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THE WASPS AND BEES (*HYMENOPTERA: ACULEATA*) OF YORK'S VICTORIAN CEMETERY IN WATSONIAN YORKSHIRE

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York's Victorian Cemetery is a good site for species of aculeate wasps and bees with 70 recorded and one vagrant species including two species of national importance and five species of regional importance. The vagrant species is the Potter Wasp, *Eumenes papillarius* (Christ), which is not a British species but is found on mainland Europe just across the English Channel. This vagrant species will not be included in any further data analysis.

The Cemetery (SE 612508) was started in 1837 and gradually expanded to its present size of 9.7 ha. The Company managing the Cemetery went into liquidation in 1944 and the Cemetery was stripped of its assets. Since neither individual people nor York City Council was willing to undertake the management of the Cemetery, it became overgrown. In 1984, a group of local people formed the York Cemetery Trust. The Trust bought the Cemetery from Crown Commissioners for a nominal sum in 1987. A grant was obtained from York City Council so that the Trust could employ a full-time warden. An ecological land management scheme was put into operation by Askham Bryan Horticultural College, which allowed the development of natural flora and habitats alongside ornamental trees and shrubs. A Butterfly Walk rich in nectar and pollen producing plants was created in front of a high wall which is warmed by the sun. A rockery and herb garden were also established. Dead wood was left in sunny and shaded places. In excess of 83 herb and 32 tree and shrub species have been recorded from the Cemetery (records held by York Cemetery Trust). Many of these herbs, e.g. yarrow, white dead nettle, dandelion, shrubs, e.g. bramble, buddleia, tansy, and trees, e.g. hawthorn, sycamore, are important pollen and nectar sources for the wasps and bees besides providing the prey needed by the wasps as a food resource for their larvae. Holes in the dead wood in sunny situations and crevices in the wall are important nesting sites for the aerial-nesting solitary wasp and bee species.

Methods

Between 1995 and 2002, 34 visits were made to the Cemetery distributed throughout the year as follows: March (1 visit), April (3), May (9), June (7), July (7), August (6) and September (1). All the visits were made during warm sunny weather. Each visit usually lasted up to two hours when all species of aculeate wasps and bees were recorded and usually collected with a hand net for identification.

In the following account, the nomenclature can be related to that of Kloet and Hincks (1978). An up-to-date checklist can be found on the Bees, Wasps and Ants Recording Society (BWARS) web pages at http://www.bwars.com.

Species present and seasonal progression of species

A full list of recorded species is given in Appendix A. Table 1 shows the taxonomic distribution of species and records. A record represents a specimen differing in one of the following three variables: name, sex and day of visit. The wasp family, Sphecidae, is the dominant solitary wasp taxon in terms of number of species and records although both the Chrysididae and Eumeninae are well represented as records. All the five solitary bee subfamilies are well represented either in terms of species and/or number of records. The subfamily with the most species is Halictinae and Colletinae has the most records.

As a rough guide, any site in Watsonian Yorkshire with over 60 aculeate wasp and bee species can be considered a good site; sites with more than 80 species are very good, and those with more than 100 species are excellent. York's Victorian Cemetery is, therefore, a

TABLE 1
Number of species and records of aculeate wasps and bees from York's Victorian Cemetery

	No. species	No. records
Solitary wasps		
Chrysididae	3	15
Sapygidae	1	6
Pompilidae	2	3
Eumeninae	5	23
Sphecidae	14	47
Total solitary wasps	25	94
Solitary bees		
Colletinae	4	54
Andreninae	6	34
Halictinae	9	45
Megachilinae	6	49
Anthophorinae	5	30
Total solitary bees	30	212
Total solitary species	55	306
Social wasps and bees		
Vespinae	4	
Apinae	11	
Total social wasps and bees	15	
Total wasp and bee species	70	

good site. Since there is no other urban site that can be compared with the Cemetery it can stand as a standard for comparison with other sites that might be investigated in the future. Good rural sites are Burton Leonard Lime Quarries, Cave Wold and Cornelian with Cayton Bay. Since Burton Leonard Lime Quarries and Cornelian Bay with Cayton Bay are SSSIs, York's Victorian Cemetery must be considered, at least, to be a wildlife area of regional importance.

Table 2 shows the average number of solitary species recorded during each visit for each month. June and July were the best months with an average of about eleven species recorded per visit. The average of species recorded for all visits was exactly eight species.

TABLE 2
Number of species of solitary wasps and bees recorded per month at York's Victorian Cemetery

	No. visits	No. species	Species per visit
March	1	1	1.0
April	3	8	2.7
May	9	71	7.9
June	7	78	11.1
July	7	72	10.3
August	6	39	6.5
September	1	3	3.0

June and July were the best months for recording solitary wasp species, with May and June the most productive months for first recording of species (Table 3). The most frequently species found, which were all aerial nesters or parasites of aerial nesters, were the mason wasps, *Ancistrocerus gazella* and *A. oviventris* with their parasites *Chrysis ignita*

TABLE 3
Number of species and first records of species of solitary wasps and bees recorded per month at York's Victorian Cemetery

	March	April	May	June	July	August	September
Solitary wasps							
First records	0	1	8	11	3	2	0
Recorded	0	1	9	18	14	9	2
Solitary bees							
First records	1	4	12	7	2	4	0
Recorded	1	5	17	20	15	14	1

and *C. impressa*; the sphecid wasps *Crossocerus annulipes, C. elongatulus, Ectemnius cephalotes* and *E. cavifrons*; and the cleptoparasite *Sapyga quinquepunctata* whose hosts are mason bees of the genus *Osmia*. The cleptoparasite female of *S. quinquepunctata* enters the nest of its host and lays an egg on or near the egg of its host probably using its sting to penetrate the cell wall. On hatching, the first instar larva, which has large mandibles, eats the egg of the host. Later instars have smaller mandibles and feed on the stored food of the host. The mason wasps with their parasites and the sapygid were usually associated with the Cemetery wall and the sphecids *Ectemnius* and *Crossocerus annulipes* were usually associated with dead wood in sunny places. *Crossocerus elongatulus* is usually a subterranean nester but it also nests in crevices in old brick walls and was usually associated with the wall.

May to August were the best months for recording solitary bee species, with May and June the most productive months for first recording of species (Table 3). The species most frequently recorded were both subterranean and aerial nesters and were usually found on flowers collecting pollen and/or nectar or sunning themselves on the tombstones. The sunning species were the sweat bees, *Lasioglossum cupromicans, L. smeathmanellum* and *L. albipes*, and the yellow-faced bees, *Hylaeus hyalinatus* and *H. communis*. The mason bees, *Osmia rufa, O. leaiana* and *O. caerulescens* were also associated with the wall in which they nested. The leaf-cutter bees, *Megachile centuncularis* and *M. willughbiella* were also associated with the dead wood in which they nested. Most of the subterranean nesters were only found on the flowers, as their nesting sites were not found. These subterranean nesters included *Colletes daviesanus, Halictus tumulorum, Andrena fulva* with its cleptoparasite *Nomada panzeri*, *A. haemorrhoa*, and *A. scotica* with its cleptoparasite *N. marshamella*. The cleptoparasites of *Colletes daviesanus* (*Epeolus variegatus*), *Andrena haemorrhoa* (*Nomada ruficornis*) and *Halictus tumulorum* (*Specodes* spp.) were not found which seems unlikely as the host species were so frequently found. Since cleptoparasites are often associated with the nest sites of their hosts, perhaps the hosts were using the Cemetery for foraging but nesting away from the Cemetery so decreasing the chances of finding their cleptoparasites.

SPECIES QUALITY OF THE SITE

Archer (2002) developed a regional quality scoring scheme for the solitary species based upon four statuses: Common, Frequent, Occasional and Rare. The Common and Frequent status species may be considered the low quality species and the Occasional and Rare status species the high quality species. Six high quality species have been recorded from the Cemetery including one species with a rare status, *Crossocerus distinguendus*, and five species with occasional status, *Sapyga quinquepunctata, Hylaeus signatus, Andrena denticulata, Megachile versicolor* and *Anthophora furcata*. None of the social species may be considered as high quality species.

Two recorded species are of national importance, *Hylaeus signatus* (Falk 1991) and *Crossocerus distinguendus* (BWARS, in press) which was only recorded recently for the first time in Kent but it has now started to extend its range. The record from the Cemetery was the first record of this species from Watsonian Yorkshire.

Archer (1999, 2002) has developed a national quality scoring scheme for the solitary species based on six statuses: Very rare, Rare, Scarce, Restricted, Widespread and Universal. Species with a very rare, rare or scarce status are high quality species while species with a restricted, widespread or universal status are low quality species. *Crossocerus distinguendus* and *Hylaeus signatus* are high quality species with a scarce status. By giving each of the 55 solitary species an Archer national quality status a national quality score of 82 can be calculated (Table 4) with a national species quality score (SQS) of 1.5 (82 divided by the 55 solitary species).

How does this SQS compare with SQSs from other Watsonian Yorkshire sites? Archer (2003) divided the SQSs of studied Yorkshire sites into three classes as follows: first class 2.4-2.9; second class 1.8-2.3; and third class 1.2-1.7. York's Victorian Cemetery is a third class site mainly because most of the recorded species have national universal or widespread statuses. Other third class sites are Skipwith Common, Burton Leonard Lime Quarries, Cayton to Cornelian Bay and South Cliffe Common. As such, again York's Victorian Cemetery must be considered, at least, of regional importance.

TABLE 4
Archer national quality scores of the solitary species recorded from York's Victorian Cemetery

Status	Status score (A)	No. species (B)	Quality score (A x B)
Universal	1	40	40
Widespread	2	13	26
Restricted	4	0	0
Scarce	8	2	16
Total		55	82

Species Quality Score (SQS) 82/55 = 1.5.

ESTIMATING THE POTENTIAL NUMBER OF SOLITARY WASP AND BEE SPECIES

One of the problems in the study of any site is the difficulty of not knowing how many more are present at a site, but, as yet, are unrecorded. Recent advances in non-parametric statistical procedures offer a way of addressing this problem. The presence/absence estimate of Chao (in Colwell & Coddington 1994) is based on the number of species that are observed in one (unique species) or two samples or visits. Because some species are only active in the spring or summer it is advisable that samples be taken throughout the months of adult activity. The software to carry out the statistical procedure was provided by Pisces Conservation Ltd.

The statistical procedure was run 34 times, equivalent to the number of samples. The software takes 1, 2, etc. samples at random 34 times, each time calculating a mean estimate of species diversity. With a small number of samples the estimates are erratic, but as more samples are selected the estimates may stabilise giving confidence in the estimates. In fact, the estimates do stabilise (Fig. 1) predicting that about 64 solitary species potentially could be present on the site. The estimate is given in Table 5 for the maximum sample size with its 95% confidence limits (meaning that there is a 95% chance that potential number of species falls within this range). Further about 86% of this potential number of species has been recorded.

Since the Chao estimator is a relatively new statistical procedure, caution is needed in accepting its estimates. Two further non-parametric statistical procedures are the first order Jackknife (Heltshe & Forrester 1983) and the Bootstrap (Smith & van Belle 1984)

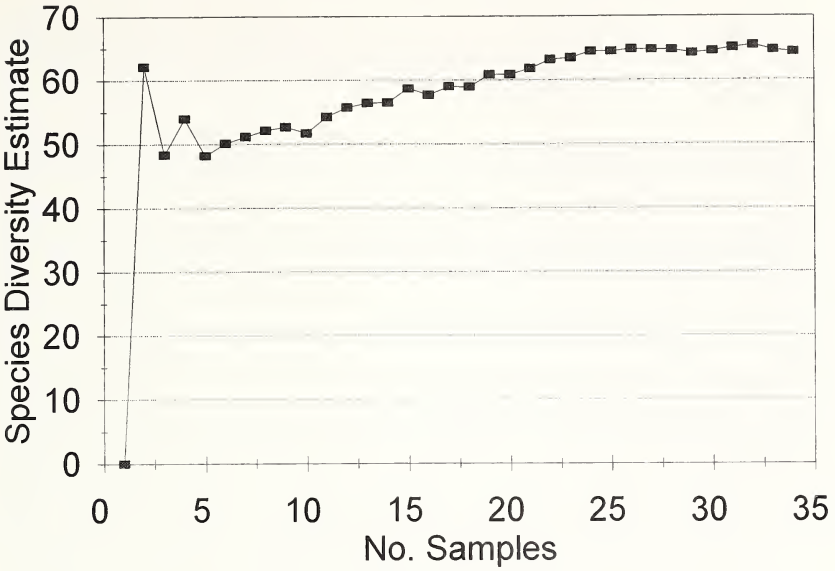

FIGURE. 1.
Chao presence/absence estimates of species richness of solitary wasps and bees from York's Victorian Cemetery

procedures (software by Pisces Conservation Ltd.). The Jackknife procedure depends only on the unique species and the Bootstrap procedure on the proportion of samples containing each species. Both these procedures, with increasing sample size, closely approach an upper asymptote value indicating a stabilised prediction (Figs 2 & 3). The Jackknife procedure gives a slightly higher estimate of 68 species and the Bookstrap a slightly lower estimate of 61 species compared with the Chao estimate. However, the Jackknife and Bootstrap estimates are included within the 95% confidence limits of the Chao estimate so that the estimates are in general agreement and confidence can be placed on the use of these relatively new statistical procedures. The use of these three procedures with several data sets also usually shows the Jackknife estimate to be slightly greater and the Bootstrap estimate slightly less, than the Chao estimate.

TABLE 5
Non-parametric estimates of species richness of solitary wasps and bees from York's Victorian Cemetery

	Chao	Jackknife	Bootstrap
Number of species			
– recorded	55	55	55
– estimated	64	68	61
95% confidence limits of estimates	53-76	60-75	
% of species recorded	85.9	80.9	90.2

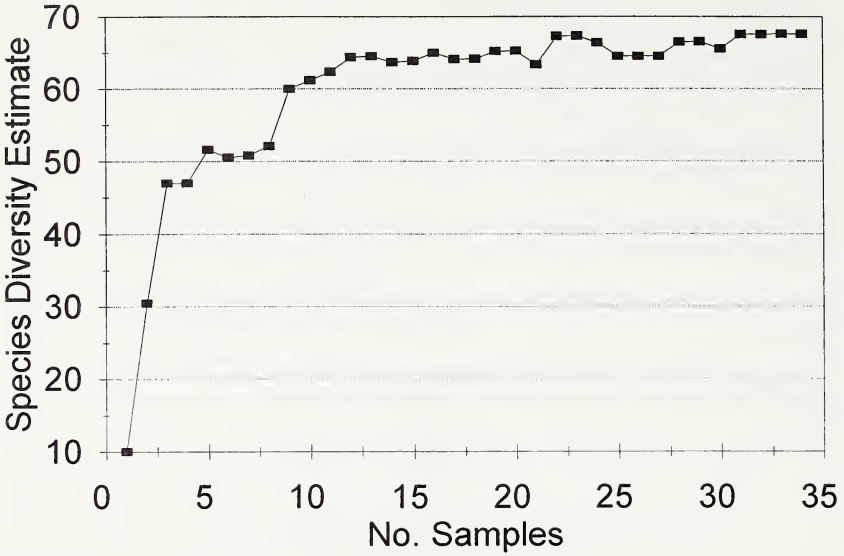

FIGURE. 2.
Jackknife estimates of species richness of solitary wasps and bees
from York's Victorian Cemetery

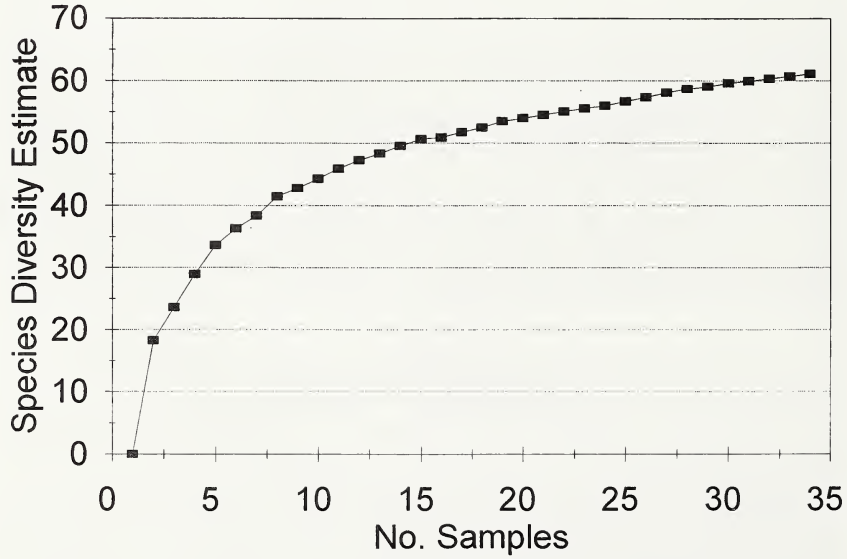

FIGURE. 3
Bootstrap estimates of species richness of solitary wasps and bees
from York's Victorian Cemetery

Comparisons with other sites

Since the species diversity investigations have shown stable estimates for the Cemetery it is possible to compare it with other sites. These will be made with respect to the areas of sites, cleptoparasitic loads and aerial nester frequencies.

Species-area Relationships

The number of solitary species can be related to site area. The species-area relationship can be found by plotting the number of solitary species recorded at a site against the area of the site, with both the number and area expressed as natural logarithms (ln). Archer (2003) showed a species-area figure for 28 sites from the north and north Midlands of England. The dot for York's Victorian Cemetery (ln 2.27 area versus ln 4.01 solitary species) falls within the dots for the 28 sites, indicating that the Cemetery has the number of species that might be expected in terms of its area.

Cleptoparasitic Load

The cleptoparasitic load (CL) is the percentage of aculeate species that are cleptoparasitic (or parasitoids) on other host aculeates. Wcislo (1987) showed that parasite behaviour among aculeate Hymenoptera correlated with geographical latitude. Thus the parasitic rates are higher in temperate regions, as host populations are more synchronised in their life-history characteristics than in tropical regions. This finding probably does not hold for desert regions where the occurrence of rainfall would tend to synchronise life-history characteristics. From a review of the literature Wcislo found that the CLs for bees in Europe varied between 16% and 33%, a range of 17%.

For 27 sites from north and north Midlands of England, the author found that CLs for solitary bees vary from 22.5%-40.0% giving a range of 17.5% (Archer 2003), which is very close to the range found by Wcislo. The CL for solitary bee species from the Cemetery (Table 6) is low, in falling outside this range. Since cleptoparasites are often associated with the nest sites of their host and if their hosts, which are subterranean nesters, were nesting outside the Cemetery the cleptoparasites would tend not to be found so lowering the CL.

Wcislo gave no CLs for solitary wasps but from 28 sites from north and north Midlands of England CLs vary from 10.3%-24.4% giving a range of 14.1% (Archer 2003). The CL for the solitary wasp species (Table 6) falls within this range. Unlike the subterranean nesting bees, the sites of the aerial nesting wasps were found so that their associated parasites were more likely to be found.

Table 6
Relative frequency of the cleptoparasitic (or parasitoid) species among the solitary species from York's Victorian cemetery

	No. hosts (H)	No. cleptoparasites (C)	Cleptoparasitic Load CL = 100 x C/(H+C)
Solitary wasps	21	4	16.0
Solitary bees	25	5	16.7

Aerial Nester Frequency

The aerial nester frequency (AF) is the percentage of host aculeate species that have aerial nest sites. Aerial nesters use old beetle burrows in dead wood, central stem cavities (e.g. bramble), crevices in old walls or exposed on the surface of rock or other hard material. Subterranean nesters nest in the soil, usually in burrows dug by themselves, but sometimes holes and crevices are used after being altered.

The AFs for the solitary species are given in Table 7. The AFs for all the British species

of solitary wasps is 46.2% and solitary bees is 17.9%. The AFs of the solitary wasps and bees of the Cemetery are much higher than the British AFs and are amongst the highest AFs recorded for any Yorkshire sites (Archer 2003). These high values illustrate the importance of the wall and dead wood in sunny situations as aerial nesting sites.

TABLE 7
Nesting habits of the host species of solitary wasps and bees from York's Victorian Cemetery

	No. aerial nesters (A)	No. subterranean nesters (S)	Aerial nester frequency AF = 100 x A/(A+S)
Solitary wasps	17	4	81.0
Solitary bees	10	15	40.0

CONCLUSIONS ABOUT YORK'S VICTORIAN CEMETERY

1. It is a good site in terms of the number of recorded species (71) including the vagrant Potter Wasp, *Eumenes papillarius*, a particularly notable record.
2. It is a third class quality conservation site because most of the recorded species have a nationally Universal and Widespread status. Two species of national importance and six species of regional importance were found.
3. Three estimates of potential species diversity gave stable estimates and closely agreed with each other. It is estimated that 80-90% of the potential species have been recorded.
4. The species-area relationship indicates that for the area of the Cemetery the expected number of solitary species was recorded.
5. The cleptoparasitic load for solitary bees is low, probably because many of the subterranean nesters are nesting outside the Cemetery.
6. The aerial nester frequencies are very high indicating the importance of the wall and dead wood as nesting resources.

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APPENDIX A.
LIST OF SPECIES RECORDED

CHRYSIDIDAE: *Chrysis angustula* Schenck, *C. ignita* (L.), *C. impressa* Schenck.
SAPGIDAE: *Sapyga quinquepunctata* (Fab.).
POMPILIDAE: *Dipogon variegatus* (L.), *Anoplius nigerrimus* (Scopoli).
EUMENINAE: *Eumenes papillarius* (Christ), *Ancistrocerus gazella* (Panzer), *A. oviventris* (Wesmael), *A. parietinus* (L.), *A. parietum* (L.), *Symmorphus bifasciatus* (L.).
VESPINAE: *Dolichovespula sylvestris* (Scopoli), *Paravespula germanica* (Fab.), *P. vulgaris* (L.), *Vespula rufa* (L.).
SPHECIDAE: *Crossocerus annulipes* (Lepeletier & Brullé), *C. cetratus* (Shuckard), *C. distinguendus* (Morawitz), *C. elongatulus* (Vander Linden), *C. megacephalus* (Rossius), *C. nigritus* (Lepeletier & Brullé), *C. pusillus* Lepeletier & Brullé, *Ectemnius cavifrons* (Thomson), *E. cephalotes* (Olivier), *Rhopalum coarctatum* (Scopoli), *Mimumesa dahlbomi* (Wesmael), *Pemphredon inornata* Say, *P. lugubris* (Fab.), *Mellinus arvensis* (L.).
COLLETINAE: *Hylaeus communis* Nylander, *H. signatus* (Panzer), *H. hyalinatus* Smith, *Colletes daviesanus* Smith.
ANDRENINAE: *Andrena denticulata* (Kirby), *A. fulva* (Müller *in* Allioni), *A. haemorrhoa* (Fab.), *A. nigroaenea* (Kirby), *A. semilaevis* Pérez (=*saundersella*), *A. scotica* Perkins.
HALICTINAE: *Halictus rubicundus* (Christ), *H. tumulorum* (L.), *Lasioglossum albipes* (Fab.), *L. calceatum* (Scopoli), *L. cupromicans* (Pérez), *L. leucopus* (Kirby), *L. smeathmanellum* (Kirby), *L. villosulum* (Kirby), *Sphecodes geoffrellus* (Kirby).
MEGACHILINAE: *Osmia caerulescens* (L.), *O. leaiana* (Kirby), *O. rufa* (L.), *Megachile centuncularis* (L.), *M. versicolor* Smith, *M. willughbiella* (Kirby).
ANTHOPHORINAE: *Nomada fabriciana* (L.), *N. goodeniana* (Kirby), *N. marshamella* (Kirby), *N. panzeri* Lepeletier, *Anthophora furcata* (Panzer).
APIDINAE: *Bombus hortorum* (L.), *B. lapidarius* (L.), *B. lucorum* (L.), *B. pascuorum* (Scopoli), *B. pratorum* (L.), *B. terrestris* (L.), *B. bohemicus* (Seidl), *B. campestris* (Panzer), *B. sylvestris* (Lepeletier), *B. vestalis* (Geoffroy *in* Fourcroy), *Apis mellifera* L.

ENTOMOLOGICAL REPORT
DIPTERA: TIPULOIDEA AND EMPIDOIDEA

ROY CROSSLEY

Introduction

The last report covering these two Superfamilies was published in 2003 (*Naturalist* **128:** 59-64). Since then much recording has continued to be undertaken across the County, and the more significant additions are noted below. A recent examination of specimens collected by Kenneth Payne in the 1950s has revealed a number which were not published as records at the time and it is a great pleasure to rectify the omissions now. Likewise the nationally important record of *Dolichocephala thomasi* from Malham has not been published previously and I am grateful to Dr Irwin for allowing me to do so here.

As always, it is a pleasure to acknowledge the assistance of many colleagues, especially P. J. Chandler for much help with *Symplecta chosenensis*; and those who have submitted records, including P. Boardman, J. D. Coldwell, W. A. Ely, A. Godfrey, D. J. Heaver, K. G. Payne, P. Skidmore and A. E. Stubbs; unattributed records are those of the writer. New County records are indicated by †, and Vice-County records by *.

The national rarity classifications which follow, where appropriate, immediately after the species names, are those provisionally recommended by Falk (1991) for Tipuloidea, and by Falk and Crossley (in prep.) for Empidoidea.

The systematic order of the following list, and nomenclature, follow Chandler (1998).