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The aculeate wasp and bee assemblage (Hymenoptera: Aculeata) of a woodland: Bernwood Forest in the English Midlands

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ABSTRACT. (1) The wasp and bee assemblage of Bernwood Forest is described in terms of the species present and the relative abundance of each species.
(2) The cleptoparasitic load and aerial nester frequency is compared with a list of species in the regional pool for Oxfordshire.
(3) Seasonal numerical changes are described for the four categories of solitary and social wasps and bees.

Key words: Aculeata, wasps, bees, assemblage, woodland, England, cleptoparasitic load, aerial nester frequency

Introduction

Recently Watts (1983) positioned a series of Malaise traps at Bernwood Forest to study the hover-flies (Diptera, Syrphidae). Aculeate Hymenoptera were also trapped and after being sorted by Watts, were sent to me for mounting and identification. This paper is primarily a descriptive report on the aculeate species present with details of the relative abundance of each species.

There is a rich tradition on the reporting of aculeates from British localities e.g. Perkins (1892), Richards (1926), Guichard & Yarrow (1948), Else (1973, 1976), Guichard (1977), O'Toole (1984), Archer (1985a). These reports, besides recording the species present, often give much qualitative information on food and nesting requirements and the distributional status of the species. Sometimes, a taxonomic survey is presented for comparison between geographical areas (Leclercq, 1968). Further analysis into the composition of the aculeate assemblage is unusual but Haeseler (1986) divided species into soil-nesters and non soil-nesters, whilst Heithaus (1979) in a pioneering study, investigated cleptoparasitic load. In the present study, where collecting was by Malaise trap, a fuller quantitative analysis of the composition of the aculeate assemblage is provided.

Bernwood Forest, about 10 km north east of Oxford, is situated on the Oxford clays which gives a fertile but heavy soil. However, there are distinct non-shaded areas with

a light, well-drained calcareous clay soil. The woodland consists of two parts: the south part (Waterperry Wood), situated in Oxfordshire and the north part (the Shabbington complex), including Oakley and York's Wood, situated in Buckinghamshire. Bernwood itself is an ancient woodland, but has been subjected to much tree-felling and replanting with oak (*Quercus robur*) and Norway Spruce (*Picea abies*) and is currently managed by the Forestry Commission. Further information on the history and vegetation of Bernwood is given by Watts (1983).

Methods

Five Townes' "Malaise" traps (Townes, 1972) were operated from 1st April – 30th September during 1980, 1981 and 1982 and were sampled at weekly intervals providing 26 samples per annum. The traps were positioned in a range of vegetational situations in Oakley, Waterperry and York's Woods.

Since orientation and siting in a habitat can greatly affect a Malaise trap catch (Disney *et al.,* 1982), no attempt has been made to compare differences between traps. The efficiency of Malaise traps in sampling an aculeate wasp and bee assemblage is unknown but traps are probably selective in the species trapped. An independent hand-net collection has also been performed at Bernwood Forest and will be reported in a future paper.

Weather data were obtained from the Radcliffe Observatory in Oxford via Watts.

Results and Analysis

The 78 weekly collections (26 per year × 3 years) of the Malaise trap sample produced 4354 specimens representing 72 species of aculeate wasps and bees (Table 1 & Appendix). In terms of individuals, the social species were dominant, the Vespidae representing 42.7% of individuals and the Apidae 41.0%. The solitary bees, representing 10.0% of individuals, were more numerous than the solitary wasps, representing 6.2% of individuals. However, more species of solitary wasp were trapped than solitary bees. Among solitary species, males were less frequently trapped than females: 8.1% of solitary wasps and 25.5% of solitary bees were males.

Richards (1939) gave a list of the aculeate Hymenoptera to be found in Oxfordshire and this list may be used as a potential pool of species from which the Bernwood species could be recruited. About a quarter of the Oxfordshire list was recorded at Bernwood but at the family level among the solitary species, the Eumenidae and Anthophoridae may be over-and the Colletidae and Megachilidae under-represented (Table 1). The social families, Vespidae and Apidae, were also over-represented.

TABLE 1. The number of species, individuals and species percentages of Richards' (1939) Oxfordshire list trapped at Bernwood from 1980-82.

Family	No. species	Species % Oxfordshire list	No. individuals	Individuals per species
Chrysididae	3	27.3	13	4.3
Pompilidae	3	20.0	3	1.0
Eumenidae	6	54.5	17	2.8
Vespidae	5	71.4	1861	372.2
Sphecidae	20	29.9	238	11.9
Colletidae	1	11.1	11	11.0
Andrenidae	9	23.1	297	33.0
Halictidae	5	18.5	56	11.2
Megachilidae	2	10.5	3	1.5
Anthophoridae	8	42.1	68	8.5
Apidae	10	50.0	1787	178.7
Solitary wasps[1]	32	29.6	271	8.5
Solitary bees[2]	25	21.9	435	17.4

[1] All wasp families except Vespidae [2] All bee families except Apidae

Three species were Red Data book category 3 species with rare status, i.e. found in 15 or fewer 10 km squares in Britain. The pompiloid *Priocnemis cordivalvata* Haupt previously known from Kent to Devon, Bedfordshire, Essex and Lincolnshire (Day, M.C., per. comm., 1985), is a species of sunny glades in mature woodland on clay soils. The eumenid *Symmorphus connexus* (Curtis), previously known from Dorset, Hampshire, Surrey, Berkshire, Kent, Hertfordshire, Essex and Suffolk (Richards, 1980) seems to prefer damp places, often near streams and ditches (Guichard, 1972), and nests in tubes such as straws whilst the crabronid sphecoid *Ectemnius ruficornis* (Zetterstedt) previously

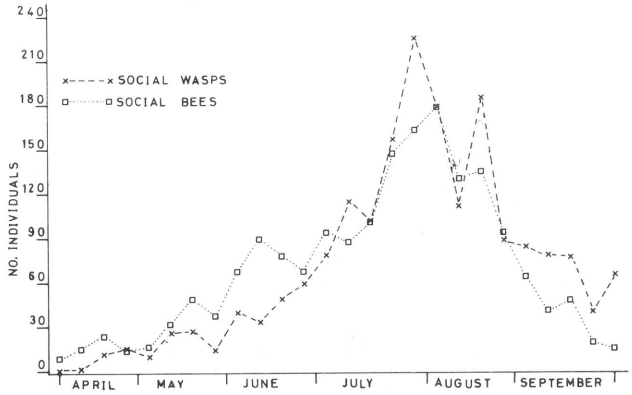

Fig. 1. The number of social wasps and bees trapped at Bernwood from 1980-82.

known from Surrey, Hampshire, Sussex, Dorset, Northamptonshire and Glamorgan (Richards, 1980), is probably a tube nester in rotten wood or plant stems.

The flight period of the social wasps (Vespidae) and bees (Apidae) were very similar (Fig.1) and can be considered in three parts: First a slow increase from April until mid-July with the Apidae usually the more numerous; secondly, a rapid increase to and decrease from peak numbers from mid-July until the end of August with the Vespidae reaching the higher peak; thirdly, the September trend when the Apidae continued to decrease but the Vespidae, with long cycle species such as *Paravespula vulgaris* (L.), maintained a higher population.

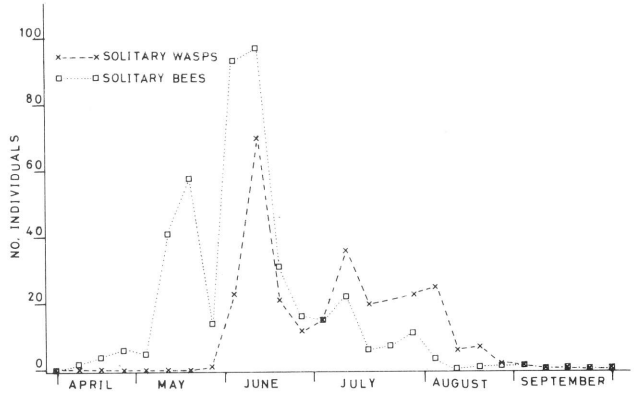

Fig. 2. The number of solitary wasps and bees trapped at Bernwood from 1980-82.

The flight period of the solitary wasps and bees showed the same three parts as the social species, but the timing and characteristics of each part were different (Fig. 2). To begin with, numbers of individuals were low, or even zero for the solitary wasps, until the beginning of May for the solitary bees and the end of May for the solitary wasps. Thereafter, a rapid increase and decrease were shown by the end of June with solitary bees reaching a higher peak. Lastly, the solitary bees slowly declined to a low level by the middle of August, whilst the solitary wasps remained at a higher level until early August before declining. In terms of number of species, the solitary wasps were more-or-less as numerous during July and early August as in June. Clearly, the solitary bees peaked before the solitary wasps.

Three years of data are rather a small data set to correlate with weather. Nevertheless, it may be noted that the number of solitary bees increased with increasing hours of sunshine (Table 2). The Davis Index of Summer Weather, which covers the months of June – August, increases in value with increases of mean temperature and sunshine, and decreases of rainfall (Davis, 1968). Most of the solitary wasps were trapped during June, July and August, the yearly catch of this group increasing in parallel with the Davis Index (Table 2).

TABLE 2. Hours of sunshine, the Davis Index of Summer Weather (Davis, 1968), the number of species and of individuals of solitary aculeates Malaise trapped at Bernwood from 1980-82.

	1980	1981	1982
Sunshine (hrs)	1055.1	817.6	952.2
Davis Index	660	682	692
No. species			
(a) Solitary wasps	15	24	20
(b) Solitary bees	22	15	14
No. of individuals			
(a) Solitary wasps	76	82	113
(b) Solitary bees	185	120	130

No attempt has been made to correlate weather conditions to numbers of individuals of the social species as bumblebees are known to forage under a wide range of weather conditions (Alford, 1975) and social wasp numbers are only partially determined by weather conditions (Archer, 1985b).

TABLE 3. The relative frequency of cleptoparasitic species trapped at Bernwood from 1980-82 and of Oxfordshire (Richards, 1939).

	No. host species (H)		No. cleptoparasitic species (C)		Cleptoparasitic load (L) $L = C/(H + C) \times 100$	
	Bernwood	Oxfordshire	Bernwood	Oxfordshire	Bernwood	Oxfordshire
Social wasps (Vespidae)	5	7	0	1	0.0	14.3
Social bees (Apidae)	7	20	3	5	30.0	25.0
Solitary wasps	26	112	4	22	12.5	19.6
Solitary bees	17	114	8	29	32.0	25.4

The cleptoparasitic load (Heithaus, 1979) for the solitary and social bees is higher than that for the solitary wasps (Table 3). No cleptoparasites of the social wasps were captured. The cleptoparasitic loads calculated from Richards (1939) list are similar to those in the current study (Table 3).

TABLE 4. The nesting habits of host wasps and bees trapped at Bernwood from 1980-82 and of Oxfordshire (Richards, 1939)

	Aerial nesters		Soil nesters		Aerial nester frequency (AF) $AF = A/(A + S) \times 100$	
	Bernwood	Oxfordshire	Bernwood	Oxfordshire	Bernwood	Oxfordshire
Social wasps (Vespidae)	2	3	3	3	40.0	50.0
Social bees (Apidae)	1	1	6	14	14.3	6.7
Solitary wasps	24	43	4	43	85.7	50.0
Solitary bees	4	25	13	60	23.5	29.4

Concerning nesting habits (Table 4), the solitary wasps are mainly aerial nesters, usually in hollow plant stems or burrows in dead wood, and only *Crossocerus pusillus* Lepeletier & Brullé, *Argogorytes mystaceus* (Linnaaeus), *Priocnemis cordivalvata* Haupt and *P. hyalinata* (Fabricius) are soil nesters. The solitary bees, by contrast, are predominately soil nesters with *Hylaeus confusus* Nylander, *Megachile ligniseca* (Kirby) and *Anthophora furcata* (Panzer) being the only aerial nesters. The aerial nester frequencies calculated from Richards (1939) are also similar – except for the solitary wasps where the frequency is lower (Table 4).

Discussion

The taxonomic spectrum of the solitary species (Table 1) may be compared with those given for Kent and Belgium by Leclercq (1968). Leclercq collected using a hand-net so that his sample sizes are smaller than in the current investigation: 567 individuals for Kent and 1103 for Belgium. The current study agrees with that of Leclercq in finding the dominant solitary wasp family to be the Sphecidae (sub-families Crabroninae and Pemphredoninae). Among the solitary bees, Leclercq found the Halictidae, Andrenidae and Megachilidae to be the dominant families with the Halictidae most numerous in terms of species and individuals. This study is similar in finding the Andrenidae and Halictidae to be the dominant families, although the Andrenidae are found to be more important, whilst it also differs in giving a lower importance to the Megachilidae and a greater importance to the Anthophoridae. The relative absence of the Megachilidae is also indicated in comparison with Richards' Oxfordshire list (Table 1). Leclercq collected in the summer so that he missed the spring species; this would explain the lesser

importance he gave to the Andrenidae and Anthophoridae which, with their respective genera *Andrena* and *Nomada,* are more numerous in the spring. The relative absence of the Megachilidae is more difficult to understand, but these species may have been able to avoid the Malaise trap. Thus O'Toole (pers. comm., 1986) found that an aggregation of 50-60 females of the megachilid *Osmia rufa* (L.) nesting less than 5m from a trap, avoided capture.

Of the solitary species trapped, the greater number of females, compared with males, could be a consequence of the shorter flight period of the males and/or that male activity may take them away from the trap areas, i.e. to the nesting or mating sites. Casual observations would suggest the former.

The larger numbers of solitary bees compared with solitary wasps (Table 1) and the larger number of host species compared with cleptoparasitic species (Table 3) are presumably a consequence of food-chain relationships with the host bees being primary consumers on pollen and nectar and wasps and cleptoparasites secondary consumers. This observation could have implications for inventory surveys of sites for conservation purposes where a greater recording effort may be needed for secondary consumer species. Of the 20 species of solitary wasps and bees trapped in 1981 and 1982 but not in 1980, 18 (i.e. 90%) were secondary consumer species. Of these however, only one species was a cleptoparasite; hence, increased recording effort is needed for the solitary wasps but not for the cleptoparasites. Presumably the increased activity of cleptoparasites in searching for the nests of their hosts makes them more likely to be trapped.

Heithaus (1979) collected together the cleptoparasitic loads as measured in several studies of bee assemblages and showed that the load values were relatively constant with most values between 10 and 13%. In the present study, the cleptoparasitic loads for both solitary and social bees were higher (Table 3). Archer (1985a) also found a higher load value for solitary bees at the open grass and heather site of Pompocali (36.8%) and the open wooded lowland heath site of Strensall Common (33.3%) (Archer, in press); in both studies, specimens were collected by hand-net. The high load value at Bernwood is readily assembled from the pool species list of Richards (1939) (Table 3).

The lower cleptoparasitic load of the solitary wasps (Table 3) was also found at Pompocali (18.2%) and Strensall Common (18.0%). Again, the load value at Bernwood is readily assembled from the pool species list of Richards.

The higher cleptoparasitic load of solitary bees could be simply a consequence of the pool species available, although there is the possibility that solitary bee cleptoparasites were more numerous as individuals and hence more likely to be taken by the Malaise trap or hand-net.

Although more investigations are needed to determine cleptoparasitic loads, the range of values from the three English sites is narrow and thus agrees with one of the conclusions of Heithaus (1979). The narrow range of the load values strongly suggests

that the cleptoparasites are at their maximum abundance in terms of some factor such as their ability to find their hosts, which could be an important factor in determining the abundance of their hosts. There is some information on the magnitude of the mortality effect of cleptoparasites. Thus Krombein (1967) showed that some cleptoparasitic species parasitised about 25% of the cells of their host and Danks (1971), that mortalities of up to 21% were caused by cleptoparasites.

Concerning the aerial nester frequencies, inspection of Richards' (1939) list clearly shows that Bernwood Forest lacks those species which require sandy soil. However by contrast, Benwood is particularly rich in aerial nesting species, with over 50% of the species on Richards' list. Haeseler (1985) found the aerial nester frequency was lower for the solitary wasps in a wooded sandy site in Germany (74.0%), while at Strensall Common I found that it decreased further to 41.5% (Archer, in press) and at the open site of Pompocali, still further to 11.1% (Archer, 1985), the only aerial nests at Pompocali being found in dead horizontally-lying tree-trunks and branches. The aerial nester frequency in all these four studies is very variable (11.1%-85.7%) – suggesting the importance of open sandy areas and aerial structures as nest site resources. The aerial nester frequency was less variable for the solitary bees, varying from 23.5% at Bernwood to zero at Pompocali. From Richards' (1939) list (Table 4) it may be seen that the solitary bees as a group are less dependent on aerial nest site resource compared with the solitary wasps.

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APPENDIX *A list of aculeate wasp and bee species and the number of each species trapped at Bernwood from 1980-82.*

Species	Number	Species	Number
Chysis angustula Schenck	5	*Argogorytes mystaceus* (L.)	28
C. impressa Schenck	4	*Hylaeus confusus* Nylander	11
C. mediata Linsenmaier	4	*Andrena fucata* Smith, F.	127
Dipogon subintermedius (Magretti)	1	*A. praecox* (Scopoli)	1
Priocnemis cordivalvata Haupt	1	*A. scotica* Perkins, R.C.L.	4
P. hyalinata (F.)	1	*A. bicolor* F.	13
Gymnomerus laevipes (Shuckard)	1	*A. nigroaenia* (Kirby)	2
Ancistrocerus gazella (Panzer)	1	*A. haemorrhoa* (F.)	11
A. parietinus (L.)	1	*A. chrysosceles* (Kirby)	17
A. trifasciatus (Müller)	4	*A. subopaca* Nylander	121
Symmorphus connexus (Curtis)	9	*A. ocreata* (Christ)	1
S. mutinensis (Baldini)	1	*Halictus rubicundus* (Christ)	2
Dolichovespula norwegica (F.)	12	*H. tumulorum* (L.)	2
D. sylvestris (Scopoli)	3	*Lasioglossum albipes* (F.)	48
Vespula rufa (L.)	1101	*L. punctatissimum* (Schenck)	3
Paravespula germanica (F.)	5	*Sphecodes ferruginatus* von Hagens	1
P. vulgaris (L.)	740	*Megachile ligniseca* (Kirby)	1
Trypoxylon attenuatum Smith, F.	3	*M. versicolor* Smith, F.	2
T. clavicerum Lepeletier & Serville	10	*Nomada fabriciana* (L.)	1
Crossocerus pusillus Lepeletier & Brullé	1	*N. flava* Panzer	24
C. annulipes (Lepeletier & Brullé)	2	*N. flavoguttata* (Kirby)	12
C. cetratus (Shuckard)	23	*N. marshamella* (Kirby)	4
C. megacephalus (Rossius)	7	*N. panzeri* Lepeletier	8
C. styrius (Kohl)	1	*N. ruficornis* (L.)	17
C. podagicus (Vander Linden)	10	*N. striata* F.	1
C. binotatus Lepeletier & Brullé	6	*Anthophora furcata* (Panzer)	1
Ectemnius ruficornis (Zetterstedt)	1	*Bombus lucorum* (L.)	654
E. continuus (F.)	1	*B. terrestris* (L.)	118
E. cephalotes (Olivier)	3	*B. pratorum* (L.)	142
E. lituratus (Panzer)	28	*B. hortorum* (L.)	236
Psenulus concolor (Dahlbom)	1	*B. pascuorum* (Scopoli)	549
P. pallipes (Panzer)	3	*B. ruderarius* (Müller)	1
Pemphredon lugubris (F.)	84	*Psithyrus barbutellus* (Kirby)	1
Passaloecus insignis (Vander Linden)	6	*P. sylvestris* (Kirby)	11
P. singularis Dahlbom	1	*P. vestalis* (Geoffroy in Fourcroy)	1
Nysson spinosus (Forster)	19	*Apis mellifera* L.	74