals on a grid pattern, partly to collect

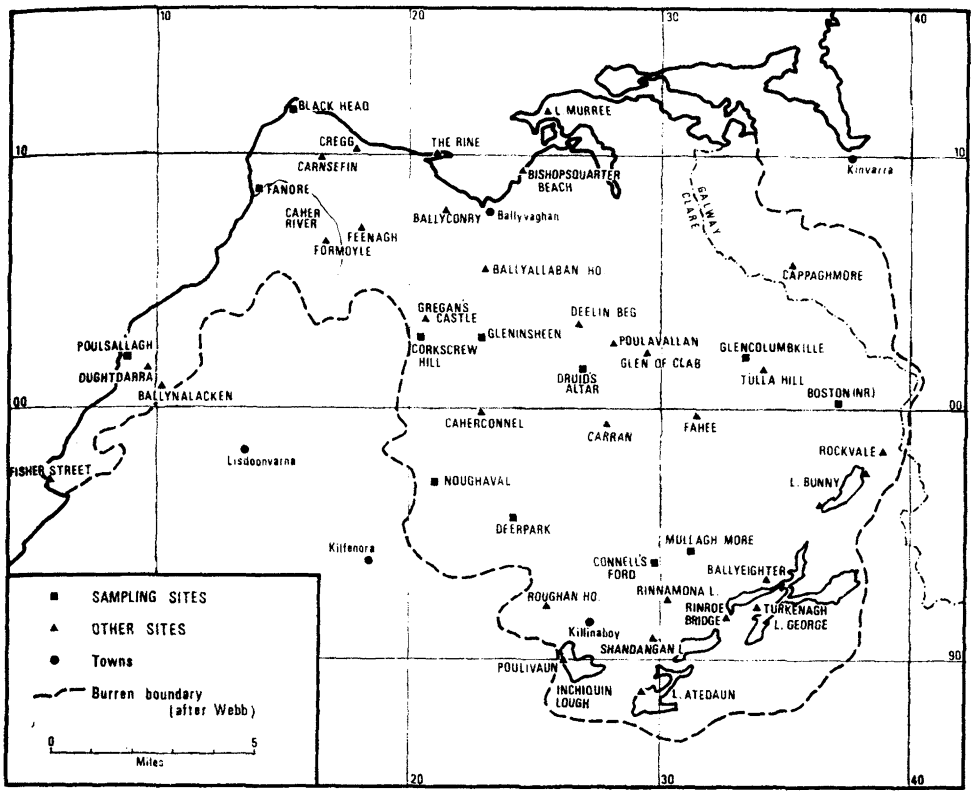

FIG. 1—Map of the Burren, showing the location of sampling and collecting sites. 10 Km lines of the Irish Grid 100 Km squares R (below the 00 line) and M (above it) are shown.

them from undisturbed grassland and partly to avoid conscious selection of sampling positions in the grassland. After collection each sample was kept in its net and placed in a polythene jar with a pad of cotton wool soaked in ethyl acetate. The dead insects were subsequently sorted and stored in 70% alcohol and all adult Auchenorhyncha identified to species and counted; no attempt was made to identify larvae to species. Vacuum net sampling has the advantage over the more frequently used technique of sweep-netting on grassland in that insects at all levels in the vegetation are collected, not merely those on the upper parts of plants. The importance of stratification in the leafhopper faunas of grasslands has been shown by Andrzejewska (1965). Several abundant species of leafhoppers are ground-living and are hardly ever taken by sweep netting. Wet vegetation can be sampled, although in the study described here two samples collected in July while rain was falling had very low counts of Auchenorhyncha.

The faunas of two or more sites may be compared using various indices of similarity and other methods, (see Southwood 1966). In the study we are describing the index of similarity devised by M. D. Mountford and

used by Morris (1969) to compare water-bug associations was employed. This index has the advantage of taking into account the numbers of individuals of the different species recorded at each site and not merely their presence or absence. The index of similarity ($\mathcal{J}$) between the Auchenorhyncha recorded at two sites, M and $\mathcal{N}$ is given by

$$\mathcal{J} = [\Sigma(m_i \times n_i)]^2 / \Sigma m_i^2 \times \Sigma n_i^2.$$

Where m_i denotes the number of specimens of any species i recorded at site M and n_i denotes the number of specimens of the same species recorded at site $\mathcal{N}$.

The indices of similarity between pairs of sites were used to construct dendrograms which give a clear visual impression of the relationship between the faunas of the sites (Mountford 1962). The sites were also compared by reference to the number of species of Auchenorhyncha recorded, the number of individuals and the diversity of the faunal samples. The last has been discussed in relation to sampling Auchenorhyncha by Morris (1971a), who used the Brillouin index (D) based on information theory and given by

$$D = \frac{1}{\mathcal{N}} \log_2 \frac{\mathcal{N}!}{\mathcal{N}_1! \, \mathcal{N}_2! \, \mathcal{N}_3! \ldots \mathcal{N}_s!}$$

Where $\mathcal{N}$ is the total number of individuals in a sample and $\mathcal{N}_1$, $\mathcal{N}_2$, $\mathcal{N}_3$ ... $\mathcal{N}_s$ the numbers of individuals belonging to species 1, 2, 3 ... s. As Pielou (1966) points out the base of the logarithms used affects only the size of the unit. Base 2 is not especially relevant to biological work, but has been frequently retained in the Brillouin formula for such work because of its use in information theory, from which the formula is derived. The same index is used in this account of Auchenorhyncha samples from Burren grasslands. At each sampling site a rough measurement was taken of the height of the vegetation by averaging four readings made directly from a ruler placed vertically in it at random. In chalk grassland sites a relationship exists between the height of the vegetation and the numbers of species, individuals and diversity of Auchenorhyncha collected in samples (Morris 1971b). The relationship between vegetation height and the Burren samples is discussed in the present paper.

In this account the names of Auchenorhyncha are those in Kloet and Hincks (1964), except where amended by Le Quesne (1969). Names of plants follow Clapham *et al.* (1962).

Species Represented in the Grassland Faunas

A total of forty-six species of Auchenorhyncha was taken during the two sampling periods, thirty-two species in July and forty-two in August/September. 1464 adult leafhoppers were collected in the fifteen samples taken in July (mean: ninety-eight individuals per sample) and 2324 in the twenty-three samples taken in August/September (mean: 101 individuals per sample) (Table 2). The maximum number of species represented in a sample was fourteen in July (mean: 8) and nineteen in August/September (mean: 10). Compared with chalk grassland samples (Morris 1971a, b) numbers of individuals and species tended to be low. Some high values of D (index of diversity)

TABLE 2. Numbers of Auchenorhyncha taken in Burren samples, with the number of site areas at which each species was taken. The species are listed in order of constancy of occurrence and then by abundance.

	July		*August/September*	
	Number of individuals	*Number of sites* (15)	*Number of individuals*	*Number of sites* (23)
Jassargus pseudocellaris	440	10	207	16
Megophthalmus scanicus	124	10	131	15
Eupteryx notata	39	7	188	14
Kelisia guttula	21	7	150	13
Aphrodes bicinctus	15	7	51	12
Philaenus spumarius	52	7	46	11
Agallia venosa	71	7	58	10
Muellerianella fairmairei	52	5	319	11
Dicranoneura citrinella	144	5	59	10
Aphrodes albifrons	24	5	35	10
Notus flavipennis	102	3	362	10
Streptanus sordidus	21	4	104	9
Paluda vitripennis	82	5	72	5
Megamelus notula	36	3	160	6
Neophilaenus lineatus	20	4	12	4
Cicadula persimilis	0	—	87	7
Arthaldeus pascuellus	10	2	21	4
Aphrodes flavostriatus	0	—	54	6
Kelisia perspicillata	10	2	15	3
Kelisia vittipennis	0	—	19	5
Euscelis incisus	10	3	4	2
Javesella pellucida	1	1	13	4
Delphacinus mesomelas	29	3	3	1
Kelisia pallidula	0	—	25	4
Macrosteles septemnotatus	17	2	7	2
Deltocephalus pulicaris	12	2	2	2
Elymana sulphurella	2	2	6	2
Criomorphus albomarginatus	8	4	0	—
Idiodonus cruentus	3	3	1	1
Psammotettix albomarginatus	14	1	14	2
Stenocranus minutus	0	—	14	3
Streptanus aemulans	0	—	8	3
Evacanthus interruptus	1	1	3	2
Turrutus socialis	44	1	31	1
Limotettix striola	1	1	14	1
Cicadella viridis	0	—	5	2
Javesella forcipata	6	2	0	—
Arocephalus punctum	52	1	0	—
Conomelus anceps	0	—	9	1
Macrosteles ossiannilssoni	0	—	6	1
Eupteryx stachydearum	0	—	3	1
Macrosteles laevis	0	—	2	1
Euconomelus lepidus	0	—	2	1
Euscelis obsoletus	0	—	1	1
Streptanus marginatus	0	—	1	1
Laodelphax elegantulus	1	1	0	—
TOTAL	1464		2324	

were recorded, however, a maximum of 3·25 for 174 individuals of sixteen species being found at Glencolumbkille (sample 2). The relationship between numbers of species, numbers of individuals and diversity is not a simple one but in samples of leafhoppers from chalk grassland in Bedfordshire Morris (1971a) noted that if large numbers of individuals were present diversity was often relatively low, even although the numbers of species were high.

The most abundant species recorded in the samples, and the one which was found at most sites was *Jassargus pseudocellaris*. This is a common and abundant insect in Great Britain but on chalk and limestone grassland in England its place appears to be taken by *Turrutus socialis*. Out of 222 samples taken on chalk and limestone grassland sites in England in 1968 and 1969 196, or 88%, contained *T. socialis* and only 12, or 5%, contained *J. pseudocellaris* (Morris, in preparation). Of these twelve samples eight were taken from Carboniferous limestone grassland sites in the Derbyshire Dales, but *J. pseudocellaris* was not recorded in samples from the Mendip Hills, Somerset, also on Carboniferous limestone. In the Burren *T. socialis* was taken in samples only from sand dunes at Fanore. Fairly large numbers were taken both in July and in September and the species also occurred at Fisherstreet and as single examples from Ballynalacken and Corkscrew Hill. What factors are responsible for the abundance of *J. pseudocellaris* on Burren limestone grasslands and the scarcity of *T. socialis* are not known, but would make a most interesting study.

Megophthalmus scanicus is a ground-living species and its abundance in Burren grasslands could not have been assessed using a sweep-net technique. In England *M. scabripennis* is about equally abundant as *M. scanicus*, neither species showing any marked habitat preferenda on chalk and limestone grasslands; however, *M. scabripennis* has not been recorded from Ireland.

Eupteryx notata is a very abundant species of calcareous grasslands in England as well as in the Burren. It feeds on species of *Thymus* and probably also on *Prunella vulgaris*. Both plants have a low-growing habit and *E. notata* tends to occur more frequently on short grasslands than on long ones.

Species of *Kelisia* are well represented in the Burren, four species being taken in the systematic samples. Probably all the species feed on various species of *Carex*. *K. guttula* was abundant in the Burren samples and is also the commonest species of English calcareous grasslands. *K. vittipennis*, another species usually abundant in Britain, was less common in the Burren, but as it occurs commonly only rather late in the year was not found in the samples taken in July. *K. perspicillata* is a generally rare, though widespread, species in Britain. Although found at several sites in the Burren it is presumably uncommon in Ireland as it has not previously been recorded from the country.

Aphrodes bicinctus and *A. albifrons* were widespread but not particularly abundant in the Burren, a pattern of occurrence which is very similar to that on calcareous grasslands in England where both species are found on a wide range of different grassland types. *A. flavostriatus* becomes adult rather later in the summer than the other two species and occurs mainly in the taller grasslands.

Philaenus spumarius is the familiar 'spittlebug' and is an extremely common and widespread, almost ubiquitous, froghopper of grasslands, herbaceous vegetation and scrub. It appears to be relatively commoner in the Burren than on English calcareous grasslands, occurring in about 47% of the samples taken in the Irish sites but only about 25% of those taken in England.

In England several *Agallia* species occur, though *A. venosa* is usually the most frequent on calcareous grasslands. *A. venosa* is evidently uncommon in Ireland, as it is not mentioned by Halbert (1935) and is cited by Le Quesne (1965) as (? Ireland). Nevertheless, it is widespread and frequent on Burren grasslands and there is a suggestion that it occurs in some situations where, in England, other species of the genus would be expected, for instance *A. consobrina* on coarse grassland and *A. laevis* on maritime grassland.

Muellerianella fairmairei is not a very constant species of calcareous grassland sites in England, occurring in less than 5% of the samples taken in 1968-70. It appears to be associated with several grasses which are not among the constants of calcareous grasslands as a whole, including *Sesleria albicans*, which is abundant on most of the Burren grasslands but very local in England, not occurring at all in the south. *M. fairmairei* was taken in samples from Magnesian Limestone at Cassop Vale, Durham, where *S. albicans* was abundant. *Dicranoneura citrinella* and *Notus flavipennis* are both associated with species of *Carex*. In England *D. citrinella* is a not uncommon constituent of Auchenorhyncha samples from calcareous grassland but *N. flavipennis* has not been recorded from such sites at all. Although the Burren sites at which *N. flavipennis* occurred include two marshy sampling areas the leafhopper is clearly characteristic of grassland types where it would not be found in Great Britain. *D. citrinella* and *N. flavipennis* were very closely associated in time and space: twelve samples contained both species as against only four which contained only one.

Streptanus sordidus is a species which tends to occur in the taller grasslands but not on short turf. The mean height of vegetation where samples with this species were taken was about 22cm, compared with an average height for all the sites of about 13cm. A species which similarly occurs mainly on the taller grasslands is *Cicadula persimilis*. Another is *Neophilaenus lineatus*, which apparently does not extend its ecological range onto short grass turf in the absence of *N. exclamationis* (not recorded from Ireland) which occupies this niche commonly on English calcareous grasslands.

Paluda vitripennis appears to be rather more common in the Burren, its only area of occurrence in the British Isles, than was thought (Le Quesne 1969). It was taken on grassland 5–10cm tall in the samples. *Megamelus notula* is associated with marshes, but like *Notus flavipennis* appears to occur more frequently on grasslands in Ireland than in England.

Psammotettix albomarginatus was recorded from the Burren by Le Quesne (1969). It is a species which, like others in the genus, occurs mainly on short swards and is absent from taller grasslands.

Most of the other species recorded in the Burren samples occurred in relatively small numbers. Many species have restricted habitats, but many

are abundant constituents of calcareous grassland faunas in England. Among the former are *Idiodonus cruentus* (heathland), *Stenocranus minutus* (coarse grasses such as *Dactylis glomerata*), *Limotettix striola* (*Carex* spp.), *Eupteryx stachydearum* (*Teucrium scorodonia*) and *Macrosteles laevis* (cut and disturbed grassland, Andrzejewska 1962). Species which were taken in small numbers in the Burren, but which are often abundant in English calcareous grasslands include *Euscelis incisus, Javesella pellucida, Deltocephalus pulicaris, Elymana sulphurella, Arocephalus punctum,* and *Laodelphax elegantulus.* The last two are perhaps the most notable; both occurred in 40% of samples taken from calcareous grassland in England. *A. punctum* is clearly rare in Ireland, where it was recorded for the first time in the course of the work being described. *L. elegantulus* is recorded from Ireland by Le Quesne (1960) but not by Halbert (1935). Both species may be associated especially with dry grasslands.

Structure of the Burren Grasslands

Although some Auchenorhyncha are specifically associated with certain species of plant, as has been made clear, leafhoppers in general, unlike some other phytophagous insects, are not markedly *mono-* or oligophagous. During the sampling and collecting programme described there was not sufficient time to record accurately the floristic composition of the vegetation at each sample site. In the limited time available some account of the range of variation of the leafhopper faunas was made but no detailed work on the factors responsible for the presence or absence of each species or their abundance could be attempted. However, grassland structure is known to be an important factor in determining the abundance of species and individuals. Andrzejewska (1965) showed the importance of stratification to the leafhopper fauna of grassland, and Whittaker (1969) and Morris (1971b) have demonstrated different aspects of the structure of grasslands in relation to leafhopper abundance and habitat. More recently Waloff and Solomon (1973) have shown the importance of vegetation 'architecture' to the Auchenorhyncha of an acid grassland.

For each sample of the Burren grassland faunas taken the approximate mean height of the vegetation was recorded. Morris (1971b) showed a good correlation between mean vegetation height and species abundance (S), abundance of individuals (N) and diversity (D) for samples of leafhoppers from chalk grassland in England. In the case of N and D better linear regression coefficients were obtained for these parameters on vegetation height than on log (vegetation height) (Table 3). For all the parameters for Burren leafhopper samples better coefficients were obtained for their regression on log (vegetation height). However, in order to compare the regression equations for the English Chalk and Burren samples, and because each coefficient was significant at the 0·01 level of probability at worst, regression equations for each parameter on vegetation height have been calculated (Fig. 2).

Comparison of the regression equations for the different parameters between the Burren and English Chalk samples is interesting. For S, the number of species represented in a sample, the two regression lines are nearly parallel

TABLE 3. Comparison of correlation coefficients (r) between three parameters of leafhopper abundance/diversity and mean vegetation height or its logarithm. The value of r marked * is significant at the 0·01 level, all the other values at the 0·001 level of probability.

		Parameter		
		N	S	D
England chalk grassland sites n = 167	vegetation height	·54	·60	·81
	log (vegetation height)	·35	·63	·50
Burren grassland sites n = 38	vegetation height	·46*	·66	·67
	log (vegetation height)	·61	·80	·84

(b = 0·30 and 0·33 respectively) although a is considerably less for the Burren samples than it is for those from the English Chalk (5·16 and 7·40 respectively). This suggests that there is almost a constant difference, on average, in the number of species present in grasslands of whatever height between Burren and Chalk sites. This is likely to be related to the fact that the Irish fauna generally is poorer than that of Great Britain. In the case of N, the number of individual leafhoppers in each sample, the two regression lines start well separated at $x = 0$ and diverge. Certainly the Burren samples of leafhoppers are on average smaller than those of the English Chalk and this may reflect differences in productivity related, for example to climatic differences. Whether the greater differences in actual numbers between samples taken from the taller grasslands suggested by the regression equations are real is more doubtful, particularly as very few samples were taken from grasslands over 25cm tall both in the Burren and on the English Chalk. Diversity (D) is a more complex parameter than either S or N and its usefulness as a biological measurement of the characteristics of faunal associations and communities has recently been questioned (e.g. Hurlbert 1971). However, provided its limitations are borne in mind, it would appear still to be of some value; no alternative parameter can as yet be regarded as being more useful. Figure 2 shows that the regression line for diversity of Burren samples on vegetation height is steeper than that for English Chalk samples (b = 0·054 and 0·037 respectively). Morris (1971a) discussed diversity of Auchenorhyncha samples from calcareous grasslands in relation to abundance of species and individuals and concluded that samples in which N and S were large often had relatively low values of D. In the case of the Burren samples it appears that diversity values are low for the shortest grassland swards because few leafhoppers were recorded there, even relative to English grasslands, but comparatively high for the taller grasslands because N is low although S is relatively high. In other words the 'equitability' (Lloyd and Ghelardi 1964) of the samples from tall grassland in the Burren is particularly high.

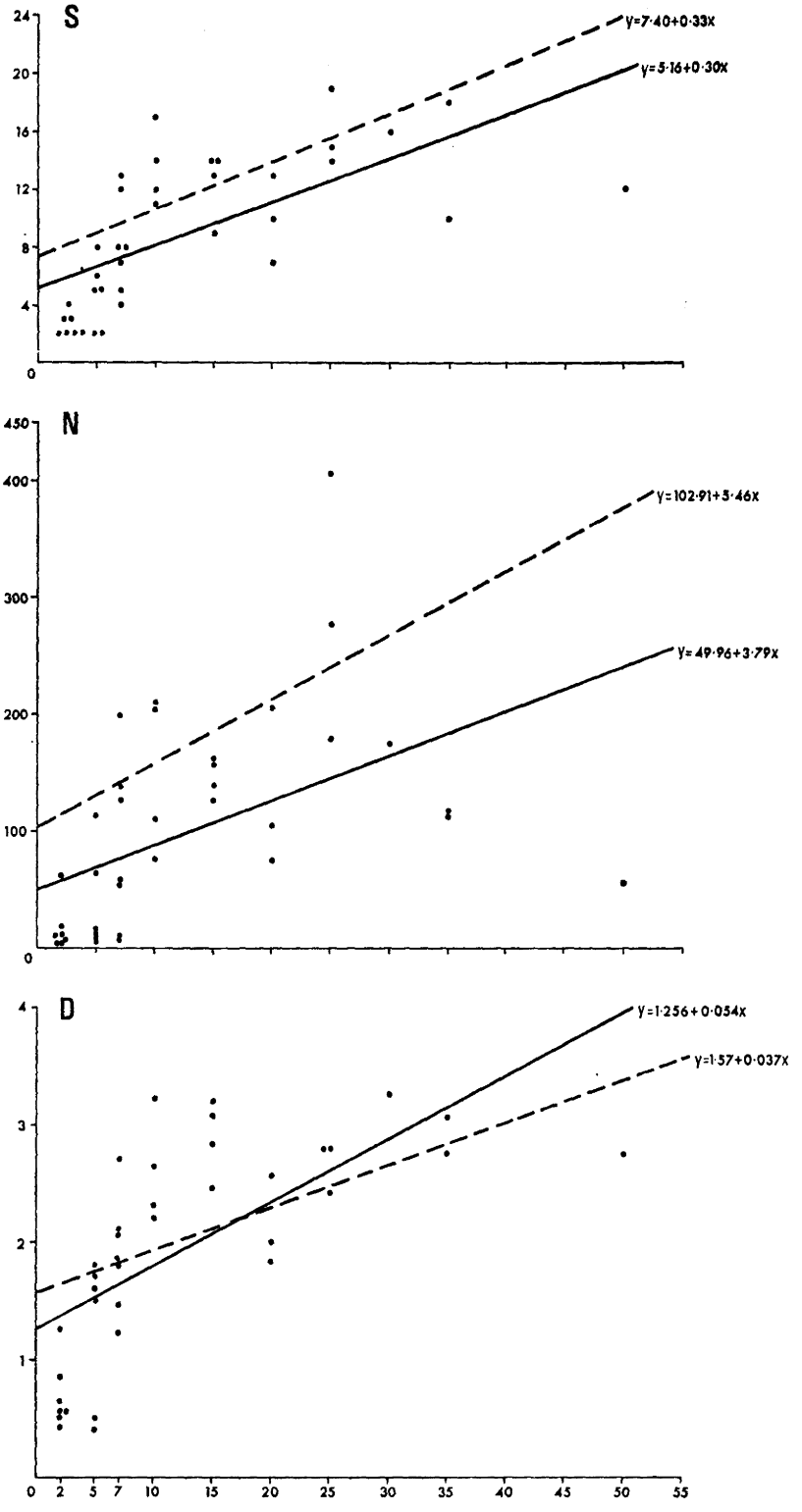

FIG. 2—Number of species (S), number of individual leafhoppers (N), and species-diversity (D) for each sample plotted against mean height of the vegetation, with linear regression equations for each parameter on mean vegetation height. The solid lines represent the regression equations for the samples, the dotted lines represent similar equations for samples from English chalk grassland (see text).

Generally speaking, most of the grassland sites sampled in the Burren were well grazed and few really tall areas were worked. Taller vegetation is probably more frequent in more inaccessible parts of the region, but, as explained earlier, these more remote areas could not easily be reached for machine sampling.

Classification of Sites

The method used to compare the samples of Auchenorhyncha from different sites was described earlier in this paper. Two dendrograms were constructed, one for the July and one for the August and September samples, which illustrate the degrees of affinity of the samples most similar to each other. These dendrograms are shown (Fig. 3 and Fig. 4 respectively). The samples do not fall into a small number of clear cut groups, suggesting, perhaps, that the Burren grasslands should be considered as one heterogeneous group from a zoological point of view. Ivimey-Cook and Proctor (1966) deal rather briefly with the grasslands in their comprehensive survey of the Burren plant communities and it has not proved possible to relate the Auchenorhyncha sample sites to their conspectus of communities.

Despite the absence of well-defined groups the dendrograms representing the similarity of the sites have some interesting features. Both diagrams show that the samples from Black Head 2 and Fanore 2 are closely related neither to each other, nor to the other samples. Poulsallagh 3, sampled only in August/September, was, however, very similar to Fanore 2. At all three sites very few species were taken and numbers were low. At Fanore 2 and Poulsallagh 3

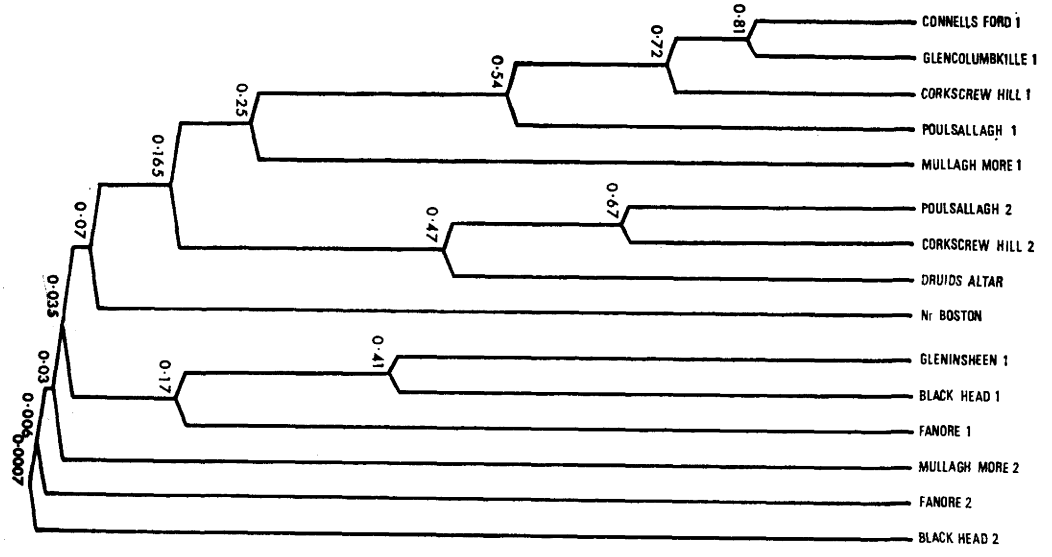

FIG. 3—Dendogram representing the affinity between the samples taken in July based on an index of similarity (see text).

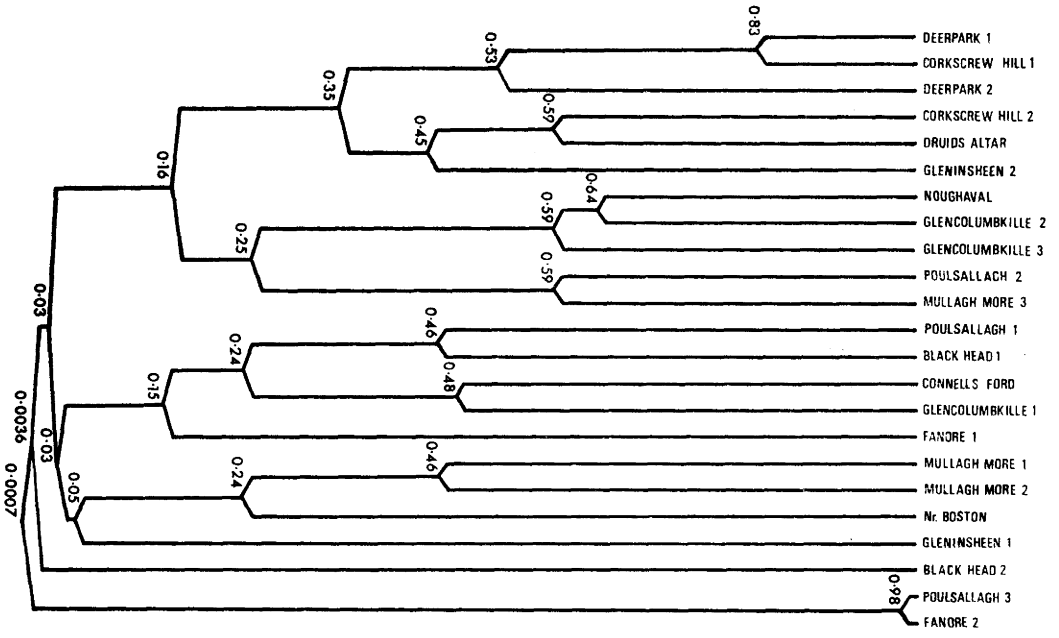

FIG. 4—Dendogram representing the affinity between the samples taken in August/September based on an index of similarity (see text).

the most abundant species was *Psammotettix albomarginatus* and the similarity of the two sites was determined by this. In July *Arocephalus punctum* was abundant at Black Head 2 but by the time of the second sampling on 30th August the species had apparently died off or gone. The July sample from Mullagh More 2 contained very few leafhoppers (single individuals of three species) and its dissimilarity with any other sample is not surprising. A feature of the bottom part of the diagram is the virtual absence of *Jassargus pseudocellaris*, the commonest leafhopper of Burren grasslands, from the samples; of the six samples Gleninsheen 1 to Black Head 2 five have no *J. pseudocellaris*, the exception being Black Head 1 with two specimens of the species in the sample. The samples on the top of the diagram, in contrast, all have *J. pseudocellaris,* although in two cases (Mullagh More 1 and nr. Boston) only one individual was taken in the samples. With the exception of these two samples the samples to the top of the diagram tend to include those with the taller vegetation while those on the bottom of the dendrogram consist mostly of the samples taken from the shorter swards. The only tall grassland on the bottom of the diagram is Fanore 1; this is the site where *Turrutus socialis* appears to replace *Jassargus pseudocellaris*.

These trends are much more clear-cut in the dendrogram representing the similarity between the samples taken in August and September. Ignoring the three samples Black Head 2, Poulsallagh 3 and Fanore 2, which have

already been considered and which may conveniently be called group III, the samples arrange themselves in two groups, Deerpark 1 to Mullagh More 3, (11 samples) and Poulsallagh 1 to Gleninsheen 1 (9 samples), which may be designated for convenience group I and group II respectively. With the exception of Fanore 1 (where *Turrutus socialis* occurs instead of *Jassargus pseudocellaris*) group II (together with group III) contains all the samples from grassland 7cm or less in height. Without exception group I contains all the samples from grassland 10cm or more in height. This suggests independently the importance of vegetation structure in influencing and determining in a large measure the composition of leafhopper associations in grassland. As in the July dendrogram the samples taken in August and September arrange themselves so that the samples without *Jassargus pseudocellaris* fall at the bottom of the diagram. Of the eight samples Fanore 1 to Fanore 2 (part of group II and group III) only Mullagh More 1 contained *J. pseudocellaris*—one specimen only. This leafhopper was present in all the remaining samples. Some other species show similar trends; all the eleven samples in group I contain *Muellerianella fairmairei* except Mullagh More 3. Of the twelve samples in groups II and III only two samples (Connell's Ford and nr. Boston) contain the species.

As species diversity of the samples is strongly correlated with vegetation height it is not surprising that the mean diversity values for the three groups of samples in the August and September dendrogram are markedly different. The mean values of D, with the standard deviations of the mean, are: Group I $2{\cdot}83 \pm 0{\cdot}12$, Group II $1{\cdot}69 \pm 0{\cdot}21$, and Group III $0{\cdot}52 \pm 0{\cdot}07$. Corresponding figures for the July dendrogram are hardly meaningful, but here too the higher values are found at the top of the diagram.

It is interesting that neither of the two 'comparative samples' taken from the grazed *Carex* fen (Mullagh More 3) and *Calluna*-dominated vegetation (Gleninsheen 2) differs markedly from other samples taken from limestone grassland. Probably the collection of single samples is insufficient to demonstrate clear and constant differences between the leafhopper associations of these areas and the limestone faunas. In this context it should be noted that the sand-dune samples (Fanore 1 and 2) are not clearly differentiated from other samples in the diagrams although the samples may be largely distinguished by reference to the presence or absence of certain leafhopper species.

Discussion

A number of interesting points is raised by the preliminary sampling o Burren grasslands described in this paper. These grasslands in many ways have similar associations of leafhoppers to calcareous grasslands in England. Not enough work has been done, however, to establish how different calcareous grassland faunas are from those of other types of grassland. From what has been shown in this and other papers about the importance of vegetation structure to the numbers of species and individuals of Auchenorhyncha represented it may be the case that structural characteristics of grasslands are more important

than soil type and base status in determining the nature of the leafhopper fauna. On the other hand, the floristic differences between calcareous and acidiphilous grasslands are considerable and undoubtedly are extremely important in determining the potential fauna, which may, however, only be realised to the full if structural diversity is also present. On a structurally very diverse acid grassland Waloff and Solomon (1973) showed that a very high number of species of Auchenorhyncha was present. It is difficult, however, to apportion the relative importance of structural and floristic characteristics in grasslands of any type without further information, not only about the associations of Auchenorhyncha themselves, but about the biology and population dynamics of the individual species.

The presence of particular species in the faunal associations of the Burren grasslands raises a number of speculations. On the one hand, biogeographical factors can be seen to be influencing the fauna. Because the Auchenorhyncha fauna of Ireland is relatively poorly known it is probably too early to be definite about the absence of some species which have not been recorded from Ireland but which are constituents of calcareous grassland faunas in Great Britain. However, several species which have not yet been recorded from Ireland not only occasionally occur but are often very abundant in and characteristic of English calcareous grasslands. Among these species may be cited *Neophilaenus exclamationis*, *Megophthalmus scabripennis*, *Batracomorphus irroratus*, *Agallia* spp. (except *venosa*) *Doratura stylata*, *Recilia coronifera*, *Adarrus multinotatus*, *Rhytistylus proceps*, *Paluda adumbrata* (perhaps to some extent replaced by *P. vitripennis*), *Mocydiopsis attenuata*, *Dikraneura variata*, *Zygina scutellaris* and *Muirodelphax exiguus*. It is presumably the absence of species such as these from Ireland which depresses the regression line of '*S*' on vegetation height of the Burren samples compared with that of samples from the English chalk. The list of species given is not, of course, complete but gives a number of the more outstanding examples. In passing, it may be noted that the fauna of the English chalk is probably impoverished compared to that of continental Europe.

No detailed analysis of the factors influencing the Auchenorhyncha of the Burren grassland has been made. One obvious non-biogeographical difference between the Burren and calcareous grasslands in Great Britain is climate. Some data on the climate of the Burren is given by Ivimey-Cook and Proctor (1966). Although the Burren enjoys a highly oceanic climate it differs little in this respect from other western districts of the British Isles. However, most of the samples from English calcareous grasslands were taken from the east or centre of the country where, for instance, mean annual rainfall at no site exceeded 35in (890mm), being less than 25in (635mm) for many sites. Corresponding figures for Burren stations vary from about 65in (1650mm) to 46in (1150mm). Species of dry grasslands in England may well be unable to exist on the wetter grasslands of the Burren. Conversely, species unable to inhabit dry grassland in Great Britain may occur on the wetter Burren grasslands. It is interesting to speculate whether *Notus flavipennis* might not be such a species. As noted previously, it was not recorded on any English calcareous grassland site but was

abundant in several Burren samples. As it probably feeds on species of *Carex* it is unlikely to be restricted by its foodplants to marshes and wet areas, since many *Carex*-feeders are found on dry grasslands, for example *Kelisia guttula*.

One practical consideration raised by work on the faunas of calcareous grasslands in England has been the management of areas set aside specifically for the conservation of wildlife, including insects and other invertebrates (Morris 1971b). This consideration is of little importance at the present time in the Burren as human population, pollution and the disappearance of habitat are all at a very low level. Nevertheless, the Burren is such an important area for wildlife that some consideration should be given to the management of its grasslands from the point of view of nature conservation, in case this should become necessary at some later date through changing circumstances. Management of the Burren grasslands is by grazing, chiefly by cattle. Grazing is generally preferred by conservationists as a method of grassland management, though there is some evidence that there are advantages in grazing by sheep rather than by cattle. In order to have a rich fauna of insects and other invertebrates it is important that grazing should be neither too close nor too continuous. These points have been made by Morris (1969b, 1971b) and may also be inferred from the data given in this paper. Other things being equal, tall grassland is much richer in animal life than short grassland, this being true of most groups as well as Auchenorhyncha.

The Burren is well-known as a unique area in the British Isles. Although some species of animals and plants which occur in the Burren have been found nowhere else in Ireland or Great Britain, most naturalists stress that it is the presence of assemblages, rather than individual species, which give the Burren its unique character. This is true of the flora (Webb 1962), the Lepidoptera (Bradley and Pelham-Clinton 1967) and some of the Coleoptera, especially the Curculionoidea (Morris 1967, 1971c). Unfortunately it is hardly possible to consider the Auchenorhyncha in this context since so little work has been done over the rest of Ireland. Although thirty species have been recorded as new to the Irish fauna in the course of work in the Burren, and are listed below, it is unknown whether they occur only in the Burren. In the case of one species, *Paraliburnia clypealis*, it is believed that it has been taken elsewhere in Ireland. Although the Burren Auchenorhyncha include some rare and interesting species none was found which does not occur elsewhere in Great Britain. The only species which, so far as is known, does not occur in Great Britain is *Paluda vitripennis*. Further work on the leafhoppers of Ireland is necessary before the Burren fauna can be assessed.

Annotated List of Burren Auchenorhyncha

In the following list species new to the Irish Fauna are indicated by **an** asterisk*****. All the records are the author's except those indicated by **L** (Lansbury 1965), P-C (Mr. E. C. Pelham-Clinton, unpublished) **and R** (Richards 1961).

CERCOPIDAE

Aphrophora alni (Fall.) Widespread, though not usually abundant, on a wide variety of trees. Recorded from *Betula, Corylus, Crataegus, Fraxinus, Populus tremula* and *Salix* spp. Ballyeighter, Ballynalacken, Corkscrew Hill, Cregg, Deelin Beg, Glen of Clab, Poulavallan, Rinnamona Lough (P-C) and Tulla Hill.

Philaenus spumarius (L.) Abundant everywhere, on trees and herbaceous vegetation in woods, grasslands and fens. Ballyconry, Ballyeighter, Ballynalacken, Black Head, nr. Caherconnell, Cappaghmore, nr. Carran, Connell's Ford, Corkscrew Hill, Cregg, Deelin Beg, Druid's Altar, Fahee, Fanore dunes, Fisherstreet, Glen of Clab, Glencolumbkille, Gleninsheen, Gregan's Castle, nr. Loughs Atedaun, Bunny, George and Shandangan, Mullagh More, Noughaval, nr. Oughtdarra, Poulavallan, Poulivaun, Poulsallagh, Rinnamona Lough (P-C), Rinroe Bridge, Tulla Hill, Turkenagh.

Neophilaenus lineatus (L.) Common and widespread, usually among grasses, *Carex* spp. and herbaceous vegetation on grasslands, fens and sand-dunes. Ballyconry, Bishopsquarter, Fisherstreet, Glencolumbkille, Gleninsheen, Loughs Bunny and George, Mullagh More, Poulivaun, Poulsallagh, Rinroe Bridge, Turkenagh.

CICADELLIDAE

Ulopa reticulata (F.) Associated with *Calluna vulgaris*. Only found at Rinroe bridge, June 1970 and July 1971.

Megophthalmus scanicus (Fall.) Very widespread and often quite numerous. It is a ground-living species and occurred mainly in vacuum net samples, but also by searching at the roots of plants. Black Head, Caher River (P-C), Connell's Ford, Corkscrew Hill, Cregg, Deerpark, Druid's Altar, Fanore dunes, Glencolumbkille, Gleninsheen, Noughaval, Poulsallagh.

Cicadella viridis (L.) In fens and marshes, often in association with species of *Carex*, although the foodplants are usually grasses; not uncommon. Mr. E. C. Pelham-Clinton (*in litt.*) states that Burren specimens are brighter green than ones from Scotland. Caher River, Connell's Ford, Druid's Altar, Glen of Clab, Mullagh More (P-C), Poulivaun, Rinroe Bridge.

Evacanthus interruptus (L.) Usually singly or in small numbers among tall herbaceous vegetation and in tall grassland. Cappaghmore, Connell's Ford, Cregg, Druid's Altar, Fahee, Glen of Clab, Noughaval, Poulivaun, Poulsallagh, Rinnamona Lough (P-C), Roughan House (L).

Idiocerus confusus Flor. On *Salix aurita, S. capraea* and *S. cinerea*. Deelin Beg, Glen of Clab, North end of Lough Bunny.

* *I. laminatus* Flor. On *Populus tremula*. Deelin Beg, South end of Lough Bunny, Poulavallan.

I. lituratus (Fall.) On *Salix cinerea*. North end of Lough Bunny, a single female, 27/9/69.

* *I. tremulae* (Estlund) On *Populus tremula*. Deelin Beg, South end of Lough Bunny.

Jassus lanio (L.) On *Quercus robur*. Ballyeighter. One male and one larva only, 22/7/71.

Oncopsis alni (Schrank) On *Alnus glutinosa*. Ballynalacken, not uncommon. Some of the females taken were rather atypical.

* *O. carpini* (Sahlberg) subsp. *avellanae* Edwards. On *Corylus avellana*. Corkscrew Hill, Poulavallan.

O. flavicollis (L.) On *Betula* spp. Tulla Hill birchwood, common. Rinnamona Lough (P-C).

O. tristis (Zett.) Also on *Betula* spp. A few females on *B. pubescens* near Boston, 6/9/71.

Macropsis fuscula (Zett.) On *Rubus fruticosus* agg. Not common in the Burren, single females from Cappaghmore, Connell's Ford and Poulsallagh.

M. impura (Boh.) Associated with *Salix repens*. Three examples swept from this plant at Rinroe Bridge, 22/7/71.

Agallia venosa (Fall.) Mainly on grasslands, where it is widespread and often common. Ballyconry, Black Head, near Boston, Connell's Ford, Corkscrew Hill, Deerpark, Fanore dunes, Glencolumbkille, Mullagh More, Poulsallagh.

Eupelix cuspidata (F.) Usually on dry grasslands. A single larva (fortunately distinctive in this species) on Fanore dunes, 24/9/69.

Aphrodes albifrons (L.) Very widespread, but not abundant, at ground level on grasslands and in other situations. Ballyallaban House, Black Head, Caher River (P-C), Carran, Connell's Ford, Druid's Altar, Fanore dunes, Feenagh (at 800 ft.) Formoyle (R), Glencolumbkille, Gleninsheen, Mullagh More, Noughaval, Poulsallagh. Very dark forms were taken on peat at Rinroe Bridge and from very sparsely vegetated pavement near Boston.

A. bicinctus (Schrank) In the same sorts of situations as *A. albifrons*, but occurring rather more widely, being more often taken in fens and woods. It also occurs in relatively small numbers. Ballyeighter, Black Head, near Boston, Caherconnell, Caher River (P-C), Carran, Corkscrew Hill, Cregg, Deerpark, Druid's Altar, Fahee, Fanore dunes, Formoyle (R), Glencolumbkille, Gleninsheen, L. Inchiquin, Mullagh More, Noughaval, Poulavallan, Poulivaun, Poulsallagh, Rinroe Bridge, Roughan House (L), Tulla Hill birchwood, Turkenagh fen.

A. flavostriatus (Donovan) At ground level on very tall grasslands and on grasses in woods etc. Much more local than *A. albifrons* and *A. bicinctus* but apparently more numerous when found. Ballyeighter, Corkscrew Hill, Deerpark, Fahee, Glencolumbkille, Poulsallagh.

Strogglocephalus agrestis (Fall.) At the bases of *Carex* tussocks in wet fens. Mullagh More, Rinnamona Lough, South end of L. Bunny.

Deltocephalus maculiceps Boh. On acid grassland in bogs. Recorded in the Burren only from Rinroe Bridge, but on several occasions.

D. pulicaris (Fall.) On grasslands; rather local and not very abundant. Black Head, Deerpark, Fisherstreet, Glencolumbkille, Poulavallan, Poulsallagh, Roughan House (L), Turkenagh (limestone grassland, not fen).

**Palus panzeri* (Flor) On bog and moorland vegetation. Only recorded in the Burren from Rinroe Bridge, but on two occasions.

* *Arocephalus punctum* (Flor) On dry grasslands in Great Britain. Recorded in some numbers from sample site 2 at Black Head and from the side of a sheltered track at Ballyconry.

Turrutus socialis (Flor) The most abundant and constant species of Auchenorhyncha of limestone grassland in Great Britain but in the Burren taken in numbers only on dunes; Fanore (on several occasions) and Fisherstreet. Single females from Ballynalacken and Corkscrew Hill.

Jassargus pseudocellaris (Flor) Very abundant and widespread on grasslands of all the dryer types. Ballyconry, Ballyeighter, near Ballyvaughan, Black Head, near Boston, Caher River (P-C), Cappaghmore, Carran, Connell's Ford, Corkscrew Hill, Deerpark, Druid's Altar, Fahee, Glencolumbkille, Gleninsheen, Glen of Clab, L. Bunny, Mullagh More, Noughaval, Poulsallagh, Rinroe Bridge, Rinnamona Lough (P-C), Rockvale, Tulla Hill birchwood, Turkenagh.

Mocuellus metrius (Flor) In marshes. A single female in a marsh near Carran, 27/7/71.

Arthaldeus pascuellus (Fall.) Among grasses, usually in the lusher grasslands. Local and not very abundant in the Burren. Carran, Corkscrew Hill, Deerpark, Druid's Altar, Glencolumbkille, Noughaval, Turkenagh.

Psammotettix nodosus (Ribaut) On short, arenaceous grasslands. Fanore dunes, three examples only.

P. albomarginatus (Wagner) On short turf near the sea. Fanore dunes and Poulsallagh, on several occasions at both places.

P. confinis (Dahlbom) In numbers on short, grazed turf on stable dunes at the Rine, but not found elsewhere in the Burren.

P. putoni (Then) On saltmarshes. Taken on several occasions on an intensively grazed '*Armeria* lawn' saltmarsh at The Rine

P. sabulicola (Curt.) On sand dunes, usually the younger, more open dunes near the sea. Bishopsquarter Beach, Fanore, Fisherstreet.

Allygus mixtus (F.) The larvae often on grasses, but the adults on trees (Le Quesne 1969). Found only at Deelin Beg in the Burren, by sweeping suckers of *Populus tremula*, 25/7/71.

Limotettix striola (Fall.) Widespread and often common in *Carex* marshes. Near Carran, Connell's Ford, Druid's Altar, Loughs Atedaun and Bunny, Mullagh More, Rinnamona Lough, Rinroe Bridge.

Euscelis lineolatus Brulle Recorded from Rinnamona Lough, 20/5/61 (P-C), det. A. R. Waterston.

E. incisus (Kirschb.) Very widely distributed, but seldom abundant, mainly on grasslands of all types. Ballyconry, Ballyeighter, nr. Ballyvaughan, Bishopsquarter Beach, Caher River (P-C), Connell's Ford, Glencolumbkille, Glen of Clab, Lough Bunny, Poulavallan, Poulsallagh, The Rine, Rinnamona Lough, Rinroe Bridge, Rockvale, Roughan House (L), Turkenagh.

E. obsoletus (Kirschb.) Local and not common in the Burren, occurring mainly on fen and bog vegetation. Gleninsheen, Lough Bunny, Rinroe Bridge.

Streptanus aemulans (Kirschb.) Rather local and not common, mainly in grasslands. Deerpark, Lough Murree, Noughaval, Poulsallagh, Poulavallan, The Rine.

* *S. marginatus* (Kirschb.) Taken in only two localities: Noughaval, in a vacuum net sample from grassland and Bishopsquarter beach, on a grazed *Festuca rubra* dune meadow.

S. sordidus (Zett.) Common and widespread in the taller grasslands. Corkscrew Hill, Deerpark, Druid's Altar, Fahee, Glencolumbkille, Mullagh More, Noughaval, Poulsallagh.

Macustus grisescens (Zett.) A few specimens only were taken from grassland and *Carex* marsh sites. Connell's Ford, Lough Bunny, Rinroe Bridge, Tulla Hill birchwood.

Paluda vitripennis (Flor) subsp. *hibernica* Le Quesne This interesting species is not known to occur in Great Britain but has been recorded (as other subspecies) from Europe, Siberia and N. Africa (Le Quesne 1969). It was first recorded from the Burren by Richards (1961) (as *Rhopalopyx monticola* Ribaut). Though described as very local by Le Quesne (1969) it proves to be widespread and often abundant in the Burren, occurring mainly on grasslands and in dune meadows. Bishopsquarter Beach, Black Head, nr. Carran, Connell's Ford, Corkscrew Hill, Fanore dunes, Glencolumbkille, Mullagh [? Mullagh More] (R), Mullagh More, Rinroe Bridge.

Mocydia crocea (H.-S.) Common and often abundant on coarse grassland in Great Britain, this species was found at only one site in the Burren, Ballyeighter, four examples swept from tall herbs and coarse grasses at a roadside.

Thamnotettix confinis (Zett.) Glencolumbkille, one female (P-C), det. A. R. Waterston.

Speudotettix subfusculus (Fall.) A woodland species, apparently uncommon in the Burren. Poulavallan, Tulla Hill birchwood; swept from woodland field layer vegetation in both places.

Idiodonus cruentus (Panz.) On acid grassland and heath/bog, widely distributed but never abundant. Black Head, nr. Boston, Caher River (P-C), Connell's Ford, Deerpark, Glencolumbkille, Gleninsheen, Mullagh More, Rinnamona Lough (P-C), Rinroe Bridge.

Lamprotettix octopunctatus (Schrank) A single male example only, swept from *Corylus avellana* at Mullagh More, 4/9/71.

* *Cicadula aurantipes* (Edwards) One male only, in a vacuum collection made at Poulsallagh on 22/9/67.

C. frontalis (H.-S.) Mainly on *Carex* marshes. Single females at Connell's Ford, Feenagh, Lough Atedaun and L. George.

C. intermedia (Boh.) Also in *Carex* marshes. Two females swept at Lough Inchiquin (near Poulivaun), 31/8/71.

* *C. persimilis* (Edwards) Fairly widely distributed and in some numbers in the tallest grasslands. Ballyeighter, Corkscrew Hill, Deerpark, Fahee, Glencolumbkille, Noughaval, Poulsallagh.

C. quadrinotata (F.) Recorded only from Rinroe Bridge and Turkenagh, by sweeping.

Elymana sulphurella (Zett.) Rather local and not abundant, usually in tall grassland. Ballyeighter, Connell's Ford, Fanore dunes, Lough Bunny.

Macrosteles horvathi Wagner Uncommon, on *Carex* marshes and also in a saltmarsh at the Rine. Mullagh More, Rinnamona Lough.

* *M. laevis* Ribaut Usually associated with short, 'disturbed' grasslands (Andrzejewska 1962). Not common, Glen of Clab, Lough Atedaun, Mullagh More, Poulavallan, Poulivaun.

* *M. ossiannilssoni* Lindberg Uncommon, recorded only from the *Carex* marsh at Mullagh More, in September, 1969 and 1971.

M. septemnotatus (Fall.) Associated with *Filipendula ulmaria*, probably occurring wherever the plant grows in abundance. Near Carran, Corkscrew Hill, Druid's Altar, Turkenagh.

Alebra albostriella (Fall.) On *Quercus*. Recorded only from oak woodland at Ballyeighter on 22/7/71, but in good numbers.

Notus flavipennis (Zett.) Widespread and often very abundant in fens, marshes and wet grasslands, probably in association with species of *Carex*. Near Carran, Connell's Ford, Corkscrew Hill, Druid's Altar, Feenagh, Glen of Clab, Glencolumbkille, Lough Atedaun, L. Bunny, L. George, Mullagh More, Noughaval, Poulivaun, Poulsallagh, Rinnamona Lough, Rinroe Bridge, Turkenagh.

Dicranoneura citrinella (Zett.) Widespread and abundant in the taller and damper grasslands. Near Carran, Connell's Ford, Corkscrew Hill, Cregg, Druid's Altar, Glencolumbkille, Gleninsheen, Mullagh More, Noughaval, Poulsallagh, Rinnamona Lough, Rinroe Bridge.

* ***Kybos smaragdula*** (Fall.) A single male and probable larvae on *Alnus glutinosa* at Ballynalacken on 23/7/1971.

Several female *Kybos* were taken on or near *Betula pubescens* at Ballyeighter, near Boston, Glen of Clab and Tulla Hill. The females of *K. betulicola* (Wagner) cannot be distinguished morphologically from those of *K. smaragdula*. Although it is likely that the birch *Kybos* in the Burren is *K. betulicola* Mr. G. E. Woodroffe informs me (personal communication) that *K. smaragdula* not infrequently occurs on *Betula* in Scotland, as well as on the more usual *Alnus*. The occurrence of *K. betulicola* in the Burren, therefore, can only be confirmed or not by the future capture of male *Kybos* on *Betula*.

* ***K. strigilifer*** (Ossiannilsson) A single male with rather anomalous genitalia was beaten from *Salix aurita* or *S. capraea* at Glen of Clab, 24/7/1971.

Empoasca decipiens Paoli On a variety of trees and shrubs. A pair was swept from a hedgerow at Cregg, 23/7/1971.

E. flavescens (F.) On a wide variety of herbaceous and woody plants. Mostly taken on hedges in the Burren. Ballyconry, Cregg, Mullagh More, Poulivaun, near Poulsallagh ('Fishing track').

Eupteryx aurata (L.) On *Urtica dioica*. Not very common. Corkscrew Hill, Cregg, Poulavallan, Roughan House (L).

* ***E. cyclops*** Mats. The rarest of the three nettle *Eupteryx* in the Burren. A single male at Poulavallan 23/9/1969.

* ***E. filicum*** (Newman) Uncommon but perhaps overlooked, on ferns such as *Dryopteris filix-mas*. Cregg, Poulavallan, Poulivaun, near Poulsallagh ('Fishing track').

E. notata Curt. Widespread and abundant, mainly on short grasslands and in association with *Thymus drucei*. Black Head, Connell's Ford, Corkscrew Hill, Deerpark, Fanore dunes, Feenagh, Glencolumbkille, Gleninsheen, Mullagh More, Noughaval, Poulsallagh, Turkenagh.

E. signatipennis (Boh.) On *Filipendula ulmaria*. Near Carran, Connell's Ford, Lough Inchiquin (near Poulivaun).

E. stachydearum (Hardy) Mainly on *Teucrium scorodonia* but more local than the host-plant. Ballyeighter, Connell's Ford, Formoyle (R), Gleninsheen, Mullagh More, Poulsallagh.

E. urticae (F.) The most widespread and abundant of the three nettle *Eupteryx*. Corkscrew Hill, Cregg, Lough Atedaun, Poulavallan, Poulivaun, Rinroe Bridge, Roughan House (L).

E. vittata (L.) Probably mostly on *Mentha* spp. and other labiates. Uncommon, single specimens only. Ballyeighter, Lough Atedaun, L. Inchiquin (near Poulivaun).

Linnavuoriana sexpunctata (Fall.) On *Salix aurita, S. cinerea* and *S. viminalis*, probably also other *Salix* spp. Ballynalacken, Corkscrew Hill, Deelin Beg, Glen of Clab, Lough Bunny.

* ***Youngiada pandellei*** (Leth.) Mainly on *Quercus*. Adults and larvae (reared) on *Q. robur* at Ballyeighter, 4/9/1971.

* ***Fagocyba carri*** Edwards On *Quercus*. A single male beaten from *Q. robur* at Ballyeighter, 4/9/1971.

* ***F. cruenta*** (H.-S.) On various trees, including species of *Salix, Fraxinus, Ulmus, Corylus* and *Crataegus* in the Burren. Ballynalacken, Gregan's Castle, Poulavallan.

Typhlocyba quercus (F.) On various trees, mainly *Quercus* and *Prunus* spp. A single male beaten from *Crataegus* at Poulavallan, 29/8/1971.

* ***T. avellanae*** Edwards On *Corylus avellana*. The forms *bidentata* Edwards and *staminata* Ribaut were formerly regarded as species. Type form: Corkscrew Hill, Glen of Clab, Mullagh More, Poulavallan. F. *bidentata*: Corkscrew Hill, Mullagh More, Poulavallan. F. *staminata*: Corkscrew Hill.

* ***T. crataegi*** Douglas Mainly on *Crataegus*. Several males at Poulavallan, 29/8/1971.

* ***T. frustrator*** Edwards On various trees, apparently only on *Corylus* in the Burren. Near Ballyallaban House, Ballyeighter, Corkscrew Hill, Mullagh More.

T. rosae (L.) On various trees. A single male beaten from a solitary apple tree (*Malus* sp.) at Ballyconry, 1/9/1971.

* ***Ribautiana debilis*** (Douglas) On a wide variety of trees and shrubs, mainly in hedgerows in the Burren. Bishopsquarter Beach, Cregg, Poulivaun, near Poulsallagh ('Fishing track').

R. tenerrima (H.-S.) On many trees and shrubs, often in hedgerows in the Burren. Ballyeighter, Cregg, Deelin Beg, Mullagh More, Poulivaun, Poulsallagh, near Poulsallagh ('Fishing track'), Rinroe Bridge.

R. ulmi (L.) On *Ulmus, U. glabra* in the Burren. Ballyeighter, Ballynalacken, Gregan's Castle, Poulivaun.

Alnetoidea alneti (Dahlbom) *sensu stricto* On *Alnus* and *Ulmus*. Ballynalacken, Gregan's Castle, near Poulsallagh ('Fishing track').

A. alneti subsp. *coryli* (Tollin) On *Corylus avellana*. Corkscrew Hill, Glen of Clab, Glencolumbkille, Mullagh More, Poulavallan.

Erythroneura flammigera (Geoff.) On a variety of trees and shrubs. Ballyconry, Ballyeighter, Cregg, Mullagh More, Poulavallan.

* *E. tiliae* (Geoff.) On a variety of trees and shrubs. A single male beaten from *Rubus fruticosus* agg. in a hedge at Poulsallagh, 22/9/1969,

CIXIIDAE

Cixius pilosus (Oliv.) Widespread, but not numerous, on a variety of trees. Ballyeighter, near Carran, Corkscrew Hill, Glen of Clab, Lough Bunny, Poulavallan, Poulsallagh, Tulla Hill birchwood.

C. nervosus (L.) Widespread, but in small numbers, on various trees. Ballyeighter, Ballynalacken, Cregg, Glen of Clab, Glencolumbkille, Mullagh More, Poulavallan, near Poulsallagh ('Fishing track').

C. distinguendus Kirschb. On trees. Two females only, Ballyeighter, 22/7/1971.

C. cunicularius (L.) Mainly on herbaceous vegetation, Doughbraneen (P-C), 'Little Corkscrew Hill' (P-C), Mullagh More, Tulla Hill birchwood.

C. simplex H.-S. Near Killinaboy, a female on *Potentilla fruticosa*, September 1960 (L).

DELPHACIDAE

Kelisia guttula (Germ.) Widely distributed and often abundant on grasslands and in fens, associated with *Carex* spp. Ballyconry, Caher River (P-C), near Carran, Connell's Ford, Corkscrew Hill, Deerpark, Druid's Altar, Fanore dunes, Glen of Clab, Glencolumbkille, Gleninsheen, Mullagh More, Poulsallagh, Rinnamona Lough, Rinroe Bridge, Rockvale, Tulla Hill birchwood, Turkenagh.

K. punctulum (Kirschb.) A single female taken in a *Carex* marsh at the side of a turlough at Mullagh More, 2/9/1971, is probably this species but has some of the characters of *K. pallidula* (Boh.).

* *K. guttulifera* (Kirschb.) Seven males and seven females were collected from a small marshy area near sample site 2 at Black Head, 30/8/1971.

* *K. pallidula* (Boh.) Not common in Great Britain, but widespread and quite numerous in the Burren in marshy places and loughsides with *Carex* spp. Ballyeighter, near Carran, Connell's Ford, Glencolumbkille, Gleninsheen, Mullagh More, Rinnamona Lough, Rinroe Bridge.

K. pannonica Mats. On sand-dunes, almost certainly on *Carex arenaria*. Fanore dunes on two occasions, but not occurring in vacuum net samples.

K. vittipennis (Sahlb.) Widespread but only occasionally numerous, mainly on grasslands but also in marshes, etc. Black Head, near Carran, Connell's Ford, Corkscrew Hill, Glencolumbkille, Mullagh More, Rinroe Bridge, Tulla Hill birchwood, Turkenagh.

* *K. perspicillata* (Boh.) Local, on grasslands only. Connell's Ford, Glencolumbkille, Poulsallagh.

* *Stenocranus fuscovittatus* (Fairm.) Probably on *Carex* sp. Taken on two occasions in small numbers on heathland at Rinroe Bridge.

S. minutus (F.) Mainly on tall and coarse grasses, sometimes abundant. Ballyeighter, Connell's Ford, Glencolumbkille, Poulsallagh, Roughan House (L), Tulla Hill birchwood.

Delphacinus mesomelas (Boh.) On dry grasslands, particularly on sand dune areas in the Burren. Bishopsquarter Beach, Connell's Ford, Fanore dunes, Glencolumbkille, Poulsallagh.

Euconomelus lepidus (Boh.) On species of *Juncus* (Le Quesne 1960). Mullagh More, Rinroe Bridge.

Conomelus anceps (Germ.) Also on *Juncus*; not common in the Burren. Druid's Altar, Glen of Clab, Lough Bunny, L. Inchiquin (near Poulivaun).

Ditropis pteridis (Spinola) On *Pteridium aquilinum*. Possibly commoner than the two records suggest, as it appears early in the summer. Mullagh More, Tulla Hill birchwood.

* *Stiroma bicarinatus* (H.-S.) A single male of this species, local in Great Britain, was swept by a track in Glencolumbkille, 27/7/1971.

Criomorphus albomarginatus Curt. Widespread, but not abundant in the Burren, mainly on grasslands. Bishopsquarter Beach, Connell's Ford, Corkscrew Hill, Druid's Altar, Fanore dunes, Glen of Clab, Lough Bunny, Poulsallagh, Tulla Hill birchwood.

Megamelus notula (Germ.) Widespread and abundant in the moister grasslands, fens and marshes. Near Carran, Connell's Ford, Corkscrew Hill, Druid's Altar, Glencolumbkille, Lough Bunny, Mullagh More, Noughaval, Poulsallagh, Rinroe Bridge, Turkenagh.

Megamelodes quadrimaculatus (Signoret) (= *fieberi* (Scott)) A single female was swept from a woodland pathway at Ballyeighter, 4/9/1971.

Muellerianella fairmairei (Perris) Widespread and abundant on grasslands, probably in association with *Sesleria albicans* in particular. Ballyconry, Ballyeighter, Ballynalacken, Connell's Ford, Corkscrew Hill, Deerpark, Druid's Altar, Formoyle (R), Glen of Clab, Glencolumbkille, Gleninsheen, Mullagh More, Noughaval, Poulivaun, Poulsallagh, Rinroe Bridge.

Laodelphax elegantulus (Boh.) On grasslands; not common in the Burren, but perhaps more abundant in early summer. Glencolumbkille, Mullagh More, Poulsallagh, Tulla Hill birchwood.

Javesella discolor (Boh.) Local in the Burren, particularly on upland grasslands (*c.* 800ft) Carnsefin, Tulla Hill.

J. dubia (Kirschb.) Local, on grasslands near woods. Near Carran, Connell's Ford, Glen of Clab, Poulavallan, Tulla Hill birchwood.

J. forcipata (Boh.) Local, on grasslands, particularly near woodland. Corkscrew Hill, Druid's Altar, Glen of Clab, Poulavallan.

J. obscurella (Boh.) One certain male and five females (probably this species) were swept from a wet *Carex* marsh at the side of Lough Inchiquin near Poulivaun, 31/8/1971. This is a typical site for the species.

J. pellucida (F.) Widespread, but seldom abundant, on grasslands of different kinds. Corkscrew Hill, Deerpark, Glen of Clab, Lough Bunny, Mullagh More, Noughaval, Poulavallan, Poulsallagh.

Nothodelphax distinctus (Flor) One male and five females were swept from the bog at Rinroe Bridge, 5/6/1970. Le Quesne (1960) suggests an association with *Eriophorum*.

* *Paradelphacodes paludosus* (Flor) A very local species of *Sphagnum* bogs in England. A pair was swept on 5/6/1970 and a single female on 22/7/1971 from the bog at Rinroe Bridge.

Muirodelphax aubei (Perris) Usually maritime in Great Britain. Recorded only from Fanore dunes and Lough Bunny.

* *Paraliburnia clypealis* (Sahlb.) Known only from Wicken Fen, Cambridgeshire, in Great Britain, but I believe that Prof. O. W. Richards has taken it in Ireland. Connell's Ford, a single brachypterous male at the base of *Phragmites communis* (7/6/1970).

P. leptosoma (Flor) (= *albofimbriata* (Signoret)) Common in Great Britain but in the Burren recorded only from the bog at Rinroe Bridge, two females being swept there, 5/6/1970.

* *Oncodelphax pullula* (Boh.) Uncommon in Great Britain, in marshy places. A single macropterous female was swept in a marsh near Carran, 10/6/1970.

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