

THE ACULEATE WASPS AND BEES (HYM., ACULEATA) OF  
SHERWOOD FOREST IN NOTTINGHAMSHIRE  
AND THE DEVELOPMENT OF A NATIONAL  
QUALITY ASSESSMENT SCHEME

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Sherwood Forest has been found to be an excellent locality for aculeate wasps and bees, having 114 recorded species, including ten species of national and five species of regional significance.

Sherwood Forest lies to the north of Edwinstowe, Nottinghamshire (VC56). The area studied, which is only a remnant of the historic Sherwood Forest, is enclosed within the grid references SK6167, SK6267, SK6269 and SK6169. The study area was about 390 hectares, at an altitude of c.60–80 m. The northern part of the study area, called Budby South Forest, is predominantly open grassland and heathland while the southern part, called Birklands and Sherwood Country Park, is predominantly wooded.

The soils, which are derived from the Triassic Bunter Pebble Beds, are freely-draining, acidic and sandy. The vegetation consists of oak-birch woodlands, acid grassland, bracken and lowland heath. The woodland includes an exceptional population of ancient standing oaks. These oaks, often in sheltered sunny situations, are used as nesting sites for aerial nesting wasps and bees. Open flat or banked sandy areas are present. Some of these banks, in sheltered sunny situations, are important nesting sites for subterranean nesting wasps and bees. Flowering shrubs, e.g. hawthorn, and herbs, are important pollen and nectar sources.

Between 1985 and 1992, I made 17 visits to Sherwood Forest although six of these visits were either brief or spoiled by poor weather conditions. Visits were distributed through the year: April (1 visit), May (2), June (5), July (6), August (3). During visits all species of aculeate wasps and bees (usually collected with a hand net for later identification), were recorded (Archer sample, AS). All relevant solitary wasp and bees specimens from Nottingham Museum were examined in April 1992 (museum sample, MS). The Keeper of Biology, Dr Sheila Wright, was extremely helpful, especially in making me aware that specimens bearing the label "Sherwood, Nottingham" referred to a district of the city of Nottingham and not to Sherwood Forest! Further records were found in the literature (Carr, 1916, 1935, Jones 1931) (literature sample, LS). Many literature records were found in the museum collections, with only one mis-identification: a male *Hylaeus hyalinatus* (Smith) from Sherwood Forest, 22–26 July 1912 from the Local Collection, was misidentified as *H. communis* Nylander.

In the following account biological names are according to Fitton *et al.* (1978).

## SPECIES PRESENT AT SHERWOOD FOREST

At the family level the taxonomic distribution is given in Table 1. A total of 114 species (100 solitary and 14 social species) were recorded. In addition five species of ants: *Myrmica ruginodis* Nylander, *Leptothorax acervorum* (F.), *Formica fusca* L., *Lasius flavus* (F.) and *L. fuliginosus* (Latreille), have been recorded, giving a total of 119 aculeate species. This represents 22.6% of the British Fauna.

TABLE 1. — THE NUMBER OF SPECIES OF ACULEATE WASPS AND BEES RECORDED IN EACH FAMILY FROM THE ARCHER, MUSEUM AND LITERATURE SAMPLES.

Family	Archer	No. species		Total
		Museum	Literature	
Solitary wasp species:				
Chrysididae	6	1	4	8
Pompilidae	9	0	2	9
Eumenidae	1	0	2	3
Sphecidae	23	8	15	32
Total	39	9	23	52
Solitary bee species:				
Colletidae	4	1	0	5
Andrenidae	12	5	5	14
Halictidae	13	7	7	16
Megachilidae	1	2	3	4
Anthophoridae	7	3	4	9
Total	37	18	19	48
Social wasp & bee species:				
Vespidae	5	-	2	5
Apidae	8	-	1	9
Total	13	-	3	14

The Archer sample of solitary wasp and bee species consists of 272 records derived from 76 species (Table 2). Forty-four species (57.9%) were recorded on one, two or three days while the other 32 species (42.1%) were recorded on from four to eleven days. For over half the species the probability of finding any particular one of them on any occasion is very small (0.004–0.01 per species).

The 24 species of solitary wasps and bees found in the museum or literature samples, but not in the Archer sample, are given in Table 3. Some of these species which nationally are regarded as common species, e.g. *Crabro cribrarius* (L.), *Pemphredon lugubris* (F.), *Sphecodes monilicornis* (Kirby), *Osmia rufa* (L.), should still be present at Sherwood Forest. I have not found these species presumably because of the small probability of finding most species.

The social wasp species found were *Vespa crabro* (L.), *Dolichovespula sylvestris* (Scopoli), *Vespula rufa* (L.), *Paravespula germanica* (F.) and *P. vulgaris* (L.). The social bee species found were *Bombus lucorum* (L.), *B.*

TABLE 2. — THE NUMBER OF DAYS ON WHICH EACH SPECIES OF SOLITARY WASP AND BEE SPECIES WAS RECORDED AT SHERWOOD FOREST IN THE ARCHER SAMPLE.

Nomenclature according to Fitton *et al.* (1978) but authors' names are omitted.

No. records	No. days	Species	No. species
20	1	<i>Omalus panzeri</i> , <i>Chrysis rutiliventris</i> , <i>Dipogon variegatus</i> , <i>Priocnemis fennica</i> , <i>P. parvula</i> , <i>P. schioedtei</i> , <i>Trypoxylon figulus</i> , <i>Crossocerus pusillus</i> , <i>C. megacephalus</i> , <i>Passaloecus corniger</i> , <i>Gorytes quadrifasciatus</i> , <i>Colletes daviesanus</i> , <i>Hylaeus brevicornis</i> , <i>Andrena fucata</i> , <i>A. barbilabris</i> , <i>A. falsifica</i> , <i>Lasioglossum calceatum</i> , <i>Sphecodes gibbus</i> , <i>S. puncticeps</i> , <i>Megachile versicolor</i> .	20
22	2	<i>Chrysis ignita</i> , <i>Crabro peltarius</i> , <i>Crossocerus tarsatus</i> , <i>C. annulipes</i> , <i>Ectemnius ruficornis</i> , <i>Psen lutarius</i> , <i>Andrena fulva</i> , <i>A. wilkella</i> , <i>Sphecodes pellucidus</i> , <i>Nomada panzeri</i> , <i>Epeolus variegatus</i> .	11
39	3	<i>Arachnospila spissa</i> , <i>Ancistrocerus trifasciatus</i> , <i>Crossocerus cetratus</i> , <i>Mellinus arvensis</i> , <i>Argogorytes mystaceus</i> , <i>Colletes succinctus</i> , <i>Hylaeus communis</i> , <i>Andrena nigroaenea</i> , <i>A. fuscipes</i> , <i>Halictus rubicundus</i> , <i>Sphecodes fasciatus</i> , <i>Nomada marshamella</i> , <i>Epeolus cruciger</i> .	13
52	4	<i>Chrysis angustula</i> , <i>Evagetes crassicornis</i> , <i>Ectemnius cavifrons</i> , <i>Oxybelus uniglumis</i> , <i>Psen dahlbomi</i> , <i>Psenulus atratus</i> , <i>Andrena lapponica</i> , <i>A. denticulata</i> , <i>Lasioglossum leucozonium</i> , <i>L. fratellum</i> , <i>L. punctatissimum</i> , <i>Nomada lathburiana</i> , <i>N. rufipes</i> .	13
25	5	<i>Crossocerus quadrimaculatus</i> , <i>Lindenius albilabris</i> , <i>Lasioglossum rufitarse</i> , <i>L. leucopum</i> , <i>Nomada goodeniana</i> .	5
30	6	<i>Chrysis impressa</i> , <i>C. cyanea</i> , <i>Arachnospila anceps</i> , <i>Trypoxylon clavicerum</i> , <i>Andrena cineraria</i> .	5
14	7	<i>Psen equestris</i> , <i>Andrena scotica</i> .	2
18	9	<i>Ammophila sabulosa</i> , <i>Andrena haemorrhoa</i> .	2
30	10	<i>Dipogon nitidus</i> , <i>Priocnemis susterae</i> , <i>Crossocerus ovalis</i> .	3
22	11	<i>Halictus tumulorum</i> , <i>Lasioglossum villosulum</i> .	2

TABLE 3. — SPECIES OF SOLITARY ACULEATE WASPS AND BEES RECORDED AT SHERWOOD FOREST FROM THE MUSEUM (MS) OR LITERATURE (LS) SAMPLES BUT NOT IN THE ARCHER SAMPLE.

Nomenclature according to Fitton *et al.* (1978), but authors' names are omitted.Chrysididae — *Omalus auratus* (MS), *Cleptes semiauratus* (LS).Eumenidae — *Ancistrocerus oviventris* (LS), *A. parietinus* (LS).Sphecidae — *Crabro cribrarius* (LS), *Crossocerus dimidiatus* (MS, LS), *Rhopalum clavipes* (MS, LS), *Psen bicolor* (LS), *Pemphredon lugubris* (LS), *P. inornata* (MS, LS), *P. lethifer* (MS, LS), *Mellinus sabulosa* (MS, LS), *Nysson spinosus* (MS, LS).Colletidae — *Hylaeus hyalinatus* (MS).Andrenidae — *Andrena pilipes* (LS), *A. saundersella* (MS, LS).Halictidae — *Lasioglossum lativentris* (MS), *L. quadrinotatum* (MS, LS), *Sphecodes monilicornis* (MS, LS).Megachilidae — *Chelostoma florissomne* (MS, LS), *Osmia rufa* (MS, LS), *Megachile centuncularis* (LS).Anthophoridae — *Anthophora plumipes* (LS), *A. furcata* (LS).

*terrestris* (L.), *B. lapidarius* (L.), *B. pratorum* (L.), *B. pascuorum* (Scopoli), *Psithyrus bohemicus* (Seidl), *P. rupestris* (F.) (literature record), *P. sylvestris* Lepeletier and *Apis mellifera* L. *Vespa crabro* seems to be a new immigrant to Sherwood Forest with the first colony found during 1986 in the Country Park. By 1992 the hornet had spread to Budby South Forest.

#### SEASONAL PROGRESSION OF SOLITARY SPECIES

From the Archer sample the number of solitary species recorded each month and the new species seen each month are given in Table 4. The most productive months for numbers of species were June and July and for new species April, June and July.

TABLE 4. — THE NUMBER OF SPECIES OF SOLITARY WASPS AND BEES RECORDED PER MONTH AND NEW SPECIES SEEN EACH MONTH AT SHERWOOD FOREST FROM THE ARCHER SAMPLE.

	April	May	June	July	August
No. species	12	17	57	39	21
No. new species	12	8	38	13	5

The April peak is due to the appearance of the mining bees *Andrena*, *Halictus*, and *Lasioglossum* with their cleptoparasites *Sphecodes* and *Nomada*. Numbers of *A. haemorrhoa* (F.) and *A. scotica* Perkins can become high on the hawthorn blossom. The spring species of *Andrena* and their cleptoparasites continue into May with the appearance of additional species, but these species complete their adult life cycle by the end of June. Also during April the spider hunting wasp *Priocnemis susterai* Haupt appears and remains a conspicuous species until the end of July. The longer cycle species of *Halictus*, e.g. *H. tumulorum* (L.), and further *Lasioglossum*, e.g. *L. villosulum* (Kirby), which appear in June, continue until August.

With June comes the appearance of solitary wasp species, including the aerial nesting spider hunting wasp *Dipogon nitidus* (Haupt), the fly hunter *Crossocerus ovalis* Lepeletier & Brullé, the homopteran bug hunter *Psen equestris* (F.) and the caterpillar hunter *Ammophila sabulosa* (L.). During July the summer *Andrena* species *A. denticulata* (Kirby) and *A. fuscipes* (Kirby) and their cleptoparasite *Nomada rufipes* F., and *Colletes* spp. and their cleptoparasites *Epeolus* and *Hylaeus* appear.

#### QUALITY ASSESSMENT OF SPECIES

Three species found in Sherwood Forest are nationally rare or Red Data Book species (Falk, 1991). *Mellinus sabulosa* (F.) was last seen in 1926 and is now considered extinct in the British Isles. *Psen bicolor* Jurine has not been seen since 1919 but could still be present as it was found in South

Yorkshire during 1979. *Nomada lathburiana* (Kirby) was found in the current survey.

Seven species are nationally scarce or notable species. Two of these species are category A species: *Andrena falsifica* Perkins seen in the current survey, and *Lasioglossum quadrinotatum* (Kirby) last seen in the 1920s. The other five species are category B species: *Cleptes semiauratus* (L.) not seen since 1919 but which might be present: *Priocnemis schiodtei* Haupt and *Ectemnius ruficornis* (Zetterstedt) seen in the current survey; and *Andrena pilipes* F. and *Psithyrus rupestris* (F.) both unseen since the 1920s, and probably locally extinct.

Five species are of regional importance as rarities: *Priocnemis susterai*, *Psen lutarius* (F.), *Hylaeus brevicornis* Nylander and *Sphecodes puncticeps* Smith. These were all seen in the current survey. *Lasioglossum lativentre* (Schenck) has not been seen since 1924.

TABLE 5. — THE REGIONAL STATUS CODING OF THE 100 SPECIES OF SOLITARY WASPS AND BEES RECORDED FROM SHERWOOD FOREST.

Status	No. species
Common	44
Frequent	30
Occasional	15
Rare	11

The 100 recorded species of solitary wasps and bees can each be considered to have a common, frequent, occasional or rare status in a regional context. Since such a status coding does not exist for Watsonian Nottinghamshire I have used the codings for Watsonian Yorkshire (Archer, 1993a) (Table 5). One species, *Lasioglossum lativentre*, has not been recorded in Watsonian Yorkshire and it has been coded rare. The nine nationally scarce and rare species, which regionally include one common, two frequent and six rare species, are given a different status (Table 6). By giving each species a score depending on its status, a quality score of 391 can be calculated for Sherwood Forest (Table 6). Dividing the quality

TABLE 6. — THE REGIONAL QUALITY SCORES OF THE SPECIES OF SOLITARY WASPS AND BEES FROM SHERWOOD FOREST.

Status	Status score (A)	No. species (B)	Quality score (A × B)
Common	1	43	43
Frequent	2	28	56
Occasional	4	15	60
Rare	8	5	40
Nationally scarce	16	6	96
Nationally rare	32	3	96

score by the 100 recorded species gives a species quality score of 3.9. If the nationally rare extinct species, *Mellinus sabulosa*, is removed the quality score becomes 359 and the species quality score 3.6. A species quality score of two or more indicates a good quality locality (Foster & Eyre, 1992).

TABLE 7. — THE NATIONAL QUALITY SCORE OF THE SPECIES OF SOLITARY WASPS AND BEES FROM SHERWOOD FOREST.

Status	Status score (A)	No. species (B)	Quality score (A × B)
Nationally common	1	62	62
Nationally local	2	24	48
Regionally notable	4	5	20
Nationally scarce B	8	4	32
Nationally scarce A	16	2	32
Nationally rare	32	3	96

Ball (1992) proposed a status category scheme for invertebrates in a national context (Table 7). Since such a status coding has not previously been applied solely to the aculeate Hymenoptera of a particular locality, the following proposals can be made. The nationally rare and scarce statuses will remain the same as previously considered. The regionally notable species are equated with the regionally rare species. Ball (1993, pers. comm.) defined the term "local" as a species either restricted to a particular habitat type or to a particular geographical area, or to widespread species which are intermediate in status between common and scarce species. At present there is no objective way of assigning a common or local status to the species of the British aculeate Hymenoptera. From personal experience I have therefore assigned common or local status based upon abundance and distribution within England and Wales. Ireland has not been included as little information is available on Irish distributions. The Channel Islands have not been included as their fauna relates more to France than to the British Isles. Scotland has not been included because its cooler climate has a profound effect in reducing the diversity of aculeate Hymenoptera. Using a national status scheme a quality score of 290 and species quality score of 2.9 can be calculated for Sherwood Forest (Table 7). If *Mellinus sabulosa* is removed the quality score becomes 258 and species quality score 2.6.

The quality score and species quality score of the national scheme are lower than those of the regional scheme because of the differences in weightings of the statuses. However, both species' quality scores exceed a value of 2.0 so indicating a good quality locality (Foster & Eyre, 1992).

#### CLEPTOPARASITIC LOAD

The cleptoparasitic load (CL) is the percentage of aculeate species that are cleptoparasites or parasites on other host aculeates (Table 8). The CL for the species of solitary bees is higher than the CL for the solitary wasps.

TABLE 8. — THE RELATIVE FREQUENCIES OF THE CLEPTOPARASITIC SPECIES AMONG THE SOLITARY WASPS AND BEES FROM SHERWOOD FOREST.

	No. hosts (H)	No. cleptoparasites (C)	Cleptoparasitic Load $CL = \frac{100 \times C}{H + C}$
Solitary wasps	42	9	17.6
Solitary bees	36	12	25.0

The CLs for the British solitary wasp species (17.8%) and bee species (26.0%) are very similar to the CLs of Sherwood Forest.

## AERIAL NESTER FREQUENCY

The aerial nester frequency (AF) is the percentage of host aculeate species that have aerial nest sites. Aerial nests are often in old beetle burrows in dead wood or the central cavities of stems such as those of bramble. Subterranean nesters nest in the soil, usually in burrows dug by themselves, but sometimes in crevices or pre-formed burrows (Table 9).

The AF for the species of solitary wasps is much higher than the AF for the solitary bees. Again the AFs for the British solitary wasp species (44.9%) and bee species (19.0%) are very similar to the AFs of Sherwood Forest.

TABLE 9. — THE NESTING HABITS OF THE HOST SOLITARY WASP AND BEE SPECIES FROM SHERWOOD FOREST.

	No. aerial nesters (A)	No. subterranean nesters (S)	Aerial nester frequency $AF = \frac{100 \times A}{A + S}$
Solitary wasps	20	22	47.6
Solitary bees	7	29	19.4

## DISCUSSION

*Quality Assessment*

At the regional level the quality scores of Sherwood Forest may be compared with those of the heathland Commons of the Vale of York (Archer, 1992a, 1993b). These Commons are characterised by having sandy soils and, except for coniferized Allerthorpe Common, dead wood and stem nesting sites. The species quality score corrects for differences in areas and survey effort between the four localities.

At a regional level Sherwood Forest is an important locality with a species quality score higher than or similar to the three Yorkshire localities (Table 10). The high score is mainly due to a higher number of nationally scarce and rare species recorded in the past. It is a pity that some of these scarce and rare species are or may now be extinct.

TABLE 10. — A COMPARISON OF THE REGIONAL QUALITY SCORES BETWEEN THE THREE HEATHLAND COMMONS OF THE VALE OF YORK AND SHERWOOD FOREST BASED ON THE SPECIES OF SOLITARY WASPS AND BEES.

	Sherwood Forest	Pre-coniferized Allerthorpe Common	Strensall Common	Coniferized Allerthorpe Common	Skipwith Common
Area (ha.)	390	2030	690	2030	312
No. species	100	129	91	75	69
No. regional rarities	5	6	5	2	2
No. national scarce & rare spp.	10	10*	6	3	2
Quality score	391	514	289	212	149
Species quality score	3.9	4.0	3.2	2.8	2.2

\*Correction to Archer, 1989, where *Mellinus sabulosa* was wrongly coded.

The quality scores of Sherwood Forest are the only national level values that have been calculated for the solitary wasp and bee species. Further national quality scores can be readily calculated for pre-coniferized Allerthorpe and Strensall Commons (Table 11). National quality scores have also been calculated for Duncombe Park, Helmsley, Yorkshire which, although a clay locality, has much dead wood (Archer, 1993b) so that a comparison with Sherwood Forest is justified.

TABLE 11. — A COMPARISON OF THE NATIONAL QUALITY SCORES BETWEEN SHERWOOD FOREST AND YORKSHIRE AND LEICESTERSHIRE LOCALITIES BASED ON THE SPECIES OF SOLITARY WASPS AND BEES.

	Sherwood Forest	Pre-coniferized Allerthorpe Common	Strensall Common	Duncombe Park	Charnwood Forest	Leicester Garden
No. species	100	129	91	69	147	71
No. regional rarities	5	6	5	0	4	4
No. national scarce spp.	7	5	4	6	8	1
No. national rare spp.	3	5	2	0	4	0
Quality score	290	381	215	134	408	101
Species quality score	2.9	3.0	2.4	1.9	2.8	1.4

The problem of calculating national quality scores for other localities in England and Wales is the lack of knowledge of the number of the regional notable or rare species. Archer (1990a) reviewed the records of solitary wasp and bee species of Leicestershire. A first estimate of the regional rare species of Leicestershire has been made based on those species that were recorded from one or two localities. National quality



scores then can be calculated for Charnwood Forest (Archer, 1992b) and a Leicester garden (1990b) (Table 11). Charnwood Forest is very similar to Sherwood Forest in having sandy soils and dead wood and stem nesting sites but is much larger in area and at a higher altitude of about 120 m to 250 m. The Leicester garden is a very small locality (688 m<sup>2</sup>) with aerial nesting sites but with a disturbed non-sandy soil.

The species quality scores of Sherwood and Charnwood Forests are similar (Table 11). The larger number of species from and higher quality score of Charnwood Forest reflects its larger area and the greater recording effort it has received.

The species quality scores of Sherwood Forest, pre-coniferized Allerthorpe and Strensall Commons are similarly ranked compared with the regional scheme (Table 10) indicating that the coding systems at the regional and national levels are measuring the same qualities. The species quality score of Duncombe Park is smaller due to the absence of national rarities. The Leicester garden has the smallest quality score because of the lack of national scarce and rare species.

#### *Cleptoparasitic Loads*

Weislo (1987) showed that parasitic 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. As such, CLs for localities in England and Wales should have similar values. Table 12 shows the CLs for the heathlands of the Vale of York and two other localities for comparison with Sherwood Forest. The CLs separately for the solitary wasp and bee species are of similar values except for the solitary bees from Duncombe Park. The low CL from Duncombe Park was due to the failure to find cleptoparasites of the genus *Sphecodes*. This is rather surprising as some of the host species, *Halictus rubicundus* (Christ), *Lasioglossum calceatum* (Scopoli) and *L. cupromicans* (Perez), were often encountered. The CLs for Sherwood and Charnwood forests are remarkably similar.

TABLE 12. — A COMPARISON OF THE CLEPTOPARASITIC LOADS AND NESTING HABITS OF THE SOLITARY WASPS AND BEES BETWEEN SHERWOOD FOREST AND SIX OTHER LOCALITIES.

	Cleptoparasitic Loads		Aerial Nester Frequency	
	Wasps	Bees	Wasps	Bees
Sherwood Forest	17.6	25.0	47.6	19.4
Charnwood Forest	18.1	27.0	71.2	22.2
Pre-coniferized Allerthorpe	16.9	32.8	45.3	16.3
Coniferized Allerthorpe	13.9	35.9	20.0	8.0
Strensall	18.0	35.0	41.5	19.2
Skipwith	13.2	35.5	42.4	30.0
Duncombe Park	20.0	17.2	84.4	16.7

*Aerial Nester Frequency*

Table 12 shows the AFs of six localities for comparison with Sherwood Forest. AFs vary greatly for the solitary wasp (20.0–84.4) and the solitary bee (8.0–30.0) species but variation for the species of solitary wasps (64.4%) is greater than for the solitary bees (22.0%).

To explain these relationships it is hypothesised that sandy soils are more easily dug by solitary wasps and bees to make nests than non-sandy soils. Sandy soils also warm up more quickly so extending the period of activity of solitary species. At higher altitudes with reduced average temperatures and amounts of sunshine, aerial nesting sites are likely to be warmer for a longer time than subterranean sites.

Archer (1990b) showed that the activity of adult solitary wasps is more affected by warmer weather conditions than solitary bees. Thus solitary wasp species should become progressively more aerial nesting with increasing altitude and latitude. Lomholdt (1975) showed that for the Sphecidae AFs were higher in European northern latitudes (France 28%, England 47%, northern Scandinavia 79%).

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