THE WASPS AND BEES (HYMENOPTERA: ACULEATA) OF HARTLEBURY COMMON LOCAL NATURE RESERVE IN WATSONIAN WORCESTERSHIRE

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Hartlebury Common is an important site for species of aculeate wasps and bees with 101 species including 15 species of national importance.

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

Hartlebury Common (SE8270) is situated to the south-east of Stourport and about 17 km north of Worcester. The Common has an area of 87.5 ha and is included within the Midland Plateau Natural Area. The Common is a Local Nature Reserve managed by the Hereford and Worcester County Council for its wildlife and recreation interests. Background information about the Common is given in Tucker *et al.* (1986) and Betts (1991).

The Common consists of Upper and Lower Terraces separated by a steep, west-facing escarpment. The Upper Terrace is mainly covered by drift deposits of coarse sand and gravel and the Lower Terrace by blown sand forming an inland dune system. Outcrops of the underlying Triassic sandstone occur on the escarpment and southern part of the Common. The Common has an urban area on its northern boundary and mainly intensively-farmed areas on its other boundaries.

The main habitats are wet and dry lowland heathland, grassy areas, shrub and mature oak/birch woodland, bogs and pools. The Upper Terrace also has pine plantations and bracken areas. Disturbed areas often with banks and mounds are associated with the vehicle parking areas. The nesting sites for the subterranean species in the dry heathland,

are usually associated with the stable bare sandy areas, often with sloping areas, and small or large banks. The Common is rich in flowering species providing nectar, pollen and prey resources and sunning and mating places for the aculeate wasps and bees, e.g. oak, hawthorn, dog rose, heather, broom, gorse, bramble, dandelion, vetch, bird's-foot-trefoil, sheep's bit and bedstraw. The disturbed areas have ruderal plant communities with garden escapes including a patch of bellflowers.

Sampling methods

Between 1990 and 1999, 17 visits were made to the Common distributed throughout the year as follows: April (2 visits), May (4), June (3), July (3), August (4) and September (1). The visits were mainly made to the open parts of the common to the east of the Stourport – Worcester road (A4025). 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 follows that of Kloet and Hincks (1978).

Species present and seasonal progression of species

A full list of the species recorded is given in the Appendix. At the family level, Table 1 shows the taxonomic distribution of species and records (Archer sample). 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 families, Andrenidae and Halictidae, are the dominant families in terms of number of species and records, although the Anthophoridae are well represented in terms of the number of records.

Tucker *et al.* (1986) recorded *Cerceris ruficornis* (Fab.) and *Bombus jonellus* (Kirby) and Fraser *et al.* (1998) recorded *Arachnospila wesmaeli* (Thomson) from Hartlebury Common. These three species were not found during the current survey. [Tucker *et al.* (1986) also recorded the three ant species: *Myrmica rubra* (Linn.), *Formica fusca* Linn. and *Lasius flavus* (Fab.)].

June and July were the best months for recording species of solitary wasps, with June the most productive month for the first recording of species (Table 2). The species most evident were the pompilid *Episyron rufipes* and the sphecids *Lindenius albilabris*, *Ammophila sabulosa*, *Mellinus arvensis*, *Cerceris arenaria*, *C. rybyensis* and *Philanthus triangulum*. All these species are subterranean nesters. *E. rufipes* was found from May until August and males were often found swarming around the nesting sites of the females. The nesting aggregations of *C. arenaria* and *C. rybyensis* were found on the Upper Terrace associated with bare patches of ground including the pathways. A lone female of *Philanthus triangulum* was first recorded on 10 August 1995 at the top of the escarpment. By 1996 its nesting aggregations were numerous, particularly on bare sloping ground facing south on the Lower Terrace.

May was the most productive month for both the number of species and first recording of solitary bees, although June, July and August were also good for the number of species (Table 2). The species most evident were: *Andrena barbilabris* with its cleptoparasite *Sphecodes pellucidus*, *A. humilis*, *Lasioglossum brevicorne*, *L. leucozonium* and *Nomada rufipes*. All these species are subterranean nesters except for the cleptoparasites which have hosts that are subterranean nesters. The host of *N. rufipes* was probably *A. fuscipes* which was found.

Species quality

The following five Red Data Book species (Shirt, 1987) have been recorded from the Archer sample: *Podalonia affinis*, *Philanthus triangulum*, *Andrena tibialis*, *Lasioglossum brevicorne* and *Sphecodes reticulatus*. The following nine national notable or scarce species (Falk, 1991) have also been recorded: *Hedychridium cupreum*, *Oxybelus argentatus*, *Hylaeus signatus*, *Andrena bimaculata*, *A. humilis*, *Lasioglossum quadrinotatum*, *Sphecodes ferruginatus*, *Dasypoda altercator* and *Nomada pleurostricta*. Falk (1991) suggested that *Andrena tibialis* and *Sphecodes reticulatus* be downgraded to national scarce species. Recent work by the Bees, Wasps and Ants Recording Society indicate that there should be further status changes. These changes arise because of better information about the distribution of species and

because some species, e.g. *Philanthus triangulum*, are increasing their range. To take account of these changes Archer and Burn (1995) introduced a new national quality scoring system and Archer (1999) gave the latest definitions for the six national statuses. High quality species have a scarce, rare or very rare status while low quality species have a universal, widespread or restricted status. According to the new national quality scoring system, nine species found by Archer have a scarce status: *Hedychridium cupreum*, *Oxybelus argentatus*, *Ammophila pubescens*, *Hylaeus signatus*, *Andrena bimaculata*, *A. humilis*, *Sphecodes ferruginatus*, *Melitta haemorrhoidalis* and *Dasypoda altercator*. Five species have a rare status: *Podalonia affinis*, *Andrena tibialis*, *Lasioglossum quadrinotatum*, *Sphecodes reticulatus* and *Nomada pleurostricta*. One species has a very rare status: *Lasioglossum brevicorne*. *Philanthus triangulum* becomes a low quality species with a widespread status.

By giving each of the 87 species of solitary wasps and bees a national status (Archer, 1999) a national quality score of 292 can be calculated (Table 3) with a national species quality score of 3.36 (292/87). How do these scores relate to other sandy habitats in England?

Data of few sites are 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 and Edwards (in press)), the midlands (Gibraltar Point, Archer (1998); Sherwood Forest, Archer (unpublished)) south Lancashire, Ainsdale-Formby sand dunes, Archer (1999)) and south Yorkshire, (Crow Wood, Archer and 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. Hartlebury Common can therefore be matched with Sherwood Forest and Ainsdale-Formby sand dunes rather than with the poorer south Yorkshire and richer south-eastern English sites.

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 a site, but as yet are unrecorded. Recent advances in non-parametric statistical procedures offer a way of addressing this problem. The presence/absence quantitative estimate of Chao (in Colwell and Coddington, 1994) is based on the number of species that are observed in one (unique species) or two (two occasion species) samples or visits. The jackknife procedure (Heltshe and Forrester, 1983) only depends on the unique species. 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 procedures was provided by Pisces Conservation Ltd.

The statistical procedures were run 17 times. 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. The estimates with the 95% confidence limits (meaning that there is a 95% chance that the potential number of species falls within this range) are given at the maximum sample size selection in Table 5 (All records).

The Chao and jackknife estimates do not stabilise but are predicting a further increase in species diversity (Figs 1 & 2). The Chao estimates are slowly increasing while the jackknife estimates are beginning to approach an upper asymptote. The estimates from the two procedures differ from each other by about 10% (Table 5, All records). These analyses indicate that further recording effort should yield more species.

There are two possible complications in making these estimates. Either some of the unique species were accidentally present, being outside their normal range (vagrant species), or were visiting from adjacent habitats (tourist species). None of the recorded species could be regarded as vagrant species but several species could be tourist species. Four reasons can be put forward to suggest that some species were tourist species:

1. Common species, e.g. *Halictus rubicundus*, should be represented by

more than one record if they were breeding on the Common.

2. Cleptoparasitic species, e.g. *Sphecodes hyalinatus* and *Sapyga quinquepunctata*, whose hosts are common species not found on the Common.
3. Dead wood is not a feature of the Common so that dead-wood nesting common species, e.g. *Ectemnius continuus*, must have come from adjacent habitats. Although it is possible that small dead-wood nesting species, e.g.*Psenulus pallipes*, were nesting in the decaying wooden supports of seats, which are artefacts having been placed on the Common.
4. *Melitta haemorrhoidalis*, which is more characteristic of calcareous habitats, was recorded visiting the bellflowers growing on the disturbed habitat.

For the above reasons, 14 unique species could be removed from the samples and the species diversity procedures run again. This time the estimates stabilise (figs 3 & 4) and the final estimates are within about 4% of each other (Table 5, reduced records). The percentage of potential species recorded is also improved.

In summary it would seem that Hartlebury Common has a resident assemblage of just under 100 species of solitary wasps and bees and a further tourist species list of perhaps 30 or more species. As such, further recording effort should yield a few more resident species and more tourist species.

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 CLs for both 'all records' and the 'reduced records' (i.e. records of unique tourist species removed) of the species of solitary bees on Hartlebury Common are given in Table 6. The CLs for the species of solitary bees fall within the European range, so supporting Wcislo's findings.

Wcislo (1987) gives no CL values for wasps, but Archer (1999) found the values for species of solitary wasps varied between 10% and 22%, a range of 12%, for sites from northern and the north midlands of England. The CLs for the species of solitary wasps (Table 6) fall within this range.

All the social species are host species, except for the *Psithyrus* species, which are social parasites on the *Bombus* species.

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 old mortar 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 species of solitary wasps and bees are given in Table 7 both for all records and reduced records. The AF for all the British species of solitary bees is 17.9, which is similar to the AFs of the solitary bees from Hartlebury Common. The AF for the reduced records of the solitary bees is lower than for all records because some dead-wood nesting species are excluded. The AF for all the British species of solitary wasps is 46.2% which is much higher than the AFs of the solitary wasps from Hartlebury Common. The relatively low value of the AFs for the solitary wasps is an indication of the lack of aerial nesting resource, although perhaps more stem-nesting species might yet be found.

All the species of social wasps and the host species of *Bombus* are subterranean nesters, although *B. pratorum* has been found in aerial situations such as old bird's nests.

Conclusions

1. Hartlebury Common is an important West Midland site for aculeate wasps and bees with 101 recorded species, of which 15 are of national importance.
2. The extension of the English range of *Philanthus triangulum* into Worcestershire was recorded at Hartlebury Common during 1995 and is now a widespread species.
3. Hartlebury Common can be grouped with the sites of Sherwood Forest and Ainsdale-Formby sand dunes rather than with sandy sites from south Yorkshire or south-eastern England.
4. The assemblage of species of solitary wasps and bees consists of resident and tourist species.
5. There is a relative lack of aerial-nesting species of solitary wasps.

Acknowledgements

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Appendix

Chrysididae: *Hedychridium ardens* (Latreille in Coquebert), *H. integrum* (Dahlbom).
Mutillidae: *Myrmosa atra* Panzer.
Sapygidae: *Sapyga quinquepunctata* (Fab.)
Pompilidae: *Priocnemis parvula* Dahlbom, *P. perturbator* (Harris), *Agenioideus cinctellus* (Spinola), *Arachnospila anceps* (Wesmael), *A. trivalis* (Dahlbom), *Evagetes crassicornis* (Shuckard), *Episyron rufipes*

(Linn.).

Eumenidae: *Ancistrocerus trifasciatus* (Müller).

Vespidae: *Vespula rufa* (Linn.), *Paravespula germanica* (Fab.), *P. vulgaris* (Linn.).

Sphecidae: *Astata pinguis* (Dahlbom), *Tachysphex pompiliformis* (Panzer), *Crabro peltarius* (Schreber), *Crossocerus quadrimaculatus* (Fab.), *C. wesmaeli* (Vander Linden), *Ectemnius continuus* (Fab.), *Lindenius albilabris* (Fab.), *Rhopalum clavipes* (Linn.), *Oxybelus argentatus* Curtis, *O. uniglumis* (Linn.), *Psen equestris* (Fab.), *P. lutarius* (Fab.), *Psenulus pallipes* (Panzer), *Pemphredon lethifer* (Shuchard), *Diodontus tristis* (Vander Linden), *Ammophila pubescens* Curtis, *A. sabulosa* (Linn.), *Podalonia affinis* (Kirby), *Mellinus arvensis* (Linn.), *Gorytes tumidus* (Panzer), *Cerceris arenaria* (Linn.), *C. rybyensis* (Linn.), *Philanthus triangulum* (Fab.).

Colletidae: *Colletes fodiens* (Geoffroy in Fourcroy), *C. succinctus* (Linn.), *Hylaeus brevicornis* Nylander, *H. signatus* (Panzer).

Andrenidae: *Andrena angustior* (Kirby), *A. barbilabris* (Kirby), *A. bicolor* Fab., *A. bimaculata* (Kirby), *A. chrysosceles* (Kirby), *A. cineraria* (Linn.), *A. dorsata* (Kirby), *A. fulva* (Müller), *A. fuscipes* (Kirby), *A. haemorrhoa* (Fab.), *A. humilis* Imhoff, *A. nigroaenea* (Kirby), *A. ovatula* (Kirby), *A. scotica* Perkins, *A. synadelpha* Perkins, *A. tarsata* Nylander, *A. tibialis* (Kirby), *A. wilkella* (Kirby).

Halictidae: *Halictus rubicundus* (Christ), *H. tumulorum* (Linn.), *Lasioglossum brevicorne* (Schenck), *L. leucozonium* (Schrank), *L. minutissiumum* (Kirby), *L. punctatissimum* (Schenck), *L. quadrinotatum* (Kirby), *L. villosulum* (Kirby), *Sphecodes ephippius* (Linn.), *S. ferruginatus* von Hagens, *S. geoffrellus* (Kirby) (=*fasciatus*), *S. hyalinatus* von Hagens, *S. monilicornis* (Kirby), *S. pellucidus* Smith, *S. puncticeps* Thomson, *S. reticulatus* Thomson.

Melittidae: *Melitta haemorrhoidalis* (Fab.), *Dasypoda altercator* (Harris).

Megachilidae: *Anthidium manicatum* (Linn.), *Osmia rufa* (Linn.), *Megachile ligniseca* (Kirby), *M. maritima* (Kirby), *M. willughbiella* (Kirby), *M. versicolor* Smith.

Anthophoridae: *Nomada flava* Panzer, *N. goodeniana* (Kirby), *N. pleurosticta* Herrich-Schäffer), *N. rufipes* Fab., *Epeolus cruciger*

(Panzer), *E. variegatus* (Linn.).

Apidae: *Bombus lucorum* (Linn.), *B. terrestris* (Linn.), *B. lapidarius* (Linn.), *B. pratorum* (Linn.), *B. hortorum* (Linn.), *B. pascuorum* (Scopoli), *Psithyrus bohemicus* (Seidl), *P. campestris* (Panzer), *P. sylvestris* Lepeletier, *P vestalis* (Geoffroy in Fourcroy), *Apis mellifera* Linn.

Table 1 — The number of species and records of aculeate wasps and bees from Hartlebury Common (Archer sample).

	Number of species	Number of records
Solitary wasps		
Chrysididae	2	5
Mutillidae	1	1
Sapygidae	1	1
Pompilidae	7	19
Eumenidae	1	1
Sphecidae	23	103
Total solitary wasps	35	130
Solitary bees		
Colletidae	4	11
Andrenidae	18	61
Halictidae	16	55
Melittidae	2	5
Megachilidae	6	17
Anthophoridae	6	31
Total solitary bees	52	180
Total solitary wasps & bees	87	310
Social species		
Vespidae	3	
Apidae	11	

Total social species	14
Total wasp and bee species	101

Table 2 — The number of species and first records of species of solitary wasps and bees recorded per month at Hartlebury Common (Archer sample).

	April	May	June	July	August	September
Solitary wasps						
First records		10	16	9		
Recorded		10	21	21	12	2
Solitary bees						
First records	10	19	6	9	8	
Recorded	10	27	18	18	17	3

Table 3 — The Archer national quality scores of the species of solitary wasps and bees recorded from Hartlebury Common (Archer sample) (Species Quality Score (SQS) = 292/87 = 3.36).

Status	Status value (A)	Number of species (B)	Quality Score (A × B)
Universal	1	38	38
Widespread	2	33	66
Restricted	4	1	4
Scarce	8	9	72
Rare	16	5	80
Very rare	32	1	32
Total		87	292

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	4.7	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
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

Table 5 — Non-parametric estimates of species richness from the Archer samples of solitary wasps and bees at Hartlebury Common based on all records and reduced records using the presence/absence Chao (C) and jackknife (J) procedures.

	All records		Reduced records	
	C	J	C	J
Number recorded species	87	87	73	73
Estimates	133	121	90	94
95% confidence limits of estimates	99–167	104–138	73–107	84–104
% of species recorded	65.4	71.9	81.1	77.7

Table 6 — The relative frequency of the cleptoparasitic (or parasitoid) species from the Archer sample among the species of solitary wasps and bees from Hartlebury Common (A = All records), R = Reduced records).

	Number hosts (H)		Number cleptoparasites (C)		Cleptoparasitic Load CL = 100 × C/(H+C)	
	A	R	A	R	A	R
Solitary wasps	30	27	5	4	14.3	12.9
Solitary bees	38	31	14	11	26.9	26.2

Table 7 — The nesting habits of the host species from the Archer sample of solitary wasps and bees recorded from Hartlebury Common (A = All records, R = Reduced records).

	Number aerial nesters (A)		Number subterranean nesters (S)		Aerial nester frequency AF = 100 × A/(A+S)	
	A	R	A	R	A	R
Solitary wasps	5	2	25	25	16.7	7.4
Solitary bees	7	4	31	27	18.4	12.9

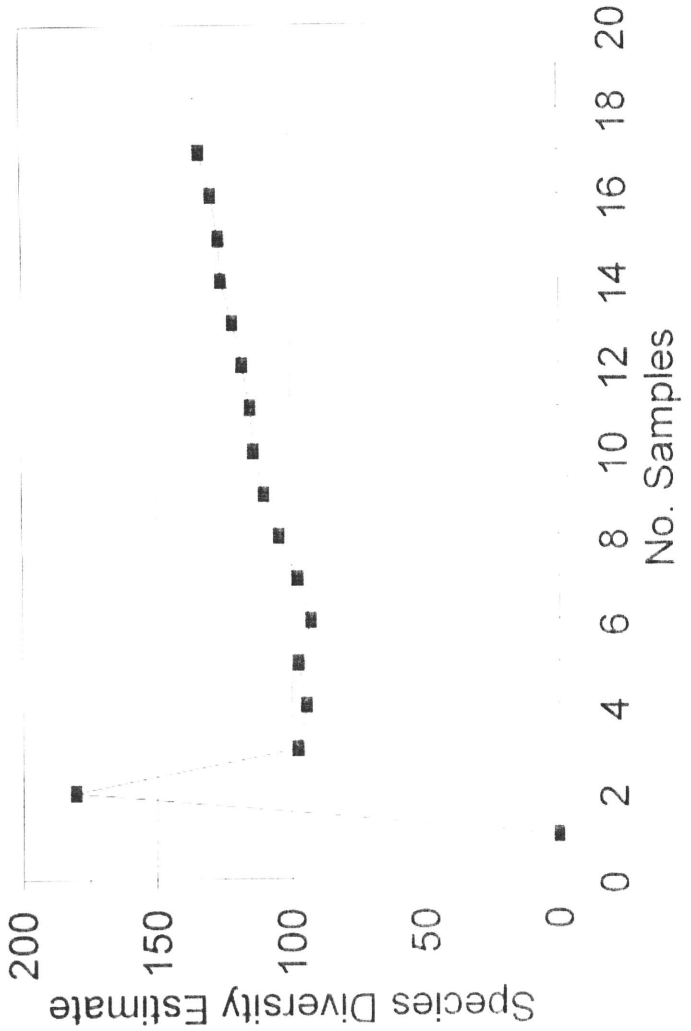

Fig. 1 — The Chao presence/absence estimate of species richness for all records from Hartlebury Common.

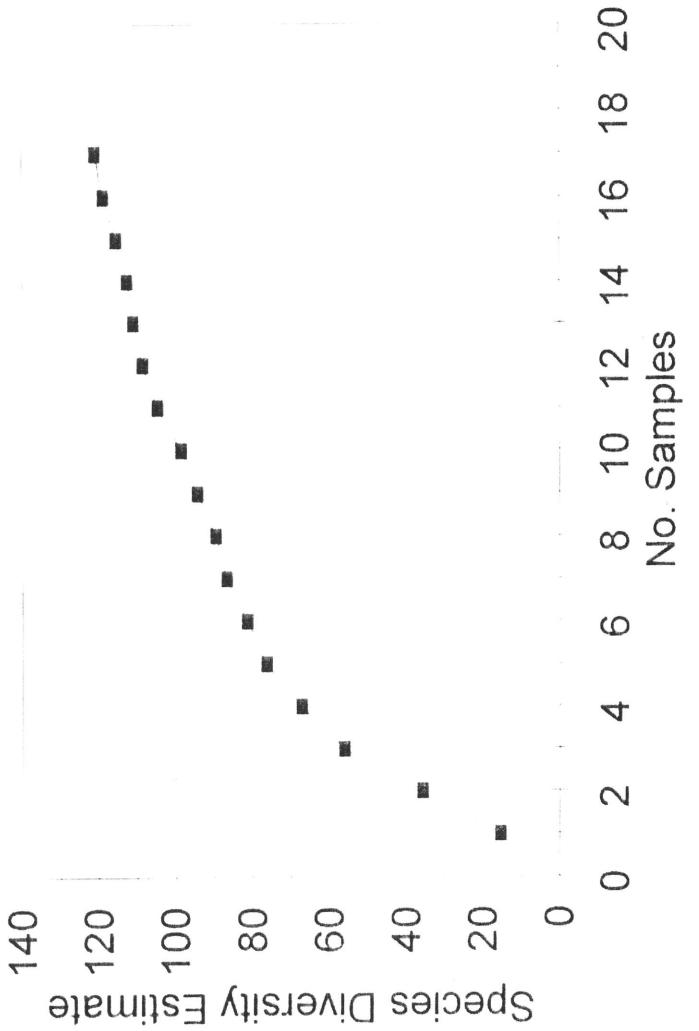

Fig. 2 — The jackknife estimate of species richness for all records from Hartlebury Common.

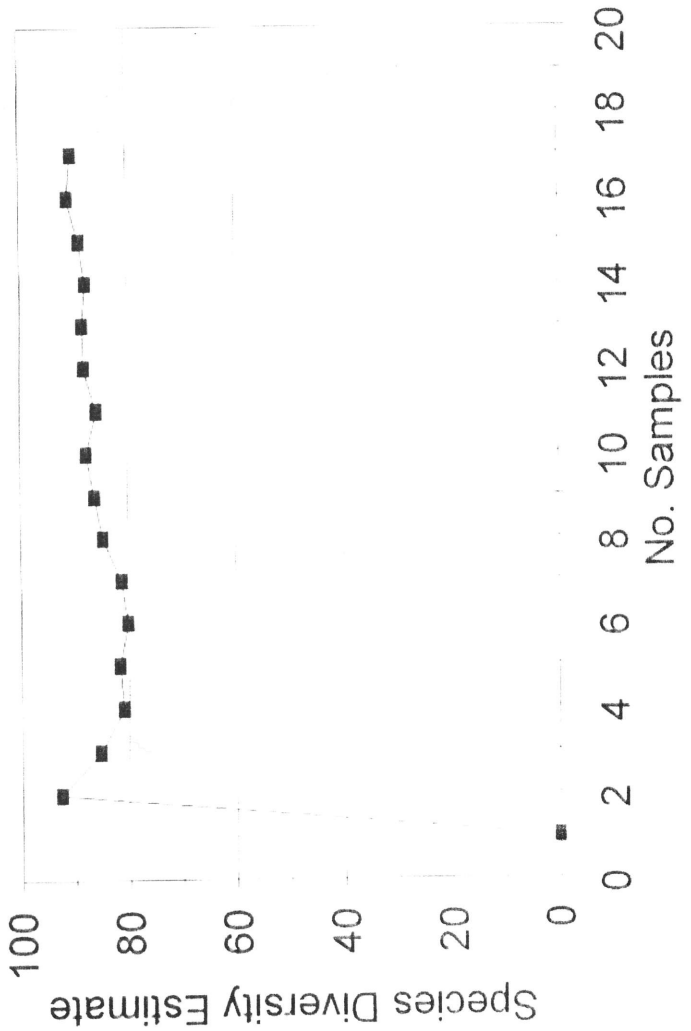

Fig. 3 — The Chao presence/absence estimate of species richness for reduced records from Hartlebury Common.

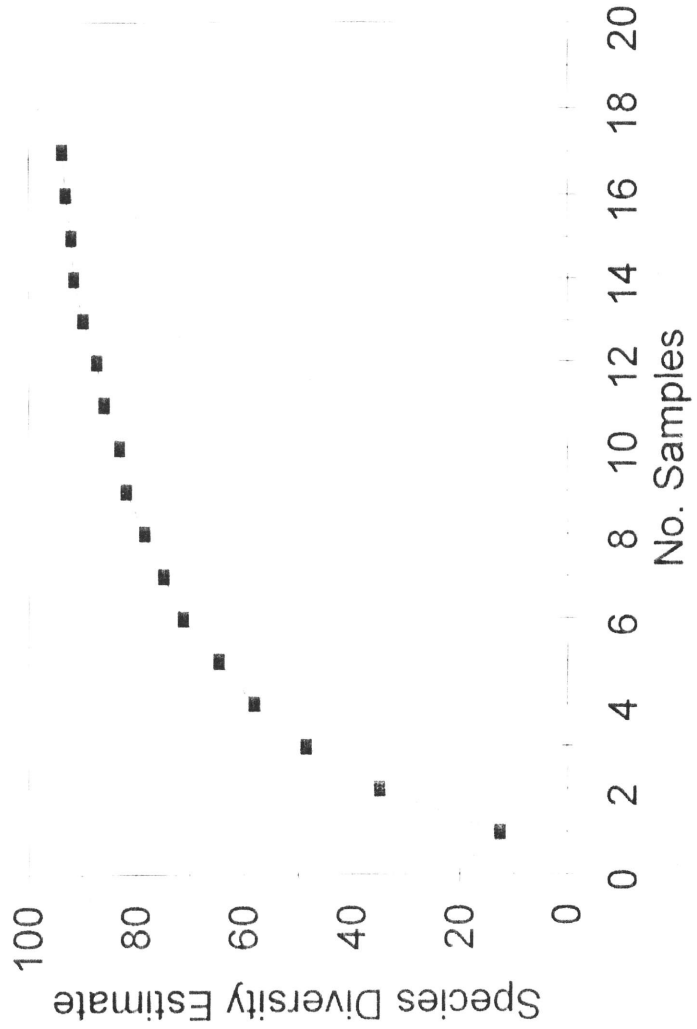

Fig. 4 — The jackknife estimate of species richness for reduced records from Hartlebury Common.