

1 **British phenological records indicate high diversity and extinction**
2 **rate among late summer-flying pollinators**

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9 **Abstract**

10 The long-term decline of wild and managed insect pollinators is a threat to both agricultural
11 output and biodiversity, and has been linked to decreasing floral resources. Further insight
12 into the temporal relationships of pollinators and their flowering partners is required to
13 inform conservation efforts. Here we examined the phenology of: (i) pollinator flight; (ii)
14 insect-pollinated plant flowering; and (iii) extinct and endangered pollinator and plant species
15 in Great Britain. Over 1 million records, spanning four centuries, were collated from the
16 historical databases of three British insect monitoring organisations, a global biodiversity
17 database and an authoritative text covering the national flora. Almost two-thirds (62%) of
18 British pollinator species have peak flight observations during late summer (July and
19 August). This was the case across three of the groups studied: aculeate wasps (71% of
20 species), bees (60%), and butterflies (72%), the exception being hoverflies (49%). By
21 contrast, there is marked temporal partitioning in the flowering of the major plant groups:
22 insect-pollinated tree species blossoming predominantly during May (74%), shrubs in June
23 (69%), and herbs in July (83%). There was a positive correlation between the number of
24 pollinator species on the wing and richness of both flowering insect-pollinated herbs and
25 trees/shrubs species, per calendar month. In addition, significantly greater extinctions
26 occurred in late summer-flying pollinator species than expected (83% observed vs 62%
27 expected). This trend was driven primarily by bee extinctions (80% vs 60%) and was not
28 apparent in other groups. Lastly, twice as many as expected extinct nest-building bee species
29 were found to be specialists (64% vs 30%; oligolectic). We hypothesize that there are three
30 principal mechanisms responsible: (i) a decline in late summer resource supplies, which are
31 almost entirely provisioned by herbs, due to historical land-use change; (ii) exacerbation of
32 late summer resource demand due to the phenology of eusocial bee species, which consume
33 and store large quantities of floral resources; and (iii) enhancement of spring nectar supply by

the preponderance of blooming trees and mass-flowering crops, which can provide large quantities of nectar and pollen relative to wildflowers. These factors may result in resource depression, increased competition and, ultimately, local extinctions.

Keywords: Endangered species, Evolution, Extinctions, Flowers, Flower visitors, Foraging resources, Phenology, Plants, Pollinators, Seasonality.

Introduction

The role of insect pollination in maintaining global biodiversity and agricultural output is well established (Klein et al., 2007; Ollerton et al., 2011). However, there are ongoing concerns regarding the long-term decline of both wild and managed insect pollinators in North America and Europe (e.g. Potts et al., 2010). While many potential causes have been identified, decreasing floral resources (chiefly nectar and pollen) are considered to be a key factor (e.g. Carvell et al., 2006; Potts et al., 2010; Scheper et al., 2011; Goulson et al., 2015). Thus, a better understanding of the temporal relationship between the supply of, and demand for, floral resources is required. The majority of research in this area has focused on single communities or the potential for climate change to disrupt plants-pollinators mutualisms (e.g. Aldridge et al., 2011). Regional analyses are rare (Burkle et al., 2013; Ollerton et al., 2014) and no study, to our knowledge, has ever quantified the phenological relationship between pollinators and floral resources at the regional level throughout the year. Further insights into the temporal relationships of these mutually reliant groups are important to better understand pollinator ecology and to develop optimal conservation strategies (Kearns et al., 1998).

Strong interspecific competition, particularly for nectar, has most commonly, if not exclusively, been reported during late summer (July and August) in both Europe (e.g. Williams 1998; Couvillon et al., 2014a; Balfour et al., 2015a) and North America (e.g. Inouye, 1978; Weatherwax, 1986). Which suggests that floral resources in these regions

may be particularly limited during this period (e.g. Von Frisch, 1967, Lack, 1982, Edwards & Williams, 2004; Balfour et al., 2013). However, recent research in the United Kingdom (UK) shows that most nectar is produced in these months (Baude et al., 2016). These seemingly contrasting results raise several questions: (i) is late-summer competition a natural phenomenon caused by a mismatch of seasonal floral resource supply and demand? and (ii) has reduced nectar availability been exacerbated by long-term environmental change? Here, we begin to address these questions by examining the phenology of British pollinator flight and the flowering of insect-pollinated plants. This information was collated from an authoritative text covering the national flora, the historical databases of three UK insect monitoring organisations and a global biodiversity database. Furthermore, to ascertain whether late summer pollinator communities have been disproportionately impacted by anthropogenic environmental change we assessed the phenology of extinct and endangered UK pollinator and plant species.

Methods

Pollinator Species Phenology

Phenology data for the four main groups of flower visitors in Britain (aculeate wasps, bees, butterflies and hoverflies) were collated from the historical records of the Bees, Wasps and Ants Recording Society (BWARS), the UK Butterfly Monitoring Scheme (UKBMS) and the Hoverfly Recording Scheme (HRS) databases. We used all records in these databases, with the exception of those that contained: (i) species listed as both *sensu stricto* and *sensu lato*, these data were combined; (ii) species aggregates (i.e. a species group composed of closely related species that are difficult to distinguish); (iii) species names we identified as defunct; (iv) species named '*binomial* Form A' or '*binomial* species B' (HFRS); and (v) dates recorded as Christmas or New Year's Day (December 25 or January 1 are commonly used for an unknown day and month, but known year).

Initially, nationwide records from all years were grouped per month and per species. For data deficient pollinator species (<50 total observations; n = 87 species, 11% of all species analysed) we incorporated additional data from the Global Biodiversity Information Facility (GBIF) database. GBIF records were taken from an area of Europe (Appendix S6) with a similar phenology as Britain (Moulin et al. 1997). The remaining species with <50 total observations were excluded from analysis.

We then calculated the flight period of each pollinator species, which was defined as all calendar months with $\geq 10\%$ records (per species) in the relevant database(s) (Fig. 2). To provide greater resolution on pollinator phenology we also calculated the month(s) with the greatest number of observations for each species (Fig. 1a). Because some pollinators have multiple generations in a year (e.g. *Andrena flavipes*) and others a protracted flight period (*Eumenes coarctatus*), many species had approximately equal and maximal observations in more than one month. Therefore, when the difference between the two months with the greatest number of observations was $\leq 10\%$, the peak abundance of that species was considered to be spread across both months (e.g. *Bombus lapidarius* observations are equal and maximal in July and August, resulting in both months being scored 0.5 for this species). When the difference was $>10\%$ the abundance of a species was considered to peak in only one month (e.g. *Bombus pratorum* peak observations are in June, resulting in this month being scored 1 for this species).

Overall, our analysis included: 87% of aculeate wasp (248/284), 97% of bee (247/254), 100% of butterfly (64/64) and 92 % of hoverfly (261/284) species listed in their respective databases.

Insect-Pollinated Plant Species Phenology

A comprehensive dataset of the peak flowering month(s) of British species could not be identified. Therefore, the complete flowering periods of British plant species was taken from

Clapham et al., (1990). A list of the British insect-pollinated plant species was generated using the Ecological Flora Database (Fitter and Peat, 1994), which combines data from a variety of sources. The Royal Horticultural Society classification of tree, shrub and herb (Brickell, 2010) was used to group plant species. We then calculated the months that insect-pollinated plant species are in flower (Fig. 1b and Fig. 2). Overall, our analysis included: 776 herb, 45 shrub and 38 tree species.

Extinct and Endangered Pollinator and Plant Species Phenology

The list of the extinct, critically endangered and endangered pollinators was compiled from the most up to date source available for each group: aculeate wasps (Falk, 1991; Ollerton et al., 2014), bees (Falk, 1991; Falk, 2015), butterflies (Fox et al., 2011) and hoverflies (Ball et al., 2013). The month(s) with the greatest number of observations per species was calculated using the methodology described previously (Appendix S5). Extinct species which have subsequently been reintroduced (*Bombus subterraneus* and *Maculinea arion*) were retained for analysis. To include all species in our analysis, no lower limit was set for the number of observations required to calculate each species' phenology. The flowering period of extinct, critically endangered and endangered insect-pollinated plant species (Cheffings et al., 2005) was determined using the methodology described previously.

Chi-squared analyses were conducted using 'R' software (R-Project, 2017) and compared raw numbers (observed values) to the given probabilities (expected proportions) from the phenological data presented in Fig. 1 and Appendices S1-S4.

Database Accuracy

With over 1 million records between them, spanning four centuries, the HRS, BWARS and UKBMS databases are probably the most detailed available for any country. However, most of the recordings are made by volunteers and whilst the data may have been collected

following a specific protocol, the majority of records in these datasets are opportunistic. Therefore, to account for sampling effort, the number of UKBMS observations per month was divided by the total number of fixed-route transects per month. Unfortunately, these data were not available for the BWARS or HRS databases. The mean number of years with ≥ 10 records per species was: aculeate wasps and bees, 15 (BWARS, 1740-2015); butterflies, 31 (UKBMS, 1976-2014); and hoverflies 17 (HRS, 1824-2013). As such, year-to-year variation of pollinator flight phenology should not have influenced our analysis. Although climate change is likely to have shifted pollinator phenology over recent centuries (e.g. Bartomeus et al., 2013), the majority of records in each of the primary databases were collected since 1990: BWARS 70%, UKBMS 74% and HFRS 53%. Therefore, the data are largely representative of modern pollinator phenologies.

The GBIF data are taken predominately from museum collections (48%) and national biodiversity recording schemes (45%). To ascertain the accuracy of the GBIF phenology data we compared the peak month(s) of 100 randomly selected species calculated from the European data (GBIF) and the British data (BWARS, UKBMS or HRS), using the methodology described above. There was 80% agreement between the datasets.

Results

The majority (62%) of British flower visitor species have peak observations in July and August, Fig. 1a. This was also the case for three of the pollinator groups studied (Appendices S1-S4): aculeate wasps (71% of species), bees (60%), and butterflies (72%); but not hoverflies (49%). Bee species richness was found to be lower in June than during May or July (Fig 1a). Tree species flower predominantly during spring (74% in May), shrubs in early summer (69% in June), while herbs peak in July (83%), Fig 1b.

A significant positive correlation was found between the number of flower-visiting insects on the wing and the richness of insect-pollinated herbs and tree/shrub species in bloom, per

calendar month (herbs: $F = 100.5$, $df = 11$, $P = <0.001$; trees and shrubs: $F = 11.6$, $df = 11$, $P = 0.007$; Fig. 2).

Analysis indicates a greater than expected proportion of extinct pollinators are late summer-flying (July-August) species (82.5% observed vs 61.8% expected; $\chi^2 = 7.3$, $df = 1$, $P = 0.007$; Fig. 3a; Appendix S5). This trend was driven primarily by the bee extinctions (80.0% observed vs 59.5% expected; $\chi^2 = 4.4$, $df = 1$, $P = 0.037$) and was not apparent among aculeate wasps or butterflies ($P > 0.05$); there have been no recorded British hoverfly extinctions. This pattern was also not repeated among extinct or endangered plants (extinct and endangered plant species were combined for analysis, Fig. 3b).

A higher than expected (30%; Westrich, 1989) proportion of extinct nest-building bee species (i.e. not cleptoparasitic) were found to be specialists (63.6% observed vs 30.0% expected; $\chi^2 = 9.9$, $df = 1$, $P = 0.002$), that is forage on a narrow range of plant species (i.e. oligolectic; Appendix F). We did not include the three extinct bumble bee species in our analysis because eusocial bees are necessarily polylectic, as their colony cycles exceed the blooming period of any one floral host (Cane & Sipes, 2006). Interestingly, however, these *Bombus* species are all considered to be quasi- or meso-oligolectic (Rasmont, 1988).

Discussion

This unique dataset confirms for the first time, at the regional scale and across multiple insect groups, that late summer (July and August) is the annual peak of pollinator and herb reproduction in the UK, Fig 1. This season is, therefore, crucial to the survival of these mutually reliant groups. Indeed, July and August have previously been noted as the height of bumble bee (Edwards & Williams, 2004), honey bee (Seeley, 2009), social wasp (Spadberry, 1973) and butterfly (Roy et al., 2007) foraging. Thus, this period is critical for the reproductive success of most British bumble bees (Goulson, 2003), including rare and

declining species (Williams & Osbourne, 2009) and for honey bee colonies to gather winter stores (Seeley, 1995).

The spring peak in bee species is largely due to the phenology of the species-rich genera *Andrena* and its cleptoparasites *Nomada* (67% of bees with peak observations in April and May were of these genera). These months are also the peak for flowering tree species (82% of species flower in April and May) and, perhaps as a consequence, *Andrena* spp. are known to frequent tree flowers (e.g. *Pyrus*, *Prunus*; Chambers, 1946), at times almost exclusively (e.g. *Salix*; Falk, 2015).

Interestingly, the data also indicate that bee diversity dips between May and July (Fig 1a). This June lull coincides with a gap between peak tree and herb flowering (Fig. 1b) and, therefore, may reflect limited forage availability at this time. The term 'June gap' is commonly used by British beekeepers to describe this period, which they consider to be relatively bereft of nectar sources (e.g. Horn et al., 2015). These early season patterns indicate that pollinator community phenology is driven by factors other than temperature alone.

We also identified a positive correlation between the number of flower-visiting insects on the wing and the richness of blooming insect-pollinated herb and tree/shrub species (Fig. 2). The data indicate that pollinator phenology is better synchronized with herbs than of trees and shrubs. A seasonal synchrony between the richness of pollinator species and that of flowering plants is perhaps intuitive, and has been described in local North American communities (Mosquin, 1971; Tepedino & Stanton 1981), but had not been quantified previously for the UK.

Our findings, therefore, indicate that the supply of floral resources is apparently well matched to demand throughout the year. However, we also found a significantly greater than expected number of extinct late summer-flying pollinator species (83%; Fig. 3). This trend was driven

206 primarily by bee extinctions (80%). Furthermore, twice as many extinct nest-building bee
207 species were found to be specialists as expected (i.e. oligolectic; 64%); a pattern previously
208 noted among European Red List bees (Westrich, 1996). The vulnerability of specialist species
209 is predicted by niche theory and their subsequent decline proposed as an indicator of the
210 impact of global changes on biodiversity (Clavel et al., 2011).

211 Interestingly, the data also indicate that the majority of endangered pollinator are spring-
212 flying (May-June) species (Fig. 3a), thus indicating that pollinator conservation efforts, such
213 as agri-environmental schemes, should not focus exclusively on providing late summer
214 forage (Carreck & Williams, 2002). From broad trends in the data presented here, and
215 elsewhere, we hypothesise that there are three important factors responsible for the
216 disproportionally high extinction rate of late summer pollinators.

217 First, floral resources during late summer (July and August) have markedly declined over the
218 past century and are now likely to be patchily distributed across Britain. Baude et al. (2016)
219 estimated that just four late summer blooming plant species provisioned over half of nectar
220 nationally in 2007. However, at least three of these once widespread species have suffered
221 acute long-term declines. Two are heathland species, *Calluna vulgaris* (-36% from 1978-
222 2007 Countryside Surveys, calculations followed those of Carvell et al., 2006) and *Erica*
223 *cinerea* (-50%, 1978-2007), which have long been casualties of agricultural improvement and
224 afforestation (Thompson et al., 1995). At the same time the use of white clover (*Trifolium*
225 *repens*) to fix nitrogen in pastureland has waned since the introduction of artificial fertilisers
226 early last century (-52%, 1978-2007). The fourth species, *Cirsium palustre* (-13%, 1978-
227 2007), is a wetland thistle that has also declined due to habitat losses (Dugan, 1990).

228 Additionally, during July-August there is a scarcity of flowering crops in Northern Europe
229 (Scheper et al., 2014) and, as shown here, few blooming trees and shrub species. Thus,
230 wildflowers represent the principal source of nectar and pollen during late-summer. However,

231 agricultural intensification during the second half of the last century (Robinson & Sutherland,
232 2002), and perhaps earlier (Ollerton et al., 2014), has severely impacted wildflower
233 populations. Currently one-fifth of English species are classified as 'threatened' and several
234 traditionally widespread species are considered 'near threatened' (Stroh et al., 2014).

235 Second, due to the seasonal colony life cycle and nest populations of of eusocial bee species,
236 the demand for floral resources will likely be far greater during summer than in spring,
237 possibly resulting in increased competition. This is because bee diets are derived almost
238 exclusively from floral sources. By contrast, aculeate wasps, butterflies and hoverflies are
239 either predatory or herbivorous during their larval stage, often carrying reserves over to their
240 adult phase (Romeis et al., 2005) and visiting flowers only to fuel their own activity.

241 Although the majority of flower visitors forage primarily for nectar rather than pollen during
242 summer (c. 90%, Balfour et al., 2015b), nectar competition is most likely to be the result of,
243 and affect, eusocial bee species (Thomson, 2004; Balfour et al., 2015a). This is because
244 eusocial bee colonies can collect large amounts of nectar per day to feed their young and to
245 store for later use, for example: *Bombus*, 50 g (Heinrich, 1979) and *Apis mellifera*, >5 kg
246 (Seeley, 1995) per colony. The vast majority (73%) of eusocial bee species have peak
247 populations during July and August. Consequently, during July-August researchers have
248 observed: (i) considerable overlap in the flower species visited by *Bombus* and *Apis* (e.g.
249 Steffan-Dewenter & Tscharntke, 2000; Balfour et al., 2015b); (ii) intense nectar competition
250 between bee species (e.g. Inouye, 1978; Weatherwax, 1986; Balfour et al., 2013); (iii)
251 foragers competing for flowers containing minute quantities of nectar (c. 0.1 µl; Williams,
252 1998; Balfour et al., 2015a); (iv) the beginning of marked nectar robbing between honey bee
253 colonies (e.g. Sakofski et al., 1990); (v) the greatest honey bee foraging distances (Couvillon
254 et al., 2014a); and (vi) the highest proportion of honey bee foragers returning with empty

crops (Couvillon et al., 2014b). Notably, summer competition has likely been exacerbated by the land-use changes described above.

Third, we hypothesise that floral resource supply per individual insect may be more plentiful in spring than summer due to the blooming period of trees (82% species flowering in April-May) and mass flowering crops (e.g. *Brassica napus*, *Malus*, *Pyrus*, *Vicia*). This is because trees are capable of providing vast quantities of nectar and pollen relative to herbaceous species, as illustrated by recent research which estimated that a single *Tilia cordata* tree attracted the same number of flower-visitors as 6000m² of flower-rich chalk grassland at a nearby National Nature Reserve (Balfour et al., 2015b). Indeed, trees are known to be important spring forage sources for honey bee colonies (Coffey & Breen, 1997; Odoux et al., 2014), solitary bees (Chambers, 1946) and bumble bee queens (Lye et al., 2009). Likewise, mass-flowering crops, such as oilseed rape, can provide abundant forage for pollinators (e.g. Westphal et al., 2003), but are usually spring flowering (Scheper et al., 2014).

Theoretically, reduced late summer forage availability and the resulting competition is likely to impact bee populations more acutely than those of other pollinator species (Balfour et al., 2015a). However, this is a topic that is poorly understood (Goulson et al., 2015).

Nevertheless, there is evidence that both hoverfly (e.g. Meyer et al., 2011) and aculeate wasp (Karem et al., 2010) densities are related to floral resources abundance. Contrastingly, a meta-analysis of 30 British species found no evidence that nectar resources influence butterfly populations (Thomas et al., 2011). The relationship between pollinating insect phenologies and the timing of the flowering of the plants that they pollinate is a complex one. However our results suggest a causal link that may be fundamental to the pattern of pollinator declines and extinctions seen in Britain. As such these topics clearly deserve further research.

Author contributions

279 NB designed the study, conducted the literature search, analysed the data, and wrote the
280 manuscript. FLWR, JO and MCC contributed to the interpretation of the data and writing of
281 the manuscript.

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284 **Conflict of interest**

285 We have no competing interests.

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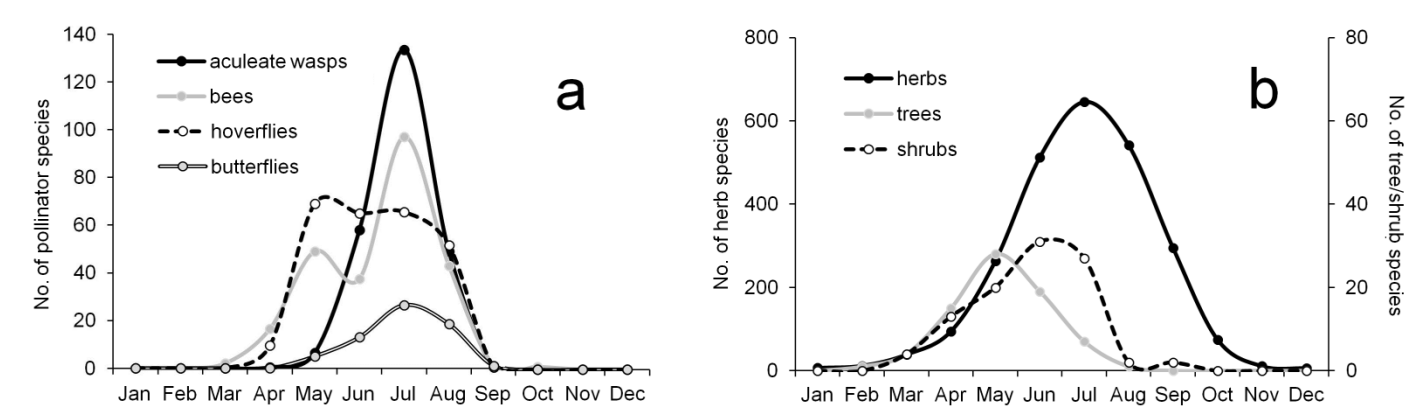
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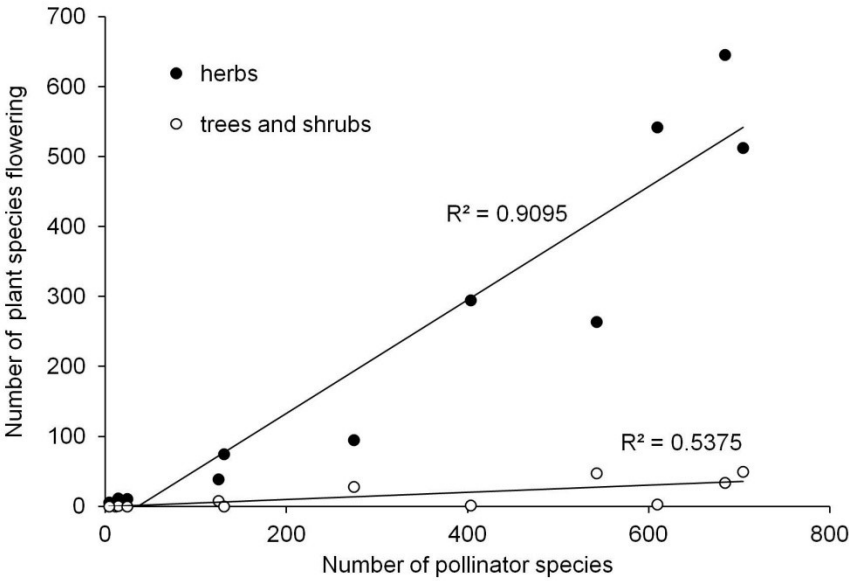
425 **Fig. 1** a) Peak numbers of observations of British pollinator species, by calendar month,
426 grouped into aculeate wasps, bees, hoverflies and butterflies b) Numbers of species of
427 flowering British insect-pollinated plants per month, grouped into herbs, trees and shrubs.

428 **Fig. 2** Relationship between the number of British flower-visiting insects species recorded on
429 the wing and the number of insect-pollinated herb and tree/shrub species in flower, per
430 calendar month. There are two significant positive relationships shown by the regression
431 lines.

432 **Fig. 3** Observed minus the expected (a) phenology of extinct ($n = 40$ species) and critically
433 endangered/endangered ($n = 33$) British pollinator species and (b) flowering phenology of
434 extinct and critically endangered/endangered insect-pollinated British plant species ($n = 57$).

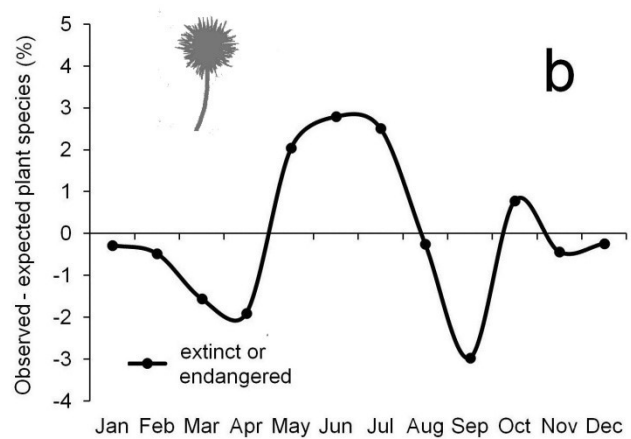
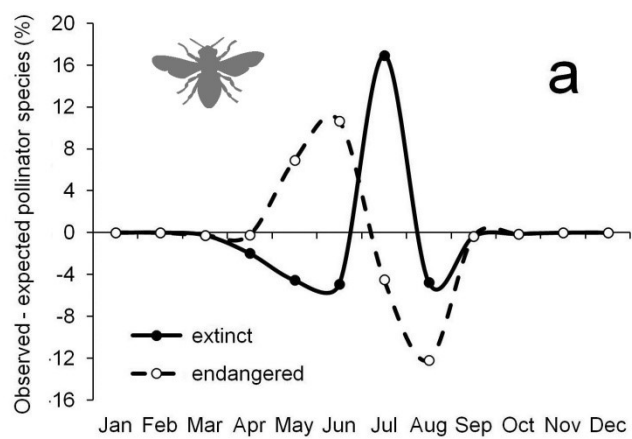


437 **Figure 2**



438

439



Appendix S1 - Peak number of aculeate wasp observations per species, per calendar month (J = January etc.) calculated from the Bees, Wasps & Ants Recording Society and the Global Biodiversity Information Facility databases. Records from all years were binned per month for all species with ≥ 50 total observations (90%; 248 out of 276 species). When the difference between the two months with the greatest number of insect observations was $< 10\%$, the peak abundance of a species was considered to be spread across both months (e.g. *Agenioideus cinctellus* observations are equal and maximal in June and July, resulting in each month being 'scored' 0.5 for this species). When the difference was $> 10\%$ the peak abundance of a species was considered to peak in only one month (e.g. *Agenioideus sericeus* peak observations are in August, resulting in this month being 'scored' 1 for this species).

Species	J	F	M	A	M	J	J	A	S	O	N	D	Records	Hectads	Source
<i>Agenioideus cinctellus</i>						0.5	0.5						457	131	BWARS
<i>Agenioideus sericeus</i>								1					55	1	BWARS/GBIF
<i>Ammophila pubescens</i>							1						604	42	BWARS
<i>Ammophila sabulosa</i>							1						2053	268	BWARS
<i>Ancistrocerus antilope</i>													17	15	BWARS
<i>Ancistrocerus gazella</i>							1						1288	335	BWARS
<i>Ancistrocerus nigricornis</i>								1					409	125	BWARS
<i>Ancistrocerus oviventris</i>						1							529	232	BWARS
<i>Ancistrocerus parietinus</i>						1							527	198	BWARS
<i>Ancistrocerus parietum</i>							1						470	210	BWARS
<i>Ancistrocerus scoticus</i>						1							449	175	BWARS
<i>Ancistrocerus trifasciatus</i>							1						934	312	BWARS
<i>Anoplius caviventris</i>							0.5	0.5					104	26	BWARS/GBIF
<i>Anoplius concinnus</i>							1						182	93	BWARS
<i>Anoplius infuscatus</i>							0.5	0.5					665	177	BWARS
<i>Anoplius nigerrimus</i>								1					1497	375	BWARS
<i>Anoplius viaticus</i>								1					997	122	BWARS
<i>Anteon arcuatum</i>						1							61	14	BWARS/GBIF

<i>Anteon brachycerum</i>					1								66	17	BWARS
<i>Anteon ephippiger</i>							1						79	15	GBIF
<i>Anteon exiguum</i>								1					52	2	BWARS/GBIF
<i>Anteon flavicorne</i>													54	13	BWARS/GBIF
<i>Anteon fulviventre</i>						1							86	22	BWARS
<i>Anteon gaullei</i>							1						71	19	BWARS
<i>Anteon infectum</i>						1							98	11	BWARS
<i>Anteon jurineanum</i>					1								110	24	BWARS
<i>Anteon pubicorne</i>						0.5	0.5						191	42	BWARS
<i>Anteon reticulatum</i>													1	1	BWARS
<i>Anteon scapulare</i>						1							63	4	BWARS
<i>Anteon tripartitum</i>													16	7	BWARS
<i>Aphelopus atratus</i>						1							84	21	BWARS
<i>Aphelopus melaleucus</i>						1							139	31	BWARS
<i>Aphelopus nigriceps</i>													7	5	BWARS
<i>Aphelopus querceus</i>													4	3	BWARS
<i>Aphelopus serratus</i>						1							57	19	BWARS/GBIF
<i>Aporus unicolor</i>								1					185	52	BWARS
<i>Arachnospila anceps</i>								1					1831	415	BWARS
<i>Arachnospila consobrina</i>							1						85	11	BWARS/GBIF
<i>Arachnospila minutula</i>								1					292	97	BWARS
<i>Arachnospila rufa</i>							1						365	1	BWARS/GBIF
<i>Arachnospila spissa</i>						1							856	255	BWARS
<i>Arachnospila trivialis</i>								1					414	112	BWARS
<i>Arachnospila wesmaeli</i>								1					93	33	BWARS
<i>Argogorytes fargeii</i>						1							90	35	BWARS
<i>Argogorytes mystaceus</i>						1							1010	309	BWARS
<i>Astata boops</i>							1						1002	136	BWARS
<i>Auplopus carbonarius</i>						1							338	77	BWARS
<i>Bethylus boops</i>													12	7	BWARS
<i>Bethylus cephalotes</i>							1						132	52	BWARS

<i>Bethylus dendrophilus</i>													6	4	BWARS
<i>Bethylus fuscicornis</i>							1						115	52	BWARS
<i>Caliadurgus fasciatellus</i>								1					464	136	BWARS
<i>Cephalonomia formiciformis</i>													17	8	BWARS
<i>Cerceris arenaria</i>							1						1811	238	BWARS
<i>Cerceris quadricincta</i>							0.5	0.5					73	15	BWARS
<i>Cerceris quinquefasciata</i>							1						216	46	BWARS
<i>Cerceris ruficornis</i>							1						402	68	BWARS
<i>Cerceris rybyensis</i>							1						2330	291	BWARS
<i>Cerceris sabulosa</i>							1						82	1	BWARS/GBIF
<i>Ceropales maculata</i>							0.5	0.5					273	87	BWARS
<i>Ceropales variegata</i>								1					72	14	BWARS/GBIF
<i>Chrysis angustula</i>						1							856	276	BWARS
<i>Chrysis fulgida</i>						1							54	22	BWARS
<i>Chrysis gracillima</i>							1						73	42	BWARS
<i>Chrysis ignita</i>						1							189	86	BWARS
<i>Chrysis illigeri</i>						0.5	0.5						245	60	BWARS
<i>Chrysis impressa</i>						1							752	239	BWARS
<i>Chrysis longula</i>							1						112	3	BWARS/GBIF
<i>Chrysis mediata</i>						1							127	73	BWARS
<i>Chrysis pseudobrevitarsis</i>						0.5	0.5						52	3	BWARS/GBIF
<i>Chrysis ruddii</i>						1							131	56	BWARS
<i>Chrysis rutiliventris</i>						0.5	0.5						244	123	BWARS
<i>Chrysis schencki</i>						0.5	0.5						298	24	BWARS/GBIF
<i>Chrysis viridula</i>						1							413	138	BWARS
<i>Chrysura hirsuta</i>					0.5	0.5							129	3	BWARS/GBIF
<i>Chrysura radians</i>						1							99	46	BWARS
<i>Cleptes nitidulus</i>							1						74	37	BWARS
<i>Cleptes semiauratus</i>							1						108	66	BWARS
<i>Crabro cribrarius</i>							1						1201	313	BWARS
<i>Crabro peltarius</i>						0.5	0.5						804	186	BWARS

<i>Crabro scutellatus</i>							1						233	49	BWARS
<i>Crossocerus annulipes</i>							1						1206	309	BWARS
<i>Crossocerus binotatus</i>							1						172	83	BWARS
<i>Crossocerus capitosus</i>						0.5	0.5						266	143	BWARS
<i>Crossocerus cetratus</i>						1							697	238	BWARS
<i>Crossocerus congener</i>								1					39	3	BWARS/GBIF
<i>Crossocerus dimidiatus</i>							1						426	192	BWARS
<i>Crossocerus distinguendus</i>							1						456	114	BWARS
<i>Crossocerus elongatulus</i>							1						1654	438	BWARS
<i>Crossocerus exiguus</i>								1					79	21	BWARS
<i>Crossocerus leucostomus</i>						1							363	20	BWARS/GBIF
<i>Crossocerus megacephalus</i>						1							1499	443	BWARS
<i>Crossocerus nigritus</i>						0.5	0.5						458	184	BWARS
<i>Crossocerus ovalis</i>						0.5	0.5						995	219	BWARS
<i>Crossocerus palmipes</i>							1						78	41	BWARS
<i>Crossocerus podagricus</i>							1						1523	381	BWARS
<i>Crossocerus quadrimaculatus</i>							0.5	0.5					2087	345	BWARS
<i>Crossocerus styrius</i>							1						90	56	BWARS
<i>Crossocerus tarsatus</i>						0.5		0.5					759	232	BWARS
<i>Crossocerus vagabundus</i>							1						305	21	BWARS/GBIF
<i>Crossocerus varus</i>							1						1519	360	BWARS
<i>Crossocerus walkeri</i>							1						69	43	BWARS
<i>Crossocerus wesmaeli</i>							1						1124	184	BWARS
<i>Cryptocheilus notatus</i>							0.5	0.5					186	48	BWARS
<i>Didineis lunicornis</i>								1					130	48	BWARS
<i>Dinetus pictus</i>							1						113	58	BWARS/GBIF
<i>Diodontus insidiosus</i>							1						175	1	BWARS
<i>Diodontus luperus</i>						0.5	0.5						391	50	BWARS
<i>Diodontus minutus</i>							1						890	120	BWARS
<i>Diodontus tristis</i>							1						411	169	BWARS
<i>Dipogon bifasciatus</i>						0.5		0.5					50	98	BWARS

<i>Dipogon subintermedius</i>							1						542	16	BWARS
<i>Dipogon variegatus</i>						0.5	0.5						400	184	BWARS
<i>Dolichovespula media</i>								1					940	147	BWARS
<i>Dolichovespula norvegica</i>							0.5	0.5					472	318	BWARS
<i>Dolichovespula saxonica</i>							0.5	0.5					523	271	BWARS
<i>Dolichovespula sylvestris</i>							0.5	0.5					2300	150	BWARS
<i>Dryinus collaris</i>													1	591	BWARS
<i>Dryinus niger</i>													1	1	BWARS
<i>Dryudella pinguis</i>							1						330	1	BWARS
<i>Ectemnius borealis</i>							0.5	0.5					66	105	BWARS
<i>Ectemnius cavifrons</i>							1						1455	12	BWARS
<i>Ectemnius cephalotes</i>							1						673	369	BWARS
<i>Ectemnius continuus</i>								1					2956	252	BWARS
<i>Ectemnius dives</i>							0.5	0.5					326	531	BWARS
<i>Ectemnius lapidarius</i>							1						555	84	BWARS
<i>Ectemnius lituratus</i>							0.5	0.5					1391	207	BWARS
<i>Ectemnius rubicola</i>							1						394	288	BWARS
<i>Ectemnius ruficornis</i>							1						290	161	BWARS
<i>Ectemnius sexcinctus</i>							1						262	111	BWARS
<i>Elampus panzeri</i>							1						360	108	BWARS
<i>Embolemus ruddii</i>							0.5	0.5					57	78	BWARS/GBIF
<i>Entomognathus brevis</i>							1						921	8	BWARS
<i>Episyron rufipes</i>							1						1181	198	BWARS
<i>Epyris bilineatus</i>													7	215	BWARS
<i>Epyris brevipennis</i>													0	4	BWARS
<i>Epyris niger</i>								1					55	18	BWARS/GBIF
<i>Eumenes coarctatus</i>							0.5	0.5					426	18	BWARS
<i>Euodynerus quadrifasciatus</i>						1							346	42	BWARS/BWA
<i>Evagetes crassicornis</i>								1					1052	6	BWARS
<i>Evagetes dubius</i>								1					276	267	BWARS
<i>Evagetes pectinipes</i>							1						365	40	BWARS/GBIF

<i>Gonatopus albosignatus</i>														11	6	BWARS
<i>Gonatopus bicolor</i>														15	7	BWARS
<i>Gonatopus clavipes</i>														28	5	BWARS
<i>Gonatopus distinguendus</i>														12	14	BWARS
<i>Gonatopus formicicolus</i>														0	2	BWARS
<i>Gonatopus helleni</i>														5	1	BWARS
<i>Gonatopus lunatus</i>														1	4	BWARS
<i>Gonatopus pedestris</i>														5	2	BWARS
<i>Gonatopus striatus</i>														4	4	BWARS
<i>Goniozus claripennis</i>							1							108	4	BWARS
<i>Gorytes bicinctus</i>														0	0	BWARS
<i>Gorytes laticinctus</i>							1							108	37	BWARS
<i>Gorytes quadrifasciatus</i>							1							435	160	BWARS
<i>Gymnomerus laevipes</i>						1								284	89	BWARS
<i>Haplogonatopus oratorius</i>														3	3	BWARS
<i>Harpactus tumidus</i>							1							454	197	BWARS
<i>Hedychridium ardens</i>						1								822	197	BWARS
<i>Hedychridium coriaceum</i>							1							86	21	BWARS
<i>Hedychridium cupreum</i>						0.5	0.5							90	34	BWARS
<i>Hedychridium roseum</i>							1							680	96	BWARS
<i>Hedychrum niemelai</i>							1							428	72	BWARS
<i>Hedychrum rutilans</i>							1							163	1	BWARS/GBIF
<i>Homonotus sanguinolentus</i>							1							1193	11	BWARS
<i>Lestica clypeata</i>						0.5	0.5							286	1	BWARS/GBIF
<i>Lestiphorus bicinctus</i>								1						257	88	BWARS
<i>Lindenius albilabris</i>							1							1842	345	BWARS
<i>Lindenius panzeri</i>							1							516	119	BWARS
<i>Lindenius pygmaeus</i>							1							50	1	BWARS/GBIF
<i>Lonchodryinus ruficornis</i>							1							152	40	BWARS
<i>Mellinus arvensis</i>								1						2438	465	BWARS
<i>Mellinus crabroneus</i>							1							91	12	BWARS/GBIF

<i>Methocha articulata</i>							1						296	68	BWARS
<i>Microdynerus exilis</i>							1						159	73	BWARS
<i>Mimesa bicolor</i>							1						155	22	BWARS/GBIF
<i>Mimesa bruxellensis</i>							1						144	41	BWARS
<i>Mimesa equestris</i>								1					1269	189	BWARS
<i>Mimesa lutaria</i>							1						558	109	BWARS
<i>Mimumesa atratina</i>							1						109	3	BWARS/GBIF
<i>Mimumesa dahlbomi</i>						0.5	0.5						720	247	BWARS
<i>Mimumesa littoralis</i>							0.5	0.5					75	22	BWARS
<i>Mimumesa spooneri</i>							0.5	0.5					79	25	BWARS
<i>Mimumesa unicolor</i>							1						118	29	BWARS
<i>Miscophus ater</i>							1						195	3	BWARS/GBIF
<i>Miscophus concolor</i>							1						199	33	BWARS
<i>Monosapyga clavicornis</i>						1							179	79	BWARS
<i>Mutilla europaea</i>								1					481	69	BWARS
<i>Nitela borealis</i>						0.5		0.5					69	5	BWARS
<i>Nitela lucens</i>						1							96	18	BWARS
<i>Nysson dimidiatus</i>							1						255	112	BWARS
<i>Nysson interruptus</i>						1							60	7	BWARS/GBIF
<i>Nysson spinosus</i>						1							572	211	BWARS
<i>Nysson trimaculatus</i>							1						437	147	BWARS
<i>Odynerus melanocephalus</i>						1							219	80	BWARS
<i>Odynerus reniformis</i>						1							95	2	BWARS/GBIF
<i>Odynerus simillimus</i>							1						75	7	BWARS
<i>Odynerus spinipes</i>						1							615	216	BWARS
<i>Omalus aeneus</i>							1						148	60	BWARS
<i>Omalus puncticollis</i>							1						69	45	BWARS
<i>Oxybelus argentatus</i>							1						176	44	BWARS
<i>Oxybelus mandibularis</i>							1						164	40	BWARS
<i>Oxybelus uniglumis</i>							1						2416	360	BWARS
<i>Passaloecus clypealis</i>							1						71	18	BWARS

<i>Passaloecus corniger</i>							1						698	221	BWARS
<i>Passaloecus eremita</i>						0.5	0.5						339	74	BWARS
<i>Passaloecus gracilis</i>							1						721	197	BWARS
<i>Passaloecus insignis</i>							1						329	148	BWARS
<i>Passaloecus monilicornis</i>							1						96	41	BWARS
<i>Passaloecus singularis</i>						0.5	0.5						959	262	BWARS
<i>Passaloecus turionum</i>							1						57	20	BWARS
<i>Pemphredon inornata</i>						0.5	0.5						1178	323	BWARS
<i>Pemphredon lethifer</i>						0.5	0.5						946	302	BWARS
<i>Pemphredon lugubris</i>						1							1729	418	BWARS
<i>Pemphredon morio</i>							1						162	81	BWARS
<i>Pemphredon mortifer</i>													0	0	BWARS
<i>Pemphredon rugifera</i>						0.5	0.5						146	0	GBIF
<i>Pemphredon wesmaeli</i>							1						246	0	GBIF
<i>Philanthus triangulum</i>								1					1549	251	BWARS
<i>Philoctetes truncatus</i>													2	2	BWARS
<i>Podalonia affinis</i>							1						179	36	BWARS
<i>Podalonia hirsuta</i>							0.5	0.5					355	58	BWARS
<i>Pompilus cinereus</i>							1						901	198	BWARS
<i>Priocnemis agilis</i>								1					103	64	BWARS
<i>Priocnemis confusor</i>								1					142	56	BWARS
<i>Priocnemis cordivalvata</i>								1					102	43	BWARS
<i>Priocnemis coriacea</i>				1									131	67	BWARS
<i>Priocnemis exaltata</i>								1					929	266	BWARS
<i>Priocnemis fennica</i>								1					466	129	BWARS
<i>Priocnemis hyalinata</i>							1						122	52	BWARS
<i>Priocnemis parvula</i>								1					712	236	BWARS
<i>Priocnemis propinqua</i>				1									951	302	BWARS
<i>Priocnemis pusilla</i>								1					407	139	BWARS
<i>Priocnemis schioedtei</i>							1						301	94	BWARS
<i>Priocnemis susterai</i>				1									228	107	BWARS

<i>Psen ater</i>														0	0	BWARS
<i>Psenulus concolor</i>						1								259	120	BWARS
<i>Psenulus pallipes</i>							1							788	274	BWARS
<i>Psenulus schencki</i>							1							110	38	BWARS
<i>Pseudepipona herrichii</i>							1							145	5	BWARS
<i>Pseudisobrachium subcyaneum</i>														2	2	BWARS
<i>Pseudomalus auratus</i>							1							652	229	BWARS
<i>Pseudomalus violaceus</i>							1							130	65	BWARS
<i>Pseudospinolia neglecta</i>						1								115	44	BWARS
<i>Rhopalum clavipes</i>							0.5	0.5						605	257	BWARS
<i>Rhopalum coarctatum</i>						0.5		0.5						777	243	BWARS
<i>Rhopalum gracile</i>								1						76	3	BWARS/GBIF
<i>Sapyga quinquepunctata</i>				0.5		0.5								506	154	BWARS
<i>Smicromyrme rufipes</i>							1							379	53	BWARS
<i>Spilomena beata</i>							1							70	48	BWARS
<i>Spilomena curruca</i>							1							71	46	BWARS
<i>Spilomena enslini</i>				0.5	0.5									56	32	BWARS
<i>Spilomena troglodytes</i>							1							232	103	BWARS
<i>Stigmus pendulus</i>							1							235	65	BWARS
<i>Stigmus solskyi</i>							1							573	189	BWARS
<i>Symmorphus bifasciatus</i>							1							684	264	BWARS
<i>Symmorphus connexus</i>							1							217	15	BWARS/GBIF
<i>Symmorphus crassicornis</i>						1								148	32	BWARS
<i>Symmorphus gracilis</i>						0.5	0.5							530	174	BWARS
<i>Tachysphex nitidus</i>						1								145	53	BWARS
<i>Tachysphex obscuripennis</i>							1							2706	1	BWARS/GBIF
<i>Tachysphex pompiliiformis</i>						0.5	0.5							1350	302	BWARS
<i>Tachysphex unicolor</i>						1								127	18	BWARS/GBIF
<i>Tiphia femorata</i>								1						778	166	BWARS
<i>Tiphia minuta</i>						1								361	170	BWARS
<i>Trichrysis cyanea</i>						0.5	0.5							1562	371	BWARS

<i>Trypoxylon attenuatum</i>							0.5	0.5					1293	354	BWARS
<i>Trypoxylon clavicerum</i>							1						1167	318	BWARS
<i>Trypoxylon figulus</i>							1						184	216	BWARS
<i>Trypoxylon medium</i>							1						565	158	BWARS
<i>Trypoxylon minus</i>						0.5	0.5						1471	1	BWARS/GBIF
<i>Vespa crabro</i>								0.5	0.5				1766	388	BWARS
<i>Vespula austriaca</i>						1							99	53	BWARS
<i>Vespula germanica</i>								1					2213	461	BWARS
<i>Vespula rufa</i>								1					1560	443	BWARS
<i>Vespula vulgaris</i>								1					4767	673	BWARS
Totals	0	0	0	0.5	6.5	58	133.5	49	0.5	0	0	0	133869	32177	

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Appendix S2 - Peak number of observations per bee species, per calendar month (J = January) calculated from the Bees, Wasps & Ants Recording Society and the Global Biodiversity Information Facility databases. Records from all years were binned per month for all species with ≥ 50 total observations (97%; 247 out of 254 species). When the difference between the two months with the greatest number of insect observations was $< 10\%$, the peak abundance of a species was considered to be spread across both months (e.g. *Andrena alfkenella* observations are equal and maximal in June and August, resulting in each month being 'scored' 0.5 for this species). When the difference was $> 10\%$ the peak abundance of a species was considered to peak in only one month (e.g. *Andrena angustior* peak observations are in May, resulting in this month being 'scored' 1 for this species).

Species	J	F	M	A	M	J	J	A	S	O	N	D	Records	Hectads	Source
<i>Andrena alfkenella</i>							0.5	0.5					154	67	BWARS
<i>Andrena angustior</i>					1								649	186	BWARS
<i>Andrena apicata</i>			1										317	83	BWARS
<i>Andrena argentata</i>							0.5	0.5					621	38	BWARS
<i>Andrena barbilabris</i>					1								1838	308	BWARS
<i>Andrena bicolor</i>							1						4540	638	BWARS
<i>Andrena bimaculata</i>							1						607	102	BWARS
<i>Andrena bucephala</i>					1								405	107	BWARS
<i>Andrena carantonica</i>					1								4979	729	BWARS
<i>Andrena chrysosceles</i>					1								2954	473	BWARS
<i>Andrena cineraria</i>					1								1903	390	BWARS
<i>Andrena clarkella</i>			0.5	0.5									1900	400	BWARS
<i>Andrena coitana</i>							1						516	184	BWARS
<i>Andrena congruens</i>				1									153	27	BWARS
<i>Andrena denticulata</i>							1						1055	258	BWARS
<i>Andrena dorsata</i>							1						3619	368	BWARS
<i>Andrena falsifica</i>					1								118	44	BWARS
<i>Andrena ferox</i>					1								84	11	BWARS
<i>Andrena flavipes</i>				0.5			0.5						6393	423	BWARS
<i>Andrena florea</i>						1							550	42	BWARS
<i>Andrena fucata</i>						1							1072	330	BWARS

<i>Andrena fulva</i>				1									3071	533	BWARS
<i>Andrena fulvago</i>						1							215	100	BWARS
<i>Andrena fuscipes</i>								1					1424	187	BWARS
<i>Andrena gravida</i>				1									52	16	BWARS
<i>Andrena haemorrhoa</i>					1								6054	829	BWARS
<i>Andrena hattorfiana</i>							1						439	81	BWARS
<i>Andrena helvola</i>					1								940	226	BWARS
<i>Andrena humilis</i>					0.5	0.5							556	174	BWARS
<i>Andrena labialis</i>						1							820	189	BWARS
<i>Andrena labiata</i>					1								838	194	BWARS
<i>Andrena lapponica</i>					1								648	159	BWARS
<i>Andrena lathyri</i>					1								950	2	BWARS/GBIF
<i>Andrena lepida</i>													3	1	BWARS
<i>Andrena marginata</i>								1					472	98	BWARS
<i>Andrena minutula</i>							1						4315	522	BWARS
<i>Andrena minutuloides</i>							1						456	83	BWARS
<i>Andrena nana</i>					0.5		0.5						52	3	BWARS/GBIF
<i>Andrena nigriceps</i>							1						185	79	BWARS
<i>Andrena nigroaenea</i>					1								3811	601	BWARS
<i>Andrena nigrospina</i>						1							108	20	BWARS
<i>Andrena nitida</i>				0.5	0.5								3278	494	BWARS
<i>Andrena nitidiuscula</i>							1						311	50	BWARS
<i>Andrena niveata</i>						1							67	21	BWARS
<i>Andrena ovatula</i>							1						1463	238	BWARS
<i>Andrena pilipes</i>								1					286	65	BWARS
<i>Andrena polita</i>													10	2	BWARS
<i>Andrena praecox</i>				1									817	189	BWARS
<i>Andrena proxima</i>					1								282	91	BWARS
<i>Andrena ruficrus</i>				1									130	29	BWARS
<i>Andrena semilaevis</i>						1							1997	441	BWARS

<i>Andrena similis</i>					1								256	109	BWARS
<i>Andrena simillima</i>							1						84	18	BWARS
<i>Andrena subopaca</i>					1								2700	477	BWARS
<i>Andrena synadelpha</i>					1								2643	160	BWARS
<i>Andrena tarsata</i>							1						590	173	BWARS
<i>Andrena thoracica</i>							1						530	163	BWARS
<i>Andrena tibialis</i>				1									1036	98	BWARS
<i>Andrena tridentata</i>													6	4	BWARS
<i>Andrena trimmerana</i>				1									986	184	BWARS
<i>Andrena vaga</i>				1									2275	3	BWARS/GBIF
<i>Andrena varians</i>				1									298	101	BWARS
<i>Andrena wilkella</i>						1							1855	443	BWARS
<i>Anthidium manicatum</i>							1						1019	284	BWARS
<i>Anthophora bimaculata</i>							1						1460	150	BWARS
<i>Anthophora furcata</i>							1						944	291	BWARS
<i>Anthophora plumipes</i>				1									1985	387	BWARS
<i>Anthophora quadrimaculata</i>							1						435	78	BWARS
<i>Anthophora retusa</i>					1								126	57	BWARS
<i>Apis mellifera</i>							1						3080	432	BWARS
<i>Bombus barbutellus</i>							1						738	359	BWARS
<i>Bombus bohemicus</i>							0.5	0.5					2145	643	BWARS
<i>Bombus campestris</i>								1					1500	575	BWARS
<i>Bombus cryptarum</i>					1								75	52	BWARS
<i>Bombus cullumanus</i>								1					53	12	BWARS/GBIF
<i>Bombus distinguendus</i>								1					1115	212	BWARS
<i>Bombus hortorum</i>							1						7806	1466	BWARS
<i>Bombus humilis</i>								1					1355	300	BWARS
<i>Bombus hypnorum</i>						1							3420	721	BWARS
<i>Bombus jonellus</i>							0.5	0.5					2599	719	BWARS
<i>Bombus lapidarius</i>							0.5	0.5					12471	1188	BWARS

<i>Bombus lucorum</i>							1						11824	1575	BWARS
<i>Bombus magnus</i>							1						832	332	BWARS
<i>Bombus monticola</i>						1							1583	341	BWARS
<i>Bombus muscorum</i>							0.5	0.5					2097	523	BWARS
<i>Bombus pascuorum</i>							0.5	0.5					19293	1732	BWARS
<i>Bombus pomorum</i>								1					94	1	BWARS/GBIF
<i>Bombus pratorum</i>						1							8761	1253	BWARS
<i>Bombus ruderarius</i>							1						1081	342	BWARS
<i>Bombus ruderatus</i>							1						393	177	BWARS
<i>Bombus rupestris</i>								1					1032	332	BWARS
<i>Bombus soroeensis</i>							1						712	282	BWARS
<i>Bombus subterraneus</i>								1					226	114	BWARS
<i>Bombus sylvarum</i>								1					886	276	BWARS
<i>Bombus sylvestris</i>						1							2055	633	BWARS
<i>Bombus terrestris</i>							1						11330	1093	BWARS
<i>Bombus vestalis</i>							1						4544	711	BWARS
<i>Ceratina cyanea</i>					0.5	0.5							547	57	BWARS
<i>Chelostoma campanularum</i>							1						656	187	BWARS
<i>Chelostoma florisomne</i>						1							559	240	BWARS
<i>Coelioxys afra</i>							1						54	1	BWARS/GBIF
<i>Coelioxys conoidea</i>							1						359	95	BWARS
<i>Coelioxys elongata</i>							1						416	134	BWARS
<i>Coelioxys inermis</i>							1						194	102	BWARS
<i>Coelioxys mandibularis</i>							1						95	17	BWARS
<i>Coelioxys quadridentata</i>						0.5	0.5						69	34	BWARS
<i>Coelioxys rufescens</i>							1						319	121	BWARS
<i>Colletes cunicularius</i>				1									140	23	BWARS
<i>Colletes daviesanus</i>							1						1588	373	BWARS
<i>Colletes floralis</i>							1						279	34	BWARS
<i>Colletes fodiens</i>							1						900	181	BWARS

<i>Colletes halophilus</i>								1					333	54	BWARS
<i>Colletes hederæ</i>									1				754	132	BWARS
<i>Colletes marginatus</i>						1							240	45	BWARS
<i>Colletes similis</i>						1							1067	211	BWARS
<i>Colletes succinctus</i>							1						1921	350	BWARS
<i>Dasypoda hirtipes</i>						1							675	115	BWARS
<i>Dufourea halictula</i>						1							284	1	BWARS/GBIF
<i>Dufourea minuta</i>						1							61	3	BWARS/GBIF
<i>Epeolus cruciger</i>							1						1240	170	BWARS
<i>Epeolus variegatus</i>						1							1225	248	BWARS
<i>Eucera longicornis</i>					1								398	138	BWARS
<i>Eucera nigrescens</i>				1									157	15	BWARS/GBIF
<i>Halictus confusus</i>						0.5	0.5						151	29	BWARS
<i>Halictus eurygnathus</i>							1						51	11	BWARS
<i>Halictus maculatus</i>						1							315	6	BWARS/GBIF
<i>Halictus rubicundus</i>				0.5			0.5						3033	707	BWARS
<i>Halictus subauratus</i>					0.5	0.5							123	0	GBIF
<i>Halictus tumulorum</i>							1						4190	602	BWARS
<i>Heriades rubicola</i>													0	0	BWARS
<i>Heriades truncorum</i>						1							246	40	BWARS
<i>Hoplitis claviventris</i>					0.5	0.5							593	184	BWARS
<i>Hoplitis leucomelana</i>						1							281	0	GBIF
<i>Hylaeus brevicornis</i>						1							1193	320	BWARS
<i>Hylaeus communis</i>						1							3089	475	BWARS
<i>Hylaeus confusus</i>						1							983	248	BWARS
<i>Hylaeus cornutus</i>						1							459	102	BWARS
<i>Hylaeus dilatatus</i>						1							1260	196	BWARS
<i>Hylaeus hyalinatus</i>					0.5	0.5							1326	329	BWARS
<i>Hylaeus incongruus</i>						1							167	35	BWARS
<i>Hylaeus pectoralis</i>						1							163	49	BWARS

<i>Hylaeus pictipes</i>							1						229	55	BWARS
<i>Hylaeus punctulatissimus</i>						1							102	0	GBIF
<i>Hylaeus signatus</i>							1						554	130	BWARS
<i>Lasioglossum albipes</i>								1					2549	538	BWARS
<i>Lasioglossum angusticeps</i>								1					94	17	BWARS
<i>Lasioglossum brevicorne</i>						1							190	41	BWARS
<i>Lasioglossum calceatum</i>							0.5	0.5					5762	802	BWARS
<i>Lasioglossum cupromicans</i>						0.5	0.5						587	173	BWARS
<i>Lasioglossum fratellum</i>								1					1556	354	BWARS
<i>Lasioglossum fulvicorne</i>							0.5	0.5					2221	360	BWARS
<i>Lasioglossum laeve</i>													0	0	BWARS
<i>Lasioglossum laevigatum</i>					0.5	0.5							780	182	BWARS
<i>Lasioglossum laticeps</i>							1						70	8	BWARS
<i>Lasioglossum lativentre</i>					0.5	0.5							981	264	BWARS
<i>Lasioglossum leucopus</i>							0.5	0.5					1999	494	BWARS
<i>Lasioglossum leucozonium</i>								1					3464	493	BWARS
<i>Lasioglossum malachurum</i>							0.5	0.5					2962	269	BWARS
<i>Lasioglossum minutissimum</i>							0.5	0.5					1243	216	BWARS
<i>Lasioglossum morio</i>							0.5	0.5					4787	546	BWARS
<i>Lasioglossum nitidiusculum</i>					0.5			0.5					317	153	BWARS
<i>Lasioglossum parvulum</i>					1								1603	238	BWARS
<i>Lasioglossum pauperatum</i>								1					116	46	BWARS
<i>Lasioglossum pauxillum</i>							1						1634	219	BWARS
<i>Lasioglossum prasinum</i>							1						575	44	BWARS
<i>Lasioglossum punctatissimum</i>						0.5	0.5						1330	265	BWARS
<i>Lasioglossum puncticolle</i>						0.5	0.5						422	80	BWARS
<i>Lasioglossum quadrinotatum</i>								1					142	62	BWARS
<i>Lasioglossum rufitarse</i>						1							857	179	BWARS
<i>Lasioglossum semilucens</i>						1							73	24	BWARS
<i>Lasioglossum sexnotatum</i>						1							418	12	BWARS/GBIF

<i>Lasioglossum smeathmanellum</i>							1						2129	419	BWARS
<i>Lasioglossum villosulum</i>								1					3418	545	BWARS
<i>Lasioglossum xanthopus</i>				1									387	133	BWARS
<i>Lasioglossum zonulum</i>								1					1255	194	BWARS
<i>Macropis europaea</i>							1						418	74	BWARS
<i>Megachile centuncularis</i>							1						1143	366	BWARS
<i>Megachile circumcincta</i>						1							276	111	BWARS
<i>Megachile lapponica</i>								1					249	1	BWARS/GBIF
<i>Megachile leacella</i>							1						567	107	BWARS
<i>Megachile ligniseca</i>							1						826	247	BWARS
<i>Megachile maritima</i>							1						684	170	BWARS
<i>Megachile versicolor</i>							1						1253	303	BWARS
<i>Megachile willughbiella</i>							1						1877	465	BWARS
<i>Melecta albifrons</i>				1									382	167	BWARS
<i>Melecta luctuosa</i>					1								84	9	BWARS/GBIF
<i>Melitta dimidiata</i>							1						748	8	BWARS
<i>Melitta haemorrhoidalis</i>							1						659	113	BWARS
<i>Melitta leporina</i>							1						2438	166	BWARS
<i>Melitta tricincta</i>							1						683	119	BWARS
<i>Nomada argentata</i>								1					88	32	BWARS
<i>Nomada armata</i>							1						66	21	BWARS
<i>Nomada baccata</i>								1					316	31	BWARS
<i>Nomada conjungens</i>					1								54	14	BWARS/GBIF
<i>Nomada errans</i>													10	1	BWARS
<i>Nomada fabriciana</i>					1								2356	501	BWARS
<i>Nomada ferruginata</i>					1								69	53	BWARS
<i>Nomada flava</i>					1								2740	479	BWARS
<i>Nomada flavoguttata</i>					1								2229	473	BWARS
<i>Nomada flavopicta</i>							1						428	141	BWARS
<i>Nomada fucata</i>							1						1720	267	BWARS

<i>Nomada fulvicornis</i>				1									510	123	BWARS
<i>Nomada goodeniana</i>					1								2766	571	BWARS
<i>Nomada guttulata</i>					1								115	19	BWARS/GBIF
<i>Nomada hirtipes</i>					1								140	49	BWARS
<i>Nomada integra</i>						1							223	87	BWARS
<i>Nomada lathburiana</i>					1								731	193	BWARS
<i>Nomada marshamella</i>					1								3043	241	BWARS
<i>Nomada obtusifrons</i>							1						109	60	BWARS
<i>Nomada panzeri</i>					1								1339	426	BWARS
<i>Nomada roberjeotiana</i>							1						99	43	BWARS
<i>Nomada ruficornis</i>					1								1622	461	BWARS
<i>Nomada rufipes</i>								1					1813	306	BWARS
<i>Nomada sexfasciata</i>					1								96	10	BWARS/GBIF
<i>Nomada sheppardana</i>					1								290	103	BWARS
<i>Nomada signata</i>				1									169	62	BWARS
<i>Nomada striata</i>						1							559	229	BWARS
<i>Osmia aurulenta</i>						1							665	142	BWARS
<i>Osmia bicolor</i>					1								959	158	BWARS
<i>Osmia bicornis</i>					1								2677	741	BWARS
<i>Osmia caerulescens</i>						1							1446	315	BWARS
<i>Osmia inermis</i>						1							85	4	BWARS/GBIF
<i>Osmia leaiana</i>						1							1038	300	BWARS
<i>Osmia niveata</i>						1							86	1	GBIF
<i>Osmia parietina</i>					0.5	0.5							88	28	BWARS
<i>Osmia pilicornis</i>					1								202	52	BWARS
<i>Osmia spinulosa</i>							1						1439	231	BWARS
<i>Osmia uncinata</i>						1							342	16	BWARS/GBIF
<i>Osmia xanthomelana</i>					0.5	0.5							226	10	BWARS/GBIF
<i>Panurgus banksianus</i>							1						634	166	BWARS
<i>Panurgus calcaratus</i>							1						915	114	BWARS

<i>Rophites quinquespinosus</i>							1						52	0	GBIF
<i>Sphecodes crassus</i>							1						722	245	BWARS
<i>Sphecodes ephippius</i>					1								2359	449	BWARS
<i>Sphecodes ferruginatus</i>							0.5	0.5					143	87	BWARS
<i>Sphecodes geoffrellus</i>					0.5		0.5						2029	453	BWARS
<i>Sphecodes gibbus</i>					0.5			0.5					1095	333	BWARS
<i>Sphecodes hyalinatus</i>								1					714	191	BWARS
<i>Sphecodes longulus</i>								1					208	65	BWARS
<i>Sphecodes miniatus</i>						1							80	38	BWARS
<i>Sphecodes monilicornis</i>								1					2106	446	BWARS
<i>Sphecodes niger</i>								1					379	131	BWARS
<i>Sphecodes pellucidus</i>					1								1544	228	BWARS
<i>Sphecodes puncticeps</i>								1					1017	272	BWARS
<i>Sphecodes reticulatus</i>								1					437	130	BWARS
<i>Sphecodes rubicundus</i>						1							264	94	BWARS
<i>Sphecodes scabricollis</i>								1					122	40	BWARS
<i>Sphecodes spinulosus</i>					1								108	43	BWARS
<i>Stelis breviscula</i>							1						97	22	BWARS
<i>Stelis ornatula</i>						0.5	0.5						102	55	BWARS
<i>Stelis phaeoptera</i>							1						71	44	BWARS
<i>Stelis punctulatissima</i>							1						184	85	BWARS
<i>Xylocopa violacea</i>			0.5			0.5							1849	23	BWARS/GBIF
Totals	0	0	2	16.5	49	37.5	97	43	1	1	0	0	330235	57644	

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Appendix S3 - Peak number of hoverfly observations per species, per calendar month (J = January etc.) calculated from the Hoverfly Recording Society and the Global Biodiversity Information Facility databases. Records from all years were binned per month for all species with ≥ 50 total observations (92%; 261 out of 284 species). When the difference between the two months with the greatest number of insect observations was $< 10\%$, the peak abundance of a species was considered to be spread across both months (e.g. *Brachypalpus laphriformis* observations are equal and maximal in May and June, resulting in each month being 'scored' 0.5 for this species). When the difference was $> 10\%$ the peak abundance of a species was considered to peak in only one month (e.g. *Anasimyia contracta* peak observations are in June, resulting in this month being 'scored' 1 for this species).

Species	J	F	M	A	M	J	J	A	S	O	N	D	Records	Hectads	Source
<i>Anasimyia contracta</i>						1							977	277	HRS
<i>Anasimyia interpuncta</i>					1								112	25	HRS
<i>Anasimyia lineata</i>						1							1689	422	HRS
<i>Anasimyia lunulata</i>							1						231	51	HRS
<i>Anasimyia transfuga</i>						0.5	0.5						495	172	HRS
<i>Arctophila superbiens</i>								1					782	293	HRS
<i>Baccha elongata</i>							0.5	0.5					1692	567	HRS
<i>Blera fallax</i>						1							380	11	HRS/GBIF
<i>Brachyopa bicolor</i>					1								65	26	HRS
<i>Brachyopa insensilis</i>					1								236	106	HRS
<i>Brachyopa pilosa</i>					1								123	41	HRS
<i>Brachyopa scutellaris</i>					1								660	259	HRS
<i>Brachypalpoides lentus</i>						1							998	327	HRS
<i>Brachypalpus laphriformis</i>					0.5	0.5							348	107	HRS
<i>Caliprobola speciosa</i>						1							92	9	HRS
<i>Callicera aurata</i>							1						151	82	HRS
<i>Callicera rufa</i>						1							72	27	HRS
<i>Callicera spinolae</i>							1						50	14	HRS/GBIF
<i>Chalcosyrphus eunotus</i>					1								102	25	HRS/GBIF
<i>Chalcosyrphus nemorum</i>						1							1600	394	HRS
<i>Chamaesyrphus caledonicus</i>													7	4	HRS
<i>Chamaesyrphus scaevoides</i>						1							135	28	HRS

<i>Cheilosia ahenea</i>				1									56	1	HRS/GBIF
<i>Cheilosia albipila</i>			1										558	260	HRS
<i>Cheilosia albitarsis</i>				1									5760	155	HRS
<i>Cheilosia antiqua</i>				1									609	290	HRS
<i>Cheilosia barbata</i>				1									679	262	HRS
<i>Cheilosia bergenstammi</i>				0.5			0.5						2273	674	HRS
<i>Cheilosia carbonaria</i>							1						138	66	HRS
<i>Cheilosia chrysocoma</i>				1									193	48	HRS
<i>Cheilosia cynocephala</i>							1						149	80	HRS
<i>Cheilosia fraterna</i>				1									1396	557	HRS
<i>Cheilosia griseiventris</i>				1									151	89	HRS
<i>Cheilosia grossa</i>			1										580	269	HRS
<i>Cheilosia illustrata</i>						1							5111	1121	HRS
<i>Cheilosia impressa</i>							1						1539	436	HRS
<i>Cheilosia lasiopa</i>				1									114	76	HRS
<i>Cheilosia latifrons</i>						1							464	221	HRS
<i>Cheilosia longula</i>						1							433	183	HRS
<i>Cheilosia mutabilis</i>					0.5	0.5							260	84	HRS
<i>Cheilosia nebulosa</i>			1										126	57	HRS
<i>Cheilosia nigripes</i>				1									57	27	HRS
<i>Cheilosia pagana</i>				1									6235	1038	HRS
<i>Cheilosia proxima</i>						0.5	0.5						1921	667	HRS
<i>Cheilosia psilophthalma</i>				1									98	8	HRS/GBIF
<i>Cheilosia pubera</i>				1									139	51	HRS
<i>Cheilosia ranunculi</i>				1									110	76	HRS
<i>Cheilosia sahlbergi</i>						1							51	14	HRS/GBIF
<i>Cheilosia scutellata</i>							1						975	319	HRS
<i>Cheilosia semifasciata</i>				1									152	22	HRS
<i>Cheilosia soror</i>							1						438	149	HRS
<i>Cheilosia urbana</i>			0.5	0.5									299	143	HRS
<i>Cheilosia uviformis</i>				1									54	3	HRS/GBIF

<i>Cheilosia variabilis</i>					1								2878	755	HRS
<i>Cheilosia velutina</i>							0.5	0.5					114	72	HRS
<i>Cheilosia vernalis</i>								1					2529	670	HRS
<i>Cheilosia vicina</i>						1							422	168	HRS
<i>Cheilosia vulpina</i>								1					537	217	HRS
<i>Chrysogaster cemiteriorum</i>							1						881	341	HRS
<i>Chrysogaster solstitialis</i>							1						3442	844	HRS
<i>Chrysogaster virescens</i>						1							474	185	HRS
<i>Chrysotoxum arcuatum</i>						1							1190	356	HRS
<i>Chrysotoxum bicinctum</i>							1						4020	876	HRS
<i>Chrysotoxum cautum</i>						1							983	322	HRS
<i>Chrysotoxum elegans</i>						1							272	93	HRS
<i>Chrysotoxum festivum</i>							1						1275	347	HRS
<i>Chrysotoxum octomaculatum nomen</i>						1							56	16	HRS
<i>Chrysotoxum vernale</i>					1								64	15	HRS
<i>Chrysotoxum verralli</i>							1						614	171	HRS
<i>Criorhina asilica</i>					1								474	168	HRS
<i>Criorhina berberina</i>					0.5	0.5							2024	512	HRS
<i>Criorhina floccosa</i>					1								1042	371	HRS
<i>Criorhina ranunculi</i>				1									664	224	HRS
<i>Dasysyrphus albostratus</i>					1								2929	759	HRS
<i>Dasysyrphus friuliensis</i>					1								80	32	HRS
<i>Dasysyrphus hilaris</i>					1								210	27	HRS/GBIF
<i>Dasysyrphus pinastri</i>						1							78	54	HRS
<i>Dasysyrphus tricinctus</i>					1								1673	551	HRS
<i>Dasysyrphus venustus</i>					1								3620	786	HRS
<i>Didea alneti</i>								1					237	20	HRS/GBIF
<i>Didea fasciata</i>								0.5	0.5				819	273	HRS
<i>Didea intermedia</i>							1						142	65	HRS
<i>Doros profuges</i>						1							96	35	HRS
<i>Epistrophe diaphana</i>						1							307	129	HRS

<i>Epistrophe eligans</i>					1								5166	882	HRS
<i>Epistrophe euchroma</i>					1								83	44	HRS
<i>Epistrophe grossulariae</i>							1						3744	769	HRS
<i>Epistrophe melanostoma</i>					1								70	18	HRS/GBIF
<i>Epistrophe nitidicollis</i>					1								632	224	HRS
<i>Epistrophe ochrostoma</i>													2	1	HRS
<i>Episyrphus balteatus</i>							0.5	0.5					21980	1873	HRS
<i>Eriozone erratica</i>						1							316	13	HRS/GBIF
<i>Eriozone syrphoides</i>								1					269	64	HRS
<i>Eristalinus aeneus</i>							0.5	0.5					837	241	HRS
<i>Eristalinus sepulchralis</i>							0.5	0.5					3467	749	HRS
<i>Eristalis abusivus</i>							1						1053	353	HRS
<i>Eristalis arbustorum</i>								1					11823	1532	HRS
<i>Eristalis cryptarum</i>					0.5			0.5					85	18	HRS
<i>Eristalis horticola</i>							1						4852	1099	HRS
<i>Eristalis intricarius</i>							1						5776	1235	HRS
<i>Eristalis nemorum</i>							0.5	0.5					6830	1172	HRS
<i>Eristalis pertinax</i>								1					19653	1795	HRS
<i>Eristalis rupium</i>							1						488	180	HRS
<i>Eristalis similis</i>							1						144	3	HRS
<i>Eristalis tenax</i>								1					15476	1575	HRS
<i>Eumerus funeralis</i>						0.5		0.5					1734	385	HRS
<i>Eumerus ornatus</i>						1							379	135	HRS
<i>Eumerus sabulonum</i>							1						200	45	HRS
<i>Eumerus strigatus</i>								1					1219	410	HRS
<i>Eupeodes bucculatus</i>					0.5		0.5						139	19	HRS/GBIF
<i>Eupeodes corollae</i>							0.5	0.5					6512	1246	HRS
<i>Eupeodes lapponicus</i>						1							183	1	HRS/GBIF
<i>Eupeodes latifasciatus</i>								1					390	178	HRS
<i>Eupeodes lundbecki</i>								1					452	1	HRS/GBIF
<i>Eupeodes luniger</i>								1					6225	1059	HRS

<i>Eupeodes nielsenii</i>						1							89	34	HRS
<i>Eupeodes nitens</i>							1						330	19	HRS/GBIF
<i>Ferdinandea cuprea</i>					0.5	0.5							2674	653	HRS
<i>Ferdinandea ruficornis</i>								1					122	40	HRS/GBIF
<i>Hammerschmidtia ferruginea</i>					0.5	0.5							259	9	HRS/GBIF
<i>Helophilus affinis</i>								1					308	1	HRS/GBIF
<i>Helophilus groenlandicus</i>													4	4	HRS
<i>Helophilus hybridus</i>								1					2075	610	HRS
<i>Helophilus pendulus</i>							0.5	0.5					17366	1707	HRS
<i>Helophilus trivittatus</i>								1					1406	483	HRS
<i>Heringia brevidens</i>													3	3	HRS
<i>Heringia heringi</i>					1								305	150	HRS
<i>Heringia latitarsis</i>													7	7	HRS
<i>Heringia pubescens</i>													6	6	HRS
<i>Heringia senilis</i>													3	3	HRS
<i>Heringia verrucula</i>													3	3	HRS
<i>Heringia vitripennis</i>								1					67	43	HRS/GBIF
<i>Lejogaster metallina</i>						1							2560	846	HRS
<i>Lejogaster tarsata</i>						0.5	0.5						302	114	HRS
<i>Lejops vittatus</i>							1						104	30	HRS
<i>Leucozona glaucia</i>								1					3471	721	HRS
<i>Leucozona laternaria</i>							1						1667	537	HRS
<i>Leucozona lucorum</i>					1								6279	1215	HRS
<i>Mallota cimbiciformis</i>							1						133	64	HRS
<i>Megasyrphus erratica</i>							1						223	81	HRS
<i>Melangyna arctica</i>					0.5		0.5						363	166	HRS
<i>Melangyna barbifrons</i>				1									89	30	HRS/GBIF
<i>Melangyna cincta</i>					1								992	346	HRS
<i>Melangyna compositarum</i>							1						376	198	HRS
<i>Melangyna ericarum</i>													12	5	HRS
<i>Melangyna guttata</i>							1						155	78	HRS

<i>Melangyna labiatarum</i>					1							674	256	HRS
<i>Melangyna lasiophthalma</i>			1									1283	469	HRS
<i>Melangyna quadrimaculata</i>			1									234	127	HRS
<i>Melangyna triangulifera</i>				1								240	112	HRS
<i>Melangyna umbellatarum</i>							1					741	362	HRS
<i>Melanogaster aerea</i>							1					273	100	HRS
<i>Melanogaster hirtella</i>					1							3816	1060	HRS
<i>Melanostoma dubium</i>					1							73	53	HRS
<i>Melanostoma mellinum</i>						0.5	0.5					10972	1654	HRS
<i>Melanostoma scalare</i>				1								15542	1746	HRS
<i>Meligramma euchromum</i>												31	18	HRS
<i>Meligramma guttatum</i>						0.5	0.5					58	12	HRS/GBIF
<i>Meligramma trianguliferum</i>				1								162	19	HRS/GBIF
<i>Meliscaeva auricollis</i>					0.5	0.5						2855	729	HRS
<i>Meliscaeva cinctella</i>							1					3960	858	HRS
<i>Merodon equestris</i>					1							3551	708	HRS
<i>Metasyrphus lapponicus</i>												15	11	HRS
<i>Metasyrphus latifasciatus</i>							1					1846	576	HRS
<i>Metasyrphus latilunulatus</i>						1						182	91	HRS
<i>Metasyrphus lundbecki</i>												23	10	HRS
<i>Metasyrphus nitens</i>				1								115	50	HRS
<i>Microdon analis</i>					1							175	50	HRS
<i>Microdon devius</i>					1							97	27	HRS
<i>Microdon mutabilis</i>					1							321	86	HRS
<i>Microdon myrmicae</i>												11	11	HRS
<i>Myathropa florea</i>					0.5	0.5						7589	1185	HRS
<i>Myolepta dubia</i>					1							152	58	HRS
<i>Myolepta potens</i>												11	3	HRS
<i>Neoascia geniculata</i>						1						374	170	HRS
<i>Neoascia interrupta</i>				1								229	73	HRS
<i>Neoascia meticulosa</i>				1								982	335	HRS

<i>Neoascia obliqua</i>					1								346	131	HRS
<i>Neoascia podagrica</i>					0.5			0.5					6632	1255	HRS
<i>Neoascia tenur</i>							1						4699	776	HRS
<i>Neocnemodon brevidens</i>													21	15	HRS
<i>Neocnemodon latitarsis</i>					1								73	48	HRS
<i>Neocnemodon pubescens</i>					1								67	40	HRS
<i>Neocnemodon verrucula</i>													13	14	HRS
<i>Neocnemodon vitripennis</i>						0.5	0.5						328	121	HRS
<i>Orthonevra brevicornis</i>					0.5	0.5							295	146	HRS
<i>Orthonevra geniculata</i>					1								221	105	HRS
<i>Orthonevra nobilis</i>						0.5		0.5					1045	407	HRS
<i>Paragus albifrons</i>							0.5	0.5					51	17	HRS/GBIF
<i>Paragus haemorrhous</i>							1						1778	477	HRS
<i>Paragus tibialis</i>							1						55	25	HRS
<i>Parasyrphus annulatus</i>						1							230	122	HRS
<i>Parasyrphus lineola</i>						0.5	0.5						296	128	HRS
<i>Parasyrphus malinellus</i>					1								151	81	HRS
<i>Parasyrphus nigratarsis</i>					1								90	37	HRS
<i>Parasyrphus punctulatus</i>					1								1175	435	HRS
<i>Parasyrphus vittiger</i>						1							452	166	HRS
<i>Parhelophilus consimilis</i>							1						165	51	HRS
<i>Parhelophilus frutetorum</i>						1							826	287	HRS
<i>Parhelophilus versicolor</i>						1							1232	334	HRS
<i>Pelecocera tricineta</i>							1						161	28	HRS
<i>Pipiza austriaca</i>						1							1040	428	HRS
<i>Pipiza bimaculata</i>					1								251	152	HRS
<i>Pipiza fenestrata</i>					1								238	137	HRS
<i>Pipiza lugubris</i>								1					133	86	HRS
<i>Pipiza luteitarsis</i>					1								454	185	HRS
<i>Pipiza noctiluca</i>					1								2221	608	HRS
<i>Pipizella maculipennis</i>													26	25	HRS

<i>Pipizella viduata</i>						1							2169	582	HRS
<i>Pipizella virens</i>						1							435	203	HRS
<i>Platycheirus albimanus</i>					0.5		0.5						17432	1773	HRS
<i>Platycheirus ambiguus</i>				1									638	225	HRS
<i>Platycheirus amplus</i>													9	7	HRS
<i>Platycheirus angustatus</i>							1						2548	861	HRS
<i>Platycheirus aurolateralis</i>													6	6	HRS
<i>Platycheirus clypeatus</i>							1						3839	1016	HRS
<i>Platycheirus discimanus</i>				1									117	69	HRS
<i>Platycheirus europaeus</i>						1							77	45	HRS
<i>Platycheirus fulviventris</i>						1							1267	383	HRS
<i>Platycheirus granditarsus</i>							0.5	0.5					4910	1065	HRS
<i>Platycheirus immarginatus</i>						0.5	0.5						203	98	HRS
<i>Platycheirus manicatus</i>					0.5	0.5							4780	1251	HRS
<i>Platycheirus melanopsis</i>							1						51	18	HRS
<i>Platycheirus nielsenii</i>							1						361	152	HRS
<i>Platycheirus occultus</i>							1						393	190	HRS
<i>Platycheirus peltatus</i>								1					1195	808	HRS
<i>Platycheirus perpallidus</i>						1							173	78	HRS
<i>Platycheirus podagratus</i>						1							219	96	HRS
<i>Platycheirus ramsarensis</i>						0.5	0.5						163	89	HRS
<i>Platycheirus rosarum</i>						0.5	0.5						2896	751	HRS
<i>Platycheirus scambus</i>						0.5	0.5						899	399	HRS
<i>Platycheirus scutatus</i>					0.5			0.5					6112	1116	HRS
<i>Platycheirus splendidus</i>					1								56	39	HRS
<i>Platycheirus sticticus</i>					1								77	60	HRS
<i>Platycheirus tarsalis</i>					1								1297	384	HRS
<i>Pocota personata</i>					1								99	42	HRS
<i>Portevinia maculata</i>					1								1298	348	HRS
<i>Psilota anthracina</i>					1								60	29	HRS
<i>Rhingia campestris</i>					1								13214	1673	HRS

<i>Rhingia rostrata</i>								1					358	95	HRS
<i>Riponnensia splendens</i>							0.5	0.5					1465	566	HRS
<i>Scaeva albomaculata</i>													2	2	HRS
<i>Scaeva mecogramma</i>													1	1	HRS
<i>Scaeva pyrastris</i>								1					4467	1090	HRS
<i>Scaeva selenitica</i>							0.5	0.5					528	239	HRS
<i>Sericomyia lappona</i>						1							1322	403	HRS
<i>Sericomyia silentis</i>							0.5	0.5					5160	1024	HRS
<i>Sphaerophoria bankowskiae</i>													3	3	HRS
<i>Sphaerophoria batava</i>								1					350	103	HRS
<i>Sphaerophoria fatarum</i>							1						328	140	HRS
<i>Sphaerophoria interrupta</i>							1						1883	682	HRS
<i>Sphaerophoria loewi</i>						1							52	12	HRS/GBIF
<i>Sphaerophoria philanthus</i>							1						921	352	HRS
<i>Sphaerophoria potentillae</i>													6	3	HRS
<i>Sphaerophoria rueppellii</i>							1						577	190	HRS
<i>Sphaerophoria scripta</i>								1					8042	1053	HRS
<i>Sphaerophoria taeniata</i>								1					404	138	HRS
<i>Sphaerophoria virgata</i>						0.5	0.5						75	45	HRS
<i>Sphegina clunipes</i>						1							1892	659	HRS
<i>Sphegina elegans</i>						1							829	329	HRS
<i>Sphegina sibirica</i>						1							70	43	HRS
<i>Sphegina verecunda</i>						1							349	171	HRS
<i>Syrpitta pipiens</i>							0.5	0.5					17086	1702	HRS
<i>Syrphus ribesii</i>							0.5	0.5					13327	1577	HRS
<i>Syrphus torvus</i>							1						3351	830	HRS
<i>Syrphus vitripennis</i>								1					6974	1264	HRS
<i>Trichopsomyia flavitarsis</i>						1							795	331	HRS
<i>Triglyphus primus</i>								1					194	80	HRS
<i>Tropidia scita</i>						1							1996	385	HRS
<i>Volucella bombylans</i>						1							5295	1215	HRS

<i>Volucella inanis</i>								1					1321	242	HRS
<i>Volucella inflata</i>						1							891	262	HRS
<i>Volucella pellucens</i>							1						7837	1317	HRS
<i>Volucella zonaria</i>								1					1249	177	HRS
<i>Xanthandrus comtus</i>								1					399	171	HRS
<i>Xanthogramma citrofasciatum</i>					1								513	224	HRS
<i>Xanthogramma pedissequum</i>						0.5	0.5						2063	458	HRS
<i>Xylota abiens</i>						1							267	95	HRS
<i>Xylota florum</i>							1						423	167	HRS
<i>Xylota jakutorum</i>						1							715	212	HRS
<i>Xylota segnis</i>						1							9049	1376	HRS
<i>Xylota sylvarum</i>							1						2926	721	HRS
<i>Xylota tarda</i>							1						202	84	HRS
<i>Xylota xanthocnema</i>						0.5	0.5						244	106	HRS
Totals	0	0	0	9.5	69	65	65.5	51.5	0.5	0	0	0	492739	97773	

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Appendix S4 - Peak number of butterfly observations per species, per calendar month (J = January etc.) calculated from the United Kingdom Butterfly Monitoring Scheme and Global Biodiversity Information Facility databases. Records from all years were binned per month for all species with ≥ 50 total observations (100%; 64 out of 64 species). When the difference between the two months with the greatest number of insect observations was $< 10\%$, the peak abundance of a species was considered to be spread across both months (e.g. *Aglais urticae* observations are equal and maximal in July and August, resulting in each month being 'scored' 0.5 for this species). When the difference was $> 10\%$ the peak abundance of a species was considered to peak in only one month (e.g.. *Boloria selene* peak observations are in June, resulting in this month being 'scored' 1 for this species).

Species	J	F	M	A	M	J	J	A	S	O	N	D	Records	Hectads	Source
<i>Aglais io</i>								1					6017	2490	UKBMS
<i>Aglais urticae</i>							0.5	0.5					6389	2607	UKBMS
<i>Anthocharis cardamines</i>					1								2765	2240	UKBMS
<i>Apatura iris</i>							1						252	213	UKBMS
<i>Aphantopus hyperantus</i>							1						2698	2262	UKBMS
<i>Aporia crataegi</i>							1						153	0	GBIF
<i>Argynnis adippe</i>							1						93	0	GBIF
<i>Argynnis aglaja</i>							1						2444	1223	UKBMS
<i>Argynnis paphia</i>							1						2223	775	UKBMS
<i>Aricia agestis</i>								1					3743	122	UKBMS
<i>Aricia artaxerxes</i>							1						1261	122	UKBMS
<i>Boloria euphrosyne</i>					1								1477	190	UKBMS
<i>Boloria selene</i>						1							2013	769	UKBMS
<i>Callophrys rubi</i>					1								2260	1107	UKBMS
<i>Carterocephalus palaemon</i>						1							195	40	UKBMS
<i>Celastrina argiolus</i>								1					3843	1431	UKBMS
<i>Coenonympha pamphilus</i>							0.5	0.5					5281	2102	UKBMS
<i>Coenonympha tullia</i>							1						528	338	UKBMS
<i>Colias croceus</i>								1					1491	996	UKBMS
<i>Cupido minimus</i>						1							2077	279	UKBMS
<i>Cyaniris semiargus</i>						0.5	0.5						11014	0	GBIF
<i>Epargyreus clarus</i>								1					1008	42	UKBMS

<i>Erebia aethiops</i>							1					911	378	UKBMS
<i>Erebia epiphron</i>							1					193	39	UKBMS
<i>Erynnis tages</i>				0.5	0.5							2239	643	UKBMS
<i>Euphydryas aurinia</i>					1							894	246	UKBMS
<i>Fabriciana adippe</i>						1						1258	21	UKBMS
<i>Gonepteryx rhamni</i>				0.5			0.5					5948	1346	UKBMS
<i>Hamearis lucina</i>				1								857	84	UKBMS
<i>Hipparchia semele</i>							1					2544	542	UKBMS
<i>Lasiommata megera</i>							1					4013	1089	UKBMS
<i>Leptidea juvernica</i>					1							263	35	UKBMS
<i>Leptidea sinapis</i>					1							1345	48	UKBMS
<i>Limenitis camilla</i>						1						1551	427	UKBMS
<i>Lycaena phlaeas</i>							0.5	0.5				5316	2081	UKBMS
<i>Lycaena dispar</i>						1						238	0	GBIF
<i>Maniola jurtina</i>							0.5	0.5				4445	2525	UKBMS
<i>Melanargia galathea</i>						1						2322	798	UKBMS
<i>Melitaea athalia</i>						1						738	13	UKBMS
<i>Melitaea cinxia</i>					1							184	17	UKBMS
<i>Neozephyrus quercus</i>						0.5	0.5					1763	934	UKBMS
<i>Nymphalis polychloros</i>						1						466	0	GBIF
<i>Ochlodes sylvanus</i>						1						3113	1553	UKBMS
<i>Papilio machaon</i>					1							409	65	UKBMS
<i>Pararge aegeria</i>						0.5	0.5					6379	2085	UKBMS
<i>Phengaris arion</i>					1							54	6	UKBMS
<i>Pieris brassicae</i>						0.5	0.5					5926	2239	UKBMS
<i>Pieris napi</i>						0.5	0.5					6186	2697	UKBMS
<i>Pieris rapae</i>						0.5	0.5					6241	2153	UKBMS
<i>Plebejus argus</i>						1						1496	105	UKBMS
<i>Polygonia c-album</i>						0.5	0.5					5253	1718	UKBMS
<i>Polyommatus bellargus</i>					1							2385	125	UKBMS
<i>Polyommatus coridon</i>							1					2242	249	UKBMS

<i>Polyommatus icarus</i>							0.5	0.5					5228	2291	UKBMS
<i>Pyrgus malvae</i>						1							1874	340	UKBMS
<i>Pyronia tithonus</i>							0.5	0.5					3165	1458	UKBMS
<i>Satyrium pruni</i>						1							155	25	UKBMS
<i>Satyrium w-album</i>							1						700	641	UKBMS
<i>Thecla betulae</i>								1					436	155	UKBMS
<i>Thymelicus acteon</i>								0.5	0.5				576	14	UKBMS
<i>Thymelicus lineola</i>							1						1660	725	UKBMS
<i>Thymelicus sylvestris</i>							1						3052	1483	UKBMS
<i>Vanessa atalanta</i>								0.5	0.5				5365	2436	UKBMS
<i>Vanessa cardui</i>								1					3551	1886	UKBMS
Totals	0	0	0	0	5	13	26.5	18.5	1	0	0	0	162159	55063	

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Appendix S5 - Peak number of Regionally Extinct (RE), Critically Endangered (CR) and Endangered (EN) pollinator species, per calendar month (J = January etc.) calculated from the Bees, Wasps & Ants Recording Society (BWARS), the United Kingdom Butterfly Monitoring Scheme (UKBMS), the Hoverfly Recording Society (HRS) and the Global Biodiversity Information Facility (GBIF) databases. The status of butterfly species was taken from Fox et al., (2010), hoverfly species from Ball & Morris (2015), extinct bees from Falk (2016), extinct wasps from Ollerton et al., (2014) and endangered bees and wasps from Falk (1991).

When the difference between the two months with the greatest number of insect observations was <10%, the peak abundance of a species was considered to be spread across both months (e.g. *Cyaniris semiargus* observations are equal and maximal in June and July, resulting in each month being 'scored' 0.5 for this species). When the difference was >10% the peak abundance of a species was consider to peak in only one month (e.g. *Maculinea arion* peak observations are in June, resulting in this month being 'scored' 1 for this species).

Species	J	F	M	A	M	J	J	A	S	O	N	D	Records	Status	Source
Butterflies															
<i>Aporia crataegi</i>							1						153	RE	GBIF
<i>Cyaniris semiargus</i>						0.5	0.5						11014	RE	GBIF
<i>Lycaena dispar</i>							1						238	RE	GBIF
<i>Maculinea arion</i>						1							54	RE	UKBMS
<i>Nymphalis polychloros</i>							1						466	RE	GBIF
<i>Argynnis adippe</i>							1						93	CE	GBIF
<i>Boloria euphrosyne</i>					1								1477	EN	UKBMS
<i>Carterocephalus palaemon</i>						1							195	EN	UKBMS
<i>Hamearis lucina</i>					1								857	EN	UKBMS
<i>Leptidea sinapis</i>						1							1345	EN	UKBMS
<i>Melitaea athalia</i>							1						738	EN	UKBMS
<i>Melitaea cinxia</i>						1							184	EN	UKBMS
<i>Satyrrium pruni</i>						1							155	EN	UKBMS
<i>Satyrrium w-album</i>							1						700	EN	UKBMS

Hoverflies															
<i>Blera fallax</i>						1							380	CE	HRS/GBIF
<i>Eristalis cryptarum</i>							0.5	0.5					85	CE	HRS
<i>Paragus albifrons</i>							0.5	0.5					51	CE	HRS/GBIF
<i>Myolepta potens</i>						1							11	CE	HRS
<i>Chrysotoxum octomaculatum</i>						1							56	EN	HRS
<i>Chrysotoxum vernale</i>					1								64	EN	HRS
<i>Hammerschmidtia ferruginea</i>						1							259	EN	HRS/GBIF
Bees															
<i>Andrena floricola</i>				0.5			0.5						47	RE	GBIF
<i>Andrena lathyri</i>					1								950	RE	BWARS/GBIF
<i>Andrena lepida</i>							1						3	RE	BWARS
<i>Andrena nana</i>					0.5		0.5						52	RE	BWARS/GBIF
<i>Andrena nanula</i>							1						80	RE	GBIF
<i>Andrena polita</i>							1						17	RE	BWARS/GBIF
<i>Andrena tridenta</i>								1					7	RE	BWARS/GBIF
<i>Bombus cullumanus</i>								1					53	RE	BWARS/GBIF
<i>Bombus pomorum</i>								1					94	RE	BWARS/GBIF
<i>Bombus subterraneus</i>								1					226	RE	BWARS
<i>Coelioxys afra</i>							1						44	RE	GBIF
<i>Duforea halictula</i>							1						281	RE	BWARS/GBIF
<i>Dufourea minuta</i>							1						61	RE	BWARS/GBIF
<i>Eucera nigrescens</i>					1								157	RE	BWARS/GBIF
<i>Halictus maculatus</i>							1						315	RE	GBIF
<i>Halictus subauratus</i>						0.5	0.5						123	RE	GBIF
<i>Hoplitis leucomelana</i>							1						277	RE	GBIF
<i>Hylaeus punctulatissimus</i>						1							102	RE	GBIF
<i>Lasioglossum laeve</i>							1						17	RE	GBIF
<i>Megachile ericetorum</i>						0.5	0.5						172	RE	GBIF
<i>Megachile lapponica</i>								1					254	RE	GBIF

<i>Megachile parietina</i>					1								16	RE	GBIF
<i>Melecta luctuosa</i>					1								74	RE	GBIF
<i>Nomada errans</i>							1						27	RE	BWARS/GBIF
<i>Rophites quinquespinosus</i>							1						44	RE	GBIF
<i>Andrena ferox</i>					1								84	EN	BWARS
<i>Andrena floricola</i>				0.5			0.5						47	EN	GBIF
<i>Andrena gravida</i>				1									52	EN	BWARS
<i>Andrena lathyri</i>					1								950	EN	BWARS/GBIF
<i>Andrena lepida</i>							1						3	EN	BWARS
<i>Andrena nana</i>					0.5		0.5						52	EN	BWARS/GBIF
<i>Andrena polita</i>							1						17	EN	BWARS/GBIF
<i>Andrena tridenta</i>								1					7	EN	BWARS/GBIF
<i>Andrena vaga</i>				1									2275	EN	BWARS/GBIF
<i>Anthophora retusa</i>					1								126	EN	BWARS
<i>Bombus cullumanus</i>								1					53	EN	BWARS/GBIF
<i>Dufourea minuta</i>							1						61	EN	BWARS/GBIF
<i>Eucera nigrescens</i>					1								157	EN	BWARS/GBIF
<i>Halictus eurygnathus</i>								1					51	EN	BWARS
<i>Halictus maculatus</i>							1						315	EN	GBIF
<i>Lasioglossum sexnotatum</i>						1							418	EN	BWRAS
<i>Melecta luctuosa</i>					1								85	EN	BWARS/GBIF
<i>Melitta dimidiata</i>							1						748	EN	BWARS
<i>Osmia xanthomelana</i>					0.5	0.5							226	EN	BWARS/GBIF
<i>Nomada armata</i>							1						66	EN	BWARS
<i>Nomada errans</i>							1						27	EN	BWARS/GBIF
<i>Nomada guttulata</i>					1								115	EN	BWARS/GBIF
<i>Nomada sexfasciata</i>					1								96	EN	BWARS/GBIF
<i>Nomada ferruginata</i>				1									69	EN	BWARS
Aculeate Wasps															
<i>Ancistrocerus antilope</i>						0.5	0.5						47	RE	BWARS/GBIF

<i>Ancistrocerus quadratus</i>							1							38	RE	GBIF
<i>Arachnospila rufa</i>							1							365	RE	BWARS/GBIF
<i>Chrysis longula</i>							1							112	RE	BWARS/GBIF
<i>Chrysis pseudobrevitarsis</i>						0.5	0.5							52	RE	BWARS/GBIF
<i>Lestica clypeata</i>						0.5	0.5							286	RE	GBIF
<i>Mellinus crabroneus</i>							1							91	RE	BWARS/GBIF
<i>Odynerus reniformis</i>						1								95	RE	BWARS/GBIF
<i>Philoctetes truncatus</i>						0.5	0.5							6	RE	BWARS/GBIF
<i>Psen ater</i>								1						19	RE	GBIF
<i>Arachnospila rufa</i>							1							365	EN	BWARS/GBIF
<i>Cerceris quadricincta</i>							0.5	0.5						73	EN	BWARS
<i>Ceropales variegata</i>								1						72	EN	BWARS/GBIF
<i>Chrysis fulgida</i>						1								54	EN	BWARS
<i>Crossocerus vagabundus</i>							1							305	EN	BWARS
<i>Evagetes pectinipes</i>							1							365	EN	BWARS/GBIF
<i>Homonotus sanguinolentus</i>							1							1193	EN	BWARS
<i>Mellinus crabroneus</i>							1							91	EN	BWARS/GBIF
<i>Odynerus reniformis</i>						1								95	EN	BWARS/GBIF
<i>Odynerus simillimus</i>							1							75	EN	BWARS
<i>Omalus puncticollis</i>							1							69	EN	BWARS
<i>Philoctetes truncatus</i>						0.5	0.5							6	EN	BWARS/GBIF
<i>Pseudepipona herrichii</i>							1							145	EN	BWARS

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Appendix S6

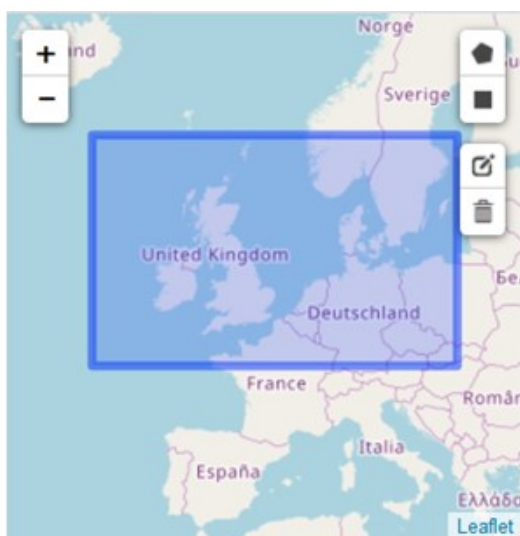


Figure A - Geographical area used to generate The Global Biodiversity Information Facility (GBIF) records used in phenological calculations

Table A - Proportion of GBIF records used per country

Country	Proportions
Sweden	0.413
Germany	0.311
Netherlands	0.077
Norway	0.076
Belgium	0.033
Czech Republic	0.021
Luxembourg	0.021
France	0.018
Austria	0.017
Ireland	0.007
Poland	0.003
Åland Islands	0.001
Denmark	0.001
Finland	0.001

458 **Appendix S7**

459 **Table B** - The diet breadth (oligolectic: larvae provisioned with pollen from only one or a
 460 few plant taxa; polylectic: larvae provisioned with pollen a variety of unrelated plant taxa) of
 461 extinct British bee species.

Bee Species	Diet	Reference
<i>Andrena floricola</i>	oligolectic	Oertli et al. (2005)
<i>Andrena lathyri</i>	oligolectic	Oertli et al. (2005)
<i>Andrena lepida</i>	polylectic	Tomozei (2014)
<i>Andrena nana</i>	polylectic	Oertli et al. (2005)
<i>Andrena nanula</i>	oligolectic	Stenmark (2013)
<i>Andrena polita</i>	oligolectic	Oertli et al. (2005)
<i>Andrena tridentata</i>	oligolectic	Радченко & Песенко (1994)
<i>Bombus cullumanus</i>	quasi-oligolectic	Rasmont (1998)
<i>Bmbus pomorum</i>	quasi-oligolectic	Rasmont (1998)
<i>Bombus subterraneus</i>	mésiolectiques	Rasmont (1998)
<i>Dufourea halictula</i>	oligolectic	Westrich (1996)
<i>Dufourea minuta</i>	oligolectic	Oertli et al. (2005)
<i>Eucera nigrescens</i>	oligolectic	Oertli et al. (2005)
<i>Halictus maculatus</i>	polylectic	Oertli et al. (2005)
<i>Halictus subauratus</i>	polylectic	Oertli et al. (2005)
<i>Hoplitis leucomelana</i>	polylectic	Stenmark (2013)
<i>Hylaeus punctulatissimus</i>	oligolectic	Oertli et al. (2005)
<i>Lasioglossum laeve</i>	polylectic	Gogala (1999)
<i>Megachile ericetorum</i>	oligolectic	Dewulf & Praz (2014)
<i>Megachile lapponica</i>	oligolectic	Stenmark (2013)
<i>Megachile parietina</i>	polylectic	Gogala (1999)
<i>Rophites quinquespinosus</i>	oligolectic	Gogala (1999)
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