THE WASPS AND BEES (HYM., ACULEATA) OF DEVILS SPITTLEFUL NATURE RESERVE IN WATSONIAN WORCESTERSHIRE

BY MICHAEL E. ARCHER

Devils Spittleful and Rifle Range Nature Reserve is an important site for species of aculeate wasps and bees with 124 recorded species including 15 species of national importance.

The aims of this paper are to describe the aculeate wasp and bee fauna of this nature reserve, and compare it with other sandy English sites. In addition, non-parametric statistical procedures will be used to estimate potential species diversity.

The Nature Reserve (SE 815752) is situated to the east of Bewdley and about 20 km north of Worcester. The nature reserve has an area of 60ha and is included within the Midland plateau Natural Area. Devils Spittleful is owned and managed by the Worcestershire Nature Conservation Trust while the Rifle Range belongs to Wyre Forest District Council. Background information about the nature reserve is given in Green & Westwood (1991). In what follows, the shortened site name Devils Spittleful will be used to include the Rifle Range.

The nature reserve overlies Triassic sandstone, and with Hartlebury Common (Archer 2002a), represents the remains of a much more extensive area of mainly dry lowland heathland. The site is flat, rising to the north to form a natural amphitheatre. The flat area has a hill of worn sandstone crowned by Scots Pine. The main habitats are areas of birch/oak woodland, dry acid grassland and heathland of which the latter two habitats are being invaded by hawthorn, birch and oak. There is a good growth of gorse and broom. The grassland has herbs such as harebell and pansy. Bare areas, particularly associated with pathways, are important for subterranean nesters. The nature reserve is surrounded by intensively farmed areas, urban development on its northern boundary and a safari park on its western boundary.

SAMPLING METHODS

Between 1990 and 1997, 17 visits were made to Devils Spittleful N.R. distributed throughout the year as follows: March (1 visit), April (1), May (3), June (3), July (4), August (4) and September (1). All the visits were made during warm sunny weather. During each, approximately three hour, visit 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 given by Kloet & Hincks (1978). An up-to-date check list 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 the species recorded (with authorities) is given at the end of the paper. At the family level, 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 solitary wasp family, Sphecidae, and the solitary bee subfamilies, Andreninae and Halictinae, are the dominant family and subfamilies in terms of number of species and records.

TABLE 1 — THE NUMBER OF SPECIES AND RECORDS OF ACULEATE WASPS AND BEES RECORDED FROM DEVILS SPITTLEFUL

	No. species	No. records
Solitary wasp species		
Chrysididae	4	5
Pompilidae	9	17
Eumeninae	1	2
Sphecidae	28	126
Total	42	150
Solitary bee species		
Colletinae	7	18
Andreninae	22	66
Halictinae	21	61
Melittinae	1	3
Megachilinae	7	17
Anthophorinae	9	25
Total	67	190
Total solitary wasps and bees	109	340
Social wasp and bee species		
Vespinae	5	
Apinae	10	
Total	15	
Total wasp and bee species	124	

June, July and August were the best months for recording solitary wasp species, with June the most productive month for the first recording of species (Table 2). The species most evident, which were all subterranean nesters, took aphid prey (*Diodontus tristis*), fly prey (*Crossocerus quadrimaculatus*, *Oxybelus uniglumis*), fly and heteropteran bug prey (*Lindenius albilabris*), moth or sawfly caterpillar prey (*Ammophila sabulosa*), weevil prey (*Cerceris arenaria*), solitary bee prey (*C. rybyensis*) or honey bee prey (*Philanthus triangulum*).

May, June, July and August were the best months for recording solitary bee species, with May and June the most productive months for the first recording of species (Table 2). The species most evident, which again were all subterranean species, were with their cleptoparasites: *Colletes succinctus* with *Epeolus cruciger*, *Andrena barbilabris* with *Sphecodes*

pellucidus, *Andrena bicolor*, *Lasioglossum calceatum* with *Sphecodes monilicornis* and *Lasioglossum leucozonium* with *Sphecodes pellucidus*. The cleptoparasite of *Andrena bicolor*, *Nomada fabriciana*, was not found. The cleptoparasite *Nomada rufipes* also was noticeable although its hosts, *Andrena denticulata*, *A. fuscipes* and *A. nigriceps*, were less so.

TABLE 2 — THE NUMBER OF SPECIES AND FIRST RECORDS OF SPECIES OF SOLITARY WASPS AND BEES RECORDED PER MONTH AT DEVILS SPITTLEFUL

	March	April	May	June	July	August	September
Solitary wasps							
First records	0	0	6	26	7	3	0
Recorded	0	0	6	29	21	20	8
Solitary bees							
First records	1	12	20	21	5	8	0
Recorded	1	12	28	29	20	22	5

SPECIES QUALITY

The following three Red Data Book species (Shirt, 1987) have been recorded: *Pemphredon morio*, *Andrena bucephala* and *Sphecodes reticulatus*. Falk (1991) suggested that these three species should be downgraded to national scarce species. In addition, the following national scarce species (Falk, 1991) have been recorded: *Hedychridium cupreum*, *Oxybelus argentatus, Andrena argentata, A. bimaculata, A. humilis, A. nigriceps, Lasioglossum quadrinotatum, Sphecodes ferruginatus, Dasypoda altercator* and *Nomada flavopicta*. Previously *Priocnemis schioedtei* was considered a national scarce species (Falk, 1991) and *Philanthus triangulum* and *Nomada lathburiana* Red Data Book species (Shirt, 1987). However, recent work carried out by BWARS indicates that these three species should lose their national status either because they have recently increased their geographical distribution (*Philanthus triangulum, Nomada lathburiana*) or their geographical distribution has become better known (*Priocnemis schioedtei, Nomada lathburiana*).

To take account of these changes, Archer (1999, 2002b) has developed a national quality scoring system of high and low quality scoring species. High quality species have a scarce, rare or very rare status while low quality species have a universal, widespread or restricted status. According to this national quality scoring system, twelve species have a scarce status: *Hedychridium cupreum, Oxybelus argentatus, Pemphredon morio, Diodontus tristis, Ammophila pubescens, Andrena bimaculata, A. humilis, A. nigriceps, Sphecodes ferruginatus, S. reticulatus, Dasypoda altercator* and *Nomada flavopicta*, and three species a rare status: *Andrena argentata*, *A. bucephala* and *Lasioglossum quadrinotatum*.

By giving each of the 109 species of solitary wasps and bees an Archer national status a national quality score of 282 can be calculated (Table 3) with a national species quality score of 2.6 (282 divided by the 109 solitary species). How do these scores compare to similar scores for other English sandy habitats?

TABLE 3 – THE ARCHER NATIONAL QUALITY SCORES OF THE SPECIES OF SOLITARY WASPS AND BEES RECORDED FROM DEVILS SPITTLEFUL

Status	Status score (A)	No. species (B)	Quality score (A x B)
Universal	1	54	54
Widespread	2	38	76
Restricted	4	2	8
Scarce	8	12	96
Rare	16	3	48
Total		109	282

Species Quality Score (SQS) 282/109 = 2.6

Data of few sites were available for comparison. Table 4 shows the species quality characteristics of some sandy English sites from the south-east: Bagmoor Common, Archer (2000), Ambersham and Iping commons, Archer & Edwards (2002); the midlands: Hartlebury Common, Archer (2002a), Gibraltar Point, Archer (1988), Sherwood Forest, Archer (unpublished); Lancashire: Ainsdale-Formby sand dunes, Archer (1999); and Yorkshire: Crow Wood, Archer & Burn (1995), Blaxton Common, Archer (1995). Although the quality scores, and the number of solitary and high quality species will be influenced by the areas of the sites, the species quality scores are relatively independent of site area (Archer, 1999), so can be used to compare sites. Devils Spittleful can be matched with other Midland and Lancashire sites rather than the generally poorer Yorkshire and Lincolnshire sites and the richer south-eastern sites. Compared with near-by Hartlebury Common, Devils Spittleful, despite

TABLE 4 — SPECIES QUALITY CHARACTERISTICS OF SOME ENGLISH SANDY SITES

	Number of solitary species	Total high quality species	Quality score	Species quality score	Area (ha)
Bagmoor Common, Surrey	148	32	730	4.9	13.8
Ambersham Common, West Sussex	190	42	863	4.5	212
Iping Common, West Sussex	189	40	853	4.5	172
Ainsdale-Formby sand dunes	94	17	361	3.8	940
Hartlebury Common, Worcestershire	87	15	292	3.4	87.5
Sherwood Forest, Nottinghamshire	100	9	296	3.0	390
Devils Spittleful, Worcestershire	109	15	282	2.6	60
Crow Wood, South Yorkshire	105	9	266	2.5	152
Blaxton Common, South Yorkshire	109	24	202	1.9	150
Gibraltar Point, Lincolnshire	84	4	140	1.7	437

having a larger recorded number of solitary species, has a lower species quality score because it has relatively more universal status species.

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 (two occasion species) samples or visits. Because some aculeate 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 17 times, equivalent to the number of samples. The software takes 1, 2, etc. samples at random 17 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 137 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).

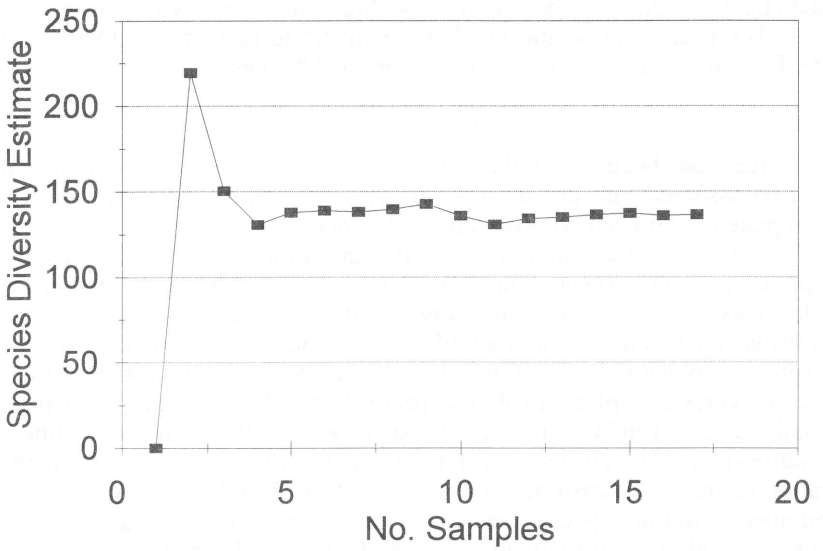

Fig. 1 — The Chao presence/absence estimate of species richness of species of solitary wasps and bees from Devils Spittleful

TABLE 5 — NON-PARAMETRIC ESTIMATES OF SPECIES RICHNESS OF SOLITARY WASPS AND BEES FROM DEVILS SPITTLEFUL USING THE PRESENCE/ABSENCE CHAO, JACKKNIFE AND BOOTSTRAP PROCEDURES

	Chao	Jackknife	Bootstrap
Number of species			
– recorded	109	109	109
– estimated	137	145	127
95% confidence limits of estimates	116–159	126–164	
% of species recorded	79.6	75.2	85.8

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) 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. The Jackknife procedure gives a slightly higher estimate of 145 species and the Bootstrap procedure a slightly lower estimate of 127 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 three 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.

SPECIES-AREA RELATIONSHIPS

Since it has been shown that the species diversity estimates stabilise, it can be assumed that the species list for Devils Spittleful is sufficiently complete to carry out comparisons with other sites.

The first comparison relates to the question as to whether Devils Spittleful has the expected number of species in relation to the area of the site. This question can be investigated by carrying out a species-area relationship where the number of species and the area of the site are expressed as natural logarithms (ln). Archer & Edwards (2002) showed that a species-area plot for solitary species from 24 inland sandy sites from south-eastern England had a statistically significant positive linear relationship. The species-area dot for Devils Spittleful falls within the range of the south-eastern sites (Fig. 2). Thus Devils Spittleful has the number of solitary species that would be expected for its area. Since the sites of south-eastern England represent the best aculeate sites in the U.K. for species diversity, Devils Spittleful can be regarded as among the best aculeate sites in the U.K.

The correlation coefficient of the species-area relationship of the 25 sites indicates a highly significant linear relationship ($r = 0.91$, $p < 0.001$) with 82% of the variation of the number of species between sites explained by the variation in the area of the sites. The species-area

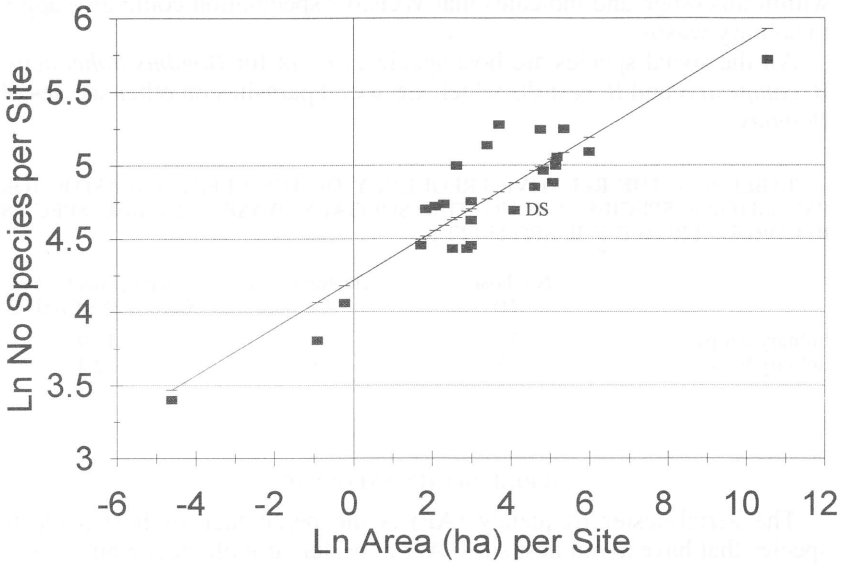

Fig. 2 — A species-area plot based of the solitary species of wasps and bees from 24 inland sandy sites in south eastern England and Devils Spittleful (DS).

regression equation is: ln number of species = 4.22 + 0.1625 x ln area (ha). Two other statistics from the regression equation are: 1, the mean number of species of solitary wasps and bees expected to be found on one ha is 68 species (anti-ln 4.22) and, 2, to double the number of solitary species of wasps and bees the mean area would need to be increased about 71-fold (2 raised to the power of 1/0.1625).

CLEPTOPARASITIC LOAD

The cleptoparasitic load (CL) is the percentage of aculeate species that are cleptoparasites (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. This finding probably does not hold for desert climates where the occurrence of rainfall would tend to synchronise life-history characteristics. From a review of the literature Wcislo (1987) found that the CLs for bees in Europe varied between 16% and 33%, a range of 17%.

The solitary bee CL for Devils Spittleful (Table 6) falls within the range of values for Europe and this supports Wcislo's speculation.

Wcislo (1987) gives no values for wasps, but Archer (1999) found that values for solitary wasps varied between 10% and 22%, a range of 12%. The solitary wasp CL for Devils Spittleful is 11.9% (Table 6) which falls within this range and indicates that Wcislo's speculation could also apply to solitary wasps.

All the social species are host species, except for *Bombus bohemicus, B. campestris* and *B. vestalis* which are social parasites on other species of *Bombus.*

TABLE 6 — THE RELATIVE FREQUENCY OF THE CLEPTOPARASITIC (OR PARASITOID) SPECIES AMONG THE SOLITARY WASP AND BEE SPECIES RECORDED FROM DEVIL SPITTLEFUL

	No. hosts (H)	No. cleptoparasites (C)	Cleptoparasitic load CL = 100 x C/(H+C)
Solitary wasps	37	5	11.9
Solitary bees	52	15	22.4

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), old snail shells, or crevices in cob walls, old mortar 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.

TABLE 7 — THE NESTING HABITS OF THE HOST SPECIES OF SOLITARY WASPS AND BEES RECORDED FROM DEVILS SPITTLEFUL

	No. aerial nesters (A)	No. subterranean nesters (S)	Aerial nester frequency AF = 100 x A/(A+S)
Solitary wasps	8	29	21.6
Solitary bees	8	44	15.4

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%. Thus the AF for the solitary wasp species is much lower than the national value while the AF for the solitary bee species is a little lower than the national value. The relatively low value of the AF for solitary wasp species may indicate a genuine lack of such species, but could also indicate that more stem-nesting species might yet be found.

The host species of *Bombus* are subterranean nesters, although *B. pratorum* has been found in aerial situations such as old birds' nests. The social wasps are usually subterranean nesters except for *Vespa crabro* which is an aerial nester usually in the hollows of trees, and *Dolichovespula sylvestris* which on heathland can be a subterranean or aerial nester.

LIST OF SPECIES RECORDED

CHRYSIDIDAE: *Hedychridium ardens* (Latreille *in* Coquebert), *H. cupreum* (Dahlbom), *Chrysis angustula* Schenck, *Trichrysis cyanea* (L.).

POMPILIDAE: *Dipogon subintermedius* (Magretti) (= *nitidus*), *Priocnemis parvula* Dahlbom, *P. schioedtei* Haupt, *P. perburbator* (Harris), *Agenioideus cinctellus* (Fab.), *Arachnospila anceps* (Wesmael), *A. spissa* (Schiødte), *Evagetes crassicornis* (Shuckard), *Episyron rufipes* (L.).

EUMENINAE: *Ancistrocerus nigricornis* (Curtis).

VESPINAE: *Vespa crabro* L., *Dolichovespula sylvestris* (Scopoli), *Vespula rufa* (L.), *Paravespula germanica* (Fab.), *P. vulgaris* (L.).

SPHECIDAE: *Tachysphex pompiliformis* (Panzer), *Trypoxylon clavicerum* Lepeletier & Serville, *Crabro cribrarius* (L.), *C. peltarius* (Schreber), *Crossocerus megacephalus* (Rossi), *C. ovalis* Lepeletier & Brullé, *C. pusillus* (Lepeletier & Brullé), *C. quadrimaculatus* (Fab.), *C. wesmaeli* (Vander Linden), *Ectemnius cavifrons* (Thomson), *Lindenius albilabris* (Fab.), *Oxybelus argentatus* Curtis, *O. uniglumis* (L.), *Mimesa equestris* (Fab.), *M. lutaria* (Fab.), *Pemphredon lugubris* (Fab.), *P. morio* Vander Linden, *Diodontus minutus* (Fab.), *D. tristis* (Vander Linden), *Passaloecus corniger* Shuckard, *Ammophila pubescens* Curtis, *A. sabulosa* (L.), *Mellinus arvensis* (L.), *Harpactus tumidus* (Panzer), *Argogorytes mystaceus* (L.), *Cerceris arenaria* (L.), *C. rybyensis* (L.), *Philanthus triangulum* (Fab.).

COLLETINAE: *Colletes daviesanus* Smith, *C. fodiens* (Geoffrey *in* Fourcroy), *C. similis* Schenck, *C. succinctus* (L.), *Hylaeus brevicornis* Nylander, *H. communis* Nylander, *H. hyalinatus* Smith.

ANDRENINAE: *Andrena angustior* (Kirby), *A. argentata* Smith, *A. barbilabris* (Kirby), *A. bicolor* Fab., *A. bimaculata* (Kirby), *A. bucephala* Stephens, *A. cineraria* (L.), *A. clarkella* (Kirby), *A. denticulata* (Kirby), *A. dorsata* (Kirby), *A. fucata* Smith, *A. fuscipes* (Kirby), *A. haemorrhoa* (Fab.), *A. humilis* Imhoff, *A. minutula* (Kirby), *A. nigroaenea* (Kirby), *A. nigriceps* (Kirby), *A. ovatula* (Kirby), *A. saundersella* Perkins, *A. scotica* Perkins, *A. subopaca* Nylander, *A. synadelpha* Perkins.

HALICTINAE: *Halictus rubicundus* (Christ), *H. tumulorum* (L.), *Lasioglossum albipes* (Fab.), *L. calceatum* (Scopoli), *L. cupromicans* (Pérez), *L. leucopus* (Kirby), *L. leucozonium* (Schrank), *L. minutissimum* (Kirby), *L. morio* (Fab.), *L. parvulum* (Schenck), *L. punctatissimum* (Schenck), *L. quadrinotatum* (Kirby), *L. rufitarse* (Zetterstedt), *L. smeathmanellum* (Kirby), *L. villosulum* (Kirby), *Sphecodes ferruginatus* von Hagens, *S. geoffrellus* (Kirby) (= *fasciatus*), *S. monilicornis* (Kirby), *S. pellucidus* Smith, *S. puncticeps* Thomson, *S. reticulatus* Thomson.

MELITTINAE: *Dasypoda altercator* (Harris).

MEGACHILINAE: *Chelostoma campanularum* (Kirby), *O. rufa* (L.), *Hoplitis claviventris* (Thomson), *Megachile ligniseca* (Kirby), *M. maritima* (Kirby), *M. versicolor* Smith, *M. willughbiella* (Kirby).

ANTHOPHORINAE: *Nomada flava* Panzer, *N. flavopicta* (Kirby), *N. goodeniana* (Kirby), *N. lathburiana* (Kirby), *N. marshamella* (Kirby), *N. ruficornis* (L.), *N. rufipes* Fab., *Epeolus cruciger* (Panzer), *E. variegatus* (L.).

APINAE: *Bombus lucorum* (L.), *B. terrestris* (L.), *B. hortorum* (L.), *B. lapidarius* (L.), *B. pratorum* (L.), *B. pascuorum* (Scopoli), *B. bohemicus* (Seidl), *B. campestris* (Panzer), *B. vestalis* (Geoffroy *in* Fourcroy), *Apis mellifera* L.

CONCLUSIONS

1. Devils Spittleful Nature Reserve is an important West Midlands site for aculeate wasps and bees with 124 recorded species, of which 15 are of national importance.
2. The conservation value of the site, as measured by the species quality score, relates it to other Midland and Lancashire sites rather than the poorer sites of Yorkshire and Lincolnshire and the richer sites of South-Eastern England.
3. It is estimated that 80% of the solitary wasp and bee species have been recorded. The remaining species to be found may be mainly aerial nesting solitary wasps.
4. The number of recorded species, given the area of the site, was similar to that expected for inland sandy sites from south-eastern England.
5. The values of the cleptoparasitic loads for the solitary wasp and bee species support Wcislo's hypothesis.
6. The aerial nester frequency is relatively low for solitary wasp species.

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Interesting records of aculeate wasps and bees from Yorkshire. — Two species can be added to the Yorkshire list. First the pompilid *Agenioideus cinctellus* (Spinola) recorded by J.T. Burn at Pot Hill, Sandall Beat Wood, near Doncaster (SE6103) on 13.viii.2000. Secondly *Anthidium manicatum* (L.) was reported by D. Whiteley from a Sheffield garden (SK3388) on 18.vii.2001 and R.M. Smith from the Sheffield urban garden survey on 26.vii.2001 at SK3483. Two further records of *Dolichovespula saxonica* (F.) were reported by R.M. Smith from Sheffield (SK3584) on 15.viii.2001 and by the author at Sand Hutton (SE6958) on 30.vii.2002. *Crossocerus distinguendus* (Morawitz) was recorded again by the author at York Cemetery (SE6150) on 26.vii.2001 and 8.vii.2002. Several specimens of *Tiphia minuta* Vander Linden were found by J.T. Burn near Armthorpe, Doncaster (SE6304) from 14–26.vi.2001. Finally the author found *Crossocerus leucostomus* (L.) at Pollington Quarry, near Snaith (SE6120) on 13.vii.2002. — Dr MICHAEL E. ARCHER, 17 Elmfield Terrace, Malton Road, York, YO31 1EH: *May 6th*, 2003.

Interesting records of aculeate wasps and bees from Lincolnshire. — The following records have been established by the author at Rauceby Warren Nature Reserve, near Sleaford (TF0341): ♀ *Priocnemis coriacea* Dahlbom on 22.v.2001; ♂ *P. gracilis* Haupt on 14.vii.2002; ♀ *Nomada fulvicornis* F. on 22.v.2002. Rauceby Warren lies on sandy warrens overlying limestone formed by glacial melt water. Much of the reserve consists of old sand and gravel pits which were worked between 1920 and 1967. — Dr MICHAEL E. ARCHER, 17 Elmfield Terrace, Malton Road, York YO31 1EH: *May 6th*, 2003.

A further record of the hornet (Vespa crabro L., Hym., Vespidae) in Wiltshire. — A dead queen hornet (*Vespa crabro* L.) was found indoors in Calne, Wiltshire, on 28.iv.2003 by Mrs M.H. Syms. This is the same locality in which Mrs Syms found a previous queen in her garden during May 1997. Archer (1998, *Entomologist's Monthly Magazine*, **134**: 306) in recording the earlier specimen commented on the sparsity of Wiltshire records. — K.G.V. SMITH, 70 Hollickwood Avenue, London, N12 0LT: *May 1st*, 2003.