THE WASPS AND BEES (HYMENOPTERA: ACULEATA) OF ROYDON COMMON IN WATSONIAN WEST NORFOLK

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On the dry sandy heathland of Roydon Common 101 species of aculeate wasps and bees have been found of which 19 are considered to be of national importance. Roydon Common (TF6822) is a nature reserve of the Norfolk Wildlife Trust and a designated National Nature Reserve. The Common is about 7.2km north-east of King's Lynn and is situated on a low sandy ridge of the Greensand Belt. The reserve of about 57ha consists of dry and wet heathland, fen, valley bog, reed swamp and very damp woodland. The study area was restricted to the dry heathland which is dominated by bracken (gradually being removed) and heather with some shrubs, e.g. hawthorn, and trees, e.g. silver birch, particularly on the higher ground. Herbs and bramble are found at the edges of the reserve. These provide food resources of pollen and nectar for the aculeate wasps and bees. Bare ground, associated with the paths and banks, are important nesting areas for the subterranean-nesting species. Wooden fences and discarded tree trunks, an introduced element to the Common, are used by the aerial-nesting species.

Methods

Between 1991 and 2002, the author made twelve visits to the Common distributed throughout the year as follows: May (2 visits), June (3), July (3), August (3) and September (1). During these approximately three hour visits all species of aculeate wasps and bees were recorded and usually collected with a hand net for identification. The walk around the study area was very similar on each visit. The weather during each visit was warm, often hot, and sunny so that conditions were suitable for the activity of aculeate adults. In the following account the nomenclature can be related to Kloet & Hincks (1978). An up-to-date checklist can be found on Bees, Wasps and Ants Recording Society (BWARS) web pages at *http:/www.bwars.com.*

Atmore (1909) gives details of previous work on the aculeates of the King's Lynn area but since these studies do not directly refer to Roydon Common they are not considered further.

Species present and the seasonal progression of species

A full list of recorded species is given in the Appendix. At the family and subfamily 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. They are a similar number of solitary wasp and bee species recorded but more records of solitary bees than solitary wasps (ratio of bees 1.8:1.0 to wasps). Of the solitary wasps the Sphecidae is the dominant family in terms of the number of species and records. Of the solitary bees the dominant subfamilies by number of species are the Andreninae and Halictinae and by number of records the Halictinae followed by the Andreninae and Anthophorinae.

Table 1. Number of wasp and bee species & records from Roydon Common

	Species	Records
Solitary wasps		
Chrysididae	3	5
Pompilidae	10	28
Eumeninae	1	1
Sphecidae	31	94
Total solitary wasps	**45**	**128**
Solitary bees		
Colletinae	5	10
Andreninae	13	23
Halictinae	15	44
Megachilinae	2	3
Anthophorinae	8	20
Total solitary bees	**43**	**100**
Total solitary species	**88**	**228**
Social species		
Vespinae	2	
Apinae	11	
Total social species	**13**	
Total wasps and bees	**101**	

Table 2 shows the number of species recorded and when first recorded for each month. The most productive months for species of solitary wasps were June, July and August with June and July the most productive months for the first recording of species. Species that were most frequently recorded and can be regarded as the common resident species include: the caterpillar hunter *Ammophila sabulosa* usually seen flying low along the sides of paths; the spider-hunters *Episyron rufipes* and *Anoplius viaticus* also associated with paths and with *E. rufipes* forming nesting aggregations in bare banks; the fly hunters *Oxybelus uniglumis* and *Crabro peltarius* which nest in the bare banks; and the weevil hunter *Cerceris arenaria*, the solitary bee hunter *C. rybyensis* and honeybee hunter *Philanthus triangulum* hunting over the heather and nesting on bare slopes or level ground. All these solitary wasps are subterranean nesters.

Table 2. Number of solitary species and months when species were first recorded at Roydon Common

	May	Jun	Jul	Aug	Sep
Number of species					
Wasps	5	21	28	20	7
Bees	14	18	15	15	6
Number of species first recorded					
Wasps	5	19	15	4	2
Bees	14	12	10	7	0

The most productive months for species of solitary bees were from May until August with from May until July being the most productive months for the first recording of species (table 2). The common resident species included: the sweat bees *Halictus confusus, Lasioglossum leucozonium* and *L. punctatissimum* often found in yellow composite flowers; the cuckoo bee *Sphecodes geoffrellus* usually looking for its hosts among the sweat bees; nesting aggregations of *Andrena barbilabris* in loose sand attended by its cuckoo *Sphecodes pellucidus*; *Colletes succinctus* and *Andrena fuscipes* collecting pollen from heather flowers; the cuckoo bee *Epeolus cruciger* searching for the nests of its host *Colletes succinctus*; and *Colletes fodiens* often associated with composite flowers, its cuckoo is *Epeolus variegatus*. Again all these host bees are subterranean nesters.

Table 3 shows the number of species of solitary wasps and bees recorded on each visit. The total number for each visit varied from nine to twenty seven. Since the weather was always suitable for adult activity, the visits when the higher number of species were recorded were probably a consequence of visits coinciding with the adult emergence of several species when the numbers representing each species would be higher.

Table 3. Number of species of solitary wasps and bees recorded on each visit to Roydon Common

	Wasps	Bees	Total
12 May 2000	1	8	9
23 May 1992	5	7	12
5 June 1993	10	13	23
13 June 1994	5	7	12
24 June 2002	10	9	19
2 July 1991	11	4	15
18 July 1996	18	9	27
22 July 1997	14	7	21
12 August 1995	4	7	11
13 August 2002	11	8	19
28 August 1998	15	9	24
3 September 2002	7	6	13

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 species are present at the site, but as yet unrecorded. Recent advances in non-parametric statistical procedures offer a way of addressing this problem. Chao (in Colwell & Coddington, 1994) and Heltshe & Forrester (1983) describe procedures to estimate the potential number of species (species richness) likely to be found on a site after a number of samples have been taken. The presence/absence quantitative estimate of Chao is based on the number of species that are recorded in one (unique species) or two (two-occasion species) samples. The Jackknife estimate of Heltshe and Forrester is based only on the unique species. Because some aculeate species are only active in the spring or summer it is advisable that sampling is distributed throughout the months of adult activity. The software to carry out these statistical procedures was provided

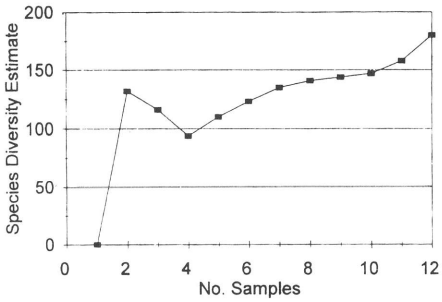
by Pisces Conservation Ltd.

The two statistical procedures were run with the samples, or visits. In practice the software takes 1, 2, etc. samples at random, each time calculating a mean estimate of species richness. The procedures are continuously repeated dependent on the number of samples. With a small number of samples the estimates are erratic, but as more samples are selected these may stabilise, giving confidence in them. The estimates for the two procedures are given in figs 1 and 2. The estimates of species richness with 95% confidence limits after 12 samples are given in table 4. The estimates do not stabilise (figs 1 & 2) and the estimates of the two procedures widely differ from each other (table 4). Why should this be so?

Table 4. Non-parametric estimates of species ricjness at Roydon Common

	Chao estimate	Jacknife estimate
All species		
No. species recorded	88	88
No.species estimated	180	129
95% confidence limits	117-243	115-143
% estimated species recorded	48.9	68.2
Tourist species removed		
No. species recorded	60	60
No. species estimated	87	80
95% confidence limits	60-114	68-92
% estimated species recorded	69.0	75.0

The statistical answer is the very high number of unique species that were recorded. Of the 88 solitary species recorded 45 species (51.1%) were unique species. From previous sandy sites that have been investigated by the author usually only up to about one-third of the species are unique species. For example, Devil's Spittleful nature reserve in Worcestershire had 34.9% (Archer, in press), Sherwood Forest in Nottinghamshire 26.3% (Archer, 1996), Risby Warren in Lincolnshire 25.4% (Archer, 1994) and Strensall Common in Yorkshire 27.8% (Archer, 1988) unique species. The question is now why should Roydon Common have such a high percentage of unique species?



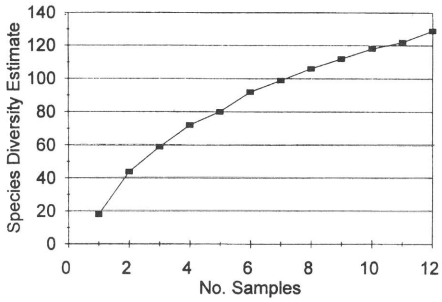


Figure 1. Chao estimate of species diversity for all species recorded from Roydon Common

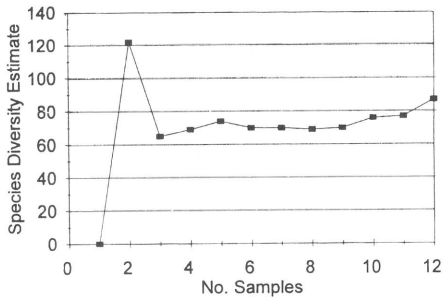
Figure 2. Jacknife estimate of species diversity for all species recorded from Roydon Common

Recorded species at any site can be resident, tourist or vagrant species. Resident species obtain all their resources, mainly nesting sites and food, from the site under study, while tourist species, although living in the geographical area of the study site, do not normally obtain their resources from there. Vagrant species which are usually found beyond the geographical area of the study site, often in another county or even country, were not found at Roydon Common.

It is often difficult to separate resident and tourist species. Probably tourist species will tend to be unique species, or found on few occasions, as only small numbers would be expected to be present on the site and hence unlikely to be found. Unfortunately unique species could also be rare resident species, which again have small numbers on site and hence are unlikely to be found. It is therefore necessary to generate more specific arguments to separate rare residents from tourist species.

Four suggestions can be proposed to separate out some tourist species. **1.** Species that are generally common and widespread and would have been expected to be found on several visits if they were resident species, e.g. *Arachnospila anceps, Crossocerus pusillus, Andrena haemorrhoa* and *Lasioglossum calceatum*. **2.** Parasitic species whose host(s) is (are) either tourist species or were not recorded, e.g. *Nysson dimidiatus, Nomada marshamella* and *Sphecodes monilicornis*. **3.** Species associated with a different habitat, e.g. *Hylaeus pectoralis,* which is a fenland species. **4.** Dead wood is not characteristically present on dry lowland heaths so dead wood nesters can be considered tourist species, e.g. *Crossocerus megacephalus, Ectemnius cavifrons, Megachile versicolor* and *Anthophora furcata.* Some dead tree stumps had been introduced to the reserve and dead wood was present in areas just outside the reserve. Using these four criteria, 28 species can be considered tourist species of which 25 species were unique species.

The two statistical procedures for estimating species diversity were now re-run with the tourist species removed. The species estimates are given in figs 3 and 4. and the species estimates with 95% confidence limits after 12



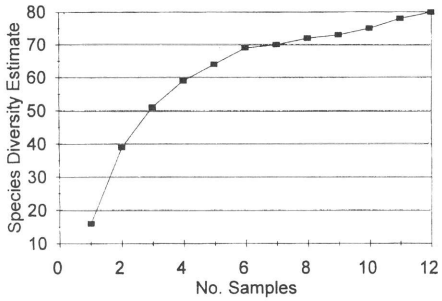


Figure 3. Chao estimate of species diversity with tourist species removed from Roydon Common

Figure 4. Jacknife estimate of species diversity with tourist species removed from Roydon Common

samples are given in table 4. The final two estimates are now closer together (table 4) indicating a resident population of about 80-90 solitary species. However, the species estimates do not stabilise (figs 3 & 4). Further visits should now be made to increase the sample size, learn more about the tourist species and obtain a stable estimate of the resident population size.

Quality assessment of the solitary species

According to Shirt (1987) the following eight species are Red Data Book species: *Podalonia affinis, Argogorytes fargeii, Cerceris quinquefasciata, Philanthus triangulum, Andrena tibialis, Halictus confusus, Lasioglossum brevicorne* and *Sphecodes reticulatus.* According to Falk (1991) three of these Red Data Book species should be downgraded to national scarce status: *Argogorytes fargeii, Andrena tibialis* and *Sphecodes reticulatus*, and a five further species should be given national scarce status: *Evagetes dubius, Andrena argentata, A. bimaculata, Sphecodes crassus* and *Megachile leachella*. Recent work by the Bees, Wasps and Ants Recording Society indicates that a further seven species are of national importance: *Priocnemis susterai, Anoplius viaticus, Tachysphex nitidus, Diodontus tristis, Ammophila pubescens, Nysson dimidiatus* and *Hylaeus pectoralis*, while *Philanthus triangulum* should lose its status of national importance. Nineteen solitary species of national importance have been recorded from Roydon Common. None of the social species (Vespinae, Apinae) recorded were of national importance.

Table 5. Archer national quality scores of solitary species recorded from Roydon Common

National status	Status value (A)	No. species (B)	Quality scores (A x B)
Universal	1	43	43
Widespread	2	24	48
Restricted	4	2	8
Scarce	8	12	96
Rare	16	5	80
Very rare	32	2	64
Total		**88**	**339**

Species Quality Score 339/88 = 3.9

By giving each of the 88 solitary species an Archer national status (Archer 1999, 2002b), a national quality score of 339 and a national species quality score (SQS) of 3.9 can be calculated (table 5). Archer (1999) showed that although quality scores are influenced by the area of sites the SQSs are relatively independent of site areas so SQSs can be used to compare sites without regard to site areas. How then does the SQS of Roydon Common compare with other inland sandy sites in England?

Table 6 shows some SQSs from the best inland sandy sites from south-east England (Surrey, West Sussex), Midlands (Worcestershire, Nottinghamshire), East Anglia, Yorkshire and Lincolnshire. The SQS for Roydon Common is similar to the SQSs of the other two East Anglia sites. The three East Anglia sites have values intermediate between SQSs from the Midlands and south-east England. Roydon Common can be considered amongst the best inland sandy sites for solitary wasps and bees in England.

Table 6. Species quality scores of solitary wasp and bee species from English sandy sites

	Species quality score
Bagmoor Common, Surrey[1]	4.7
Ambersham Common, West Sussex[2]	4.5
Iping Common, West Sussex[2]	4.5
Elvedon Center Parc, Suffolk[3]	4.0
Santon Downham, Norfolk[3]	3.9
Roydon Common, Norfolk	3.9
Hartlebury Common, Worcestershire[4]	3.4
Sherwood Forest, Nottinghamshire[5]	3.0
Devil's Spittleful, Worcestershire[6]	2.6
Strensall Common, Yorkshire[7]	2.5
Crow Wood, Yorkshire[8]	2.5
Blaxton Common, Yorkshire[9]	1.9
Messingham Sand Quarry, Lincolnshire[10]	1.9
Kirkby Moor, Lincolnshire[11]	1.9
Risby Warren, Lincolnshire[12]	1.8

1 (Archer, 2000), 2 (Archer & Edwards, 2002), 3 (See acknowledgements), 4 (Archer, 2002a), 5 (Archer, 1996), 6 (Archer, in press), 7 (Archer, 1988), 8 (Archer & Burn, 1995), 9 (Archer, 1995), 10 (Archer, 2003), 11 (Archer, 2001), 12 (Archer, 1994).

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, except hot deserts 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%. As such, CLs for sites in Britain should have similar values. For the north Midlands and north England, the CLs for species of solitary bees varies from 21.7%-36.6% (range 14.9%) (Archer, 1999). The CL for Roydon Common (table 7) falls within this range and therefore supports Wcislo's hypothesis.

Wcislo (1987) gives no CLs for wasps, but Archer (1999) found that CLs of solitary wasps for sites from north Midlands and north England varies from 10.3%-22.2%. The CL for Roydon Common (table 7) falls within this range. Thus Wcislo's hypothesis can also be applied to solitary wasps.

Table 7. Relative frequency of the cleptoparasitic (or parasitoid) species among the solitary species recorded from Roydon Common

	No. hosts (H)	No. cleptoparasites (C)	Cleptoparasitic Load CL = 100 x C/(H+C)
Solitary wasps	38	7	15.6%
Solitary bees	30	13	30.2%

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 plant stem cavities (e.g. bramble), old snail shells, or crevices in 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 8. Nesting habits of the solitary species from Roydon Common

	No. aerial nesters (A)	No. subterranean nesters (S)	Aerial Nester Frequency AF = 100 x A/(A+S)
Solitary wasps	6	32	15.8%
Solitary bees	5	25	16.7%

The AFs for the solitary wasp and bee species are given in table 8. 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 wasps of Roydon Common is much lower than the national value which indicates the lack of dead wood in sunny situations. The AF for the solitary bees is similar to the British AF despite the lack of dead wood on the reserve. It is possible that because wood-nesting bees are physically larger than wood-nesting wasps they are more ably to fly onto the reserve as tourist species. This would explain the higher value of the AF of the solitary bees.

Summary

Roydon Common:

1. has 101 recorded species of aculeate wasps and bees, of which 19 species are of national importance;

2. has an unusually large number of 45 solitary species (51.1%) only recorded on one occasion, of which at least 25 species were considered to be tourist species;

3. has a tentative estimate of 80 to 90 resident solitary species although further recording is recommended;

4. has a species quality score that might be expected of the best inland sandy sites in East Anglia;

5. has solitary wasp and bee cleptoparasitic loads similar to other sites as predicted by Wcislo (1987); and

6. has a low aerial nester frequency for solitary wasp species due to the lack of dead wood. The aerial nesting solitary bee species are considered to be tourist species.

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Appendix

Chrysididae. *Elampus panzeri* (Fab.), *Chrysis impressa* Schenck, *Trichrysis cyanea* (L.).

Pompilidae. *Priocnemis susterai* Haupt, *Agenioideus cinctellus* (Spinola), *Pompilus cinereus* (Fab.), *Episyron rufipes* (L.), *Anoplius infuscatus* (Vander Linden), *A. viaticus* (L.), *Arachnospila anceps* (Wesmael), *A. spissa* (Schiødte), *Evagetes crassicornis* (Shuckard), *E. dubius* (Vander Linden).

Eumeninae. *Ancistrocerus parietum* (L.).

Vespinae. *Vespula rufa* (L.), *V. vulgaris* (L.).

Sphecidae. *Astata boops* (Schrank), *Dryudella pinguis* (Dahlbom), *Tachysphex nitidus* (Spinola), *Trypoxylon medium* de Beaumont, *Crabro cribrarius* (L.), *C. peltarius* (Schreber), *Crossocerus pusillus* Lepeletier & Brullé, *C. tarsatus* (Shuckard), *C. wesmaeli* (Vander Linden), *C. megacephalus* (Rossi), *C. quadrimaculatus* (Fab.), *Ectemnius cavifrons* (Thomson), *E. continuus* (Fab.), *Lindenius albilabris* (Fab.), *Oxybelus uniglumis* (L.), *Mimesa equestris* (Fab.), *M. lutaria* (Fab.), *Diodontus minutus* (Fab.), *D. tristis* (Vander Linden), *Passaloecus gracilis* (Curtis), *Ammophila pubescens* Curtis, *A. sabulosa* (L.), *Podalonia affinis* (Kirby), *Mellinus arvensis* (L.), *Nysson dimidiatus* Jurine, *N. spinosus* Forster, *Argogorytes fargeii* (Shuckard), *Cerceris arenaria* (L.), *C. quinquefasciata* (Rossi), *C. rybyensis* (L.), *Philanthus triangulum* (Fab.).

Colletinae. *Colletes fodiens* (Geoffroy *in* Fourcroy), *C. succinctus* (L.), *Hylaeus brevicornis* Nylander, *H. confusus* Nylander, *H. pectoralis* Förster.

Andreninae. *Andrena fucata* Smith, *A. scotica* Perkins, *A. bicolor* Fab., *A. nigroaenea* (Kirby), *A. fuscipes* (Kirby), *A. haemorrhoa* (Fab.), *A. bimaculata* (Kirby), *A. tibialis* (Kirby), *A. argentata* Smith, *A. barbilabris* (Kirby), *A. dorsata* (Kirby), *A. ovatula* (Kirby), *A. wilkella* (Kirby).

Halictinae. *Halictus confusus* Smith, *Lasioglossum leucozonium* (Schrank), *L. albipes* (Fab.), *L. brevicorne* (Schenck), *L. calceatum* (Scopoli), *L. punctatissimum* (Schenck), *L. villosulum* (Kirby), *L. leucopus* (Kirby), *L. morio (Fab.), Sphecodes crassus* Thomson, *S. ephippius* (L.), *S. geoffrellus* (Kirby) (=*fasciatus), S. monilicornis* (Kirby), *S. pellucidus* Smith, *S. reticulatus* Thomson.

Megachilinae. *Megachile versicolor* Smith, *M. dorsalis* Pérez (=*leachella*).
Anthophorinae. *Nomada flava* Panzer, *N. goodeniana* (Kirby), *N. leucophthalma* (Kirby), *N. marshamella* (Kirby), *N. rufipes* Fab., *Epeolus cruciger* (panzer), *E. variegatus* (L.), *Anthophora furcata* (Panzer).

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

Miscellaneous observations

Swallowtails *Papilio machaon*. It is well known that there can be a wide variation in size between adults in many species of insect, not just over their entire range but often at the same locality. This can be due to genetic differences between individuals or simply because the larva of one fed on a more nutritious source than another. While unusually large individuals are very rare, particularly small (or runt) examples do occur from time to time. I came across such an individual on 20th July 2000 while looking at the butterflies feeding from hemp-agrimony *Eupatorium cannabinum* flowerheads at Sutton High Fen. As well as a few green-veined whites *Pieris napi,* small tortoiseshells *Aglais urticae* and a single worn painted lady *Cynthia cardui,* there were two swallowtails. One was a standard sized individual, but the other was startlingly small and only just larger than a small tortoiseshell it was feeding next to.

A huge range of creatures predate the caterpillars of butterflies and moths. In the case of the swallowtail about 90% of larvae succumb to attacks by spiders, particularly in the early instar stages. Despite their camouflage and