

Using ecological and field survey data to establish a national list of the wild bee pollinators of crops

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**Using ecological and field survey data to establish a national list of the wild bee
pollinators of crops.**

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Abstract

The importance of wild bees for crop pollination is well established, but less is known about which species contribute to service delivery to inform agricultural management, monitoring and conservation. Using sites in Great Britain as a case study, we use a novel qualitative approach combining ecological information and field survey data to establish a national list of crop pollinating bees for four economically important crops (apple, field bean, oilseed rape and strawberry). A traits data base was used to establish potential pollinators, and combined with field data to identify both dominant crop flower visiting bee species and other species that could be important crop pollinators, but which are not presently sampled in large numbers on crops flowers. Whilst we found evidence that a small number of common, generalist species make a disproportionate contribution to flower visits, many more species were identified as potential pollinators, including rare and specialist species. Furthermore, we found evidence of substantial variation in the bee communities of different crops. Establishing a national list of crop pollinators is important for practitioners and policy makers, allowing targeted management approaches for improved ecosystem services, conservation and species monitoring. Data can be used to make recommendations about how pollinator diversity could be promoted in agricultural landscapes. Our results suggest agri-environment schemes need to support a higher diversity of species than at present, notably of solitary bees. Management would also benefit from targeting specific species to enhance crop pollination services to particular crops. Whilst our study is focused upon Great Britain, our methodology can easily be applied to other countries, crops and groups of pollinating insects.

Key-words

Agri-environment Schemes, Apple, Biodiversity, Crop pollination, Dominant Pollinators, Ecosystem Services, Field Bean, Oilseed Rape, Rare Species, Strawberry.

1. Introduction

Insect pollination is key to global agricultural productivity (IPBES, 2016) due to growing demand for entomophilous crops (Godfray and Garnett 2014). The nutritional and economic importance of insect pollinated crops (Vanbergen et al., 2014), and the inability of managed pollinators (e.g., *Apis mellifera*) to meet service demand, mean agriculture is highly dependent upon wild pollinators (Aizen and Harder 2009; Breeze et al., 2014). Yet conventional agricultural practices are a key driver of pollinator declines (Senapathi et al., 2015). Whilst agri-environment scheme options have had positive impacts (Tonietto et al., 2018), most benefit a limited suite of common species (Scheper et al., 2013) and homogeneous communities provide less reliable pollination services (Grab et al., 2019). Currently agri-environment schemes tend preferentially to benefit bumblebee populations (Wood et al., 2015a; Wood et al., 2015b, 2016a, b), yet solitary bee species are more important pollinators of some crops (Woodcock et al., 2013). As such, current agri-environment schemes may not be optimally designed to increase pollination services to many crops. Identifying key pollinating species to individual crops, and ones which may provide additional pollination and insurance against declines in other species, would help inform agricultural management for bee pollinators (Garratt et al., 2014a). Yet there is insufficient information on bee communities for many crops (Kremen and Chaplin-Kramer, 2007) and no studies have attempted to establish a 'national list' of crop pollinators to advise management or monitoring programmes.

Whilst the majority of crop flower visitation is attributed to a small proportion of bee species (Kleijn et al., 2015), species-rich communities have been shown to positively influence crop yields and pollination service stability (Hoehn et al., 2008; Garibaldi et al., 2011; Martins et al., 2015; Dainese et al., 2019; Woodcock et al., 2019). Biodiversity conservation and ecosystem service management are often seen as distinct objectives (Sutter et al., 2017), however management that only targets common crop pollinators will not safeguard production if it fails to encompass species that supplement service provision (Fijen et al., 2018). High species turnover means that diverse communities, including rare and specialist species, are required

to maintain crop pollination service at regional scales (Winfree et al., 2018). With climate change reducing the occupancy and richness of some wild bee species (Soroye et al., 2020), supporting wider species diversity may be crucial for crop pollination service stability under the substantial future environmental change that is predicted (Oliver et al., 2015; Dainese et al., 2019). Additionally, different crops have distinct pollinator communities and it will be beneficial to identify the pollinating taxa of individual crops and target management accordingly (Garratt et al., 2014a). Furthermore, a national list of crop pollinators can inform monitoring schemes to ensure they include important crop pollinating species (Carvell et al., 2017; Garratt et al., 2019).

In order to inform pollinator management and monitoring, our study aimed to compile the bee species visiting four crops: apple (*Malus domestica*), field bean (*Vicia faba*), oilseed rape (*Brassica napus*) and strawberry (*Fragaria x ananassa*). Insect pollination has been shown to enhance yield quantity and quality in all four crops (Bartomeus et al., 2014; Garratt et al., 2014b). Additionally, they differ in flower phenology and morphology (Garibaldi et al., 2015) and likely show corresponding differences in their pollinator community composition (Garratt et al., 2014a). We use sites in Great Britain as a case study because its bee fauna is comprehensively described and their occupancy is well recorded over a long time period (Powney et al. 2019). We compiled a list of all British bee species and their available physiological and ecological traits, and combined it with field survey data in order to devise an approach to generate lists of (i) definite flower visitors to each crop (ii) likely flower visitors, which are expected to also contribute to crop pollination (iii) possible crop flower visitors whose contribution to pollination is not well understood and merits further investigation. Our aim was to compile these lists for reference purposes, but not to statistically compare pollinator communities between crops, due to the unstandardised nature of the datasets used to generate the lists of bee species. Additionally, we identify dominant crop pollinating species, and assess the contribution of wild bees compared to honey bees for crop flower visitation.

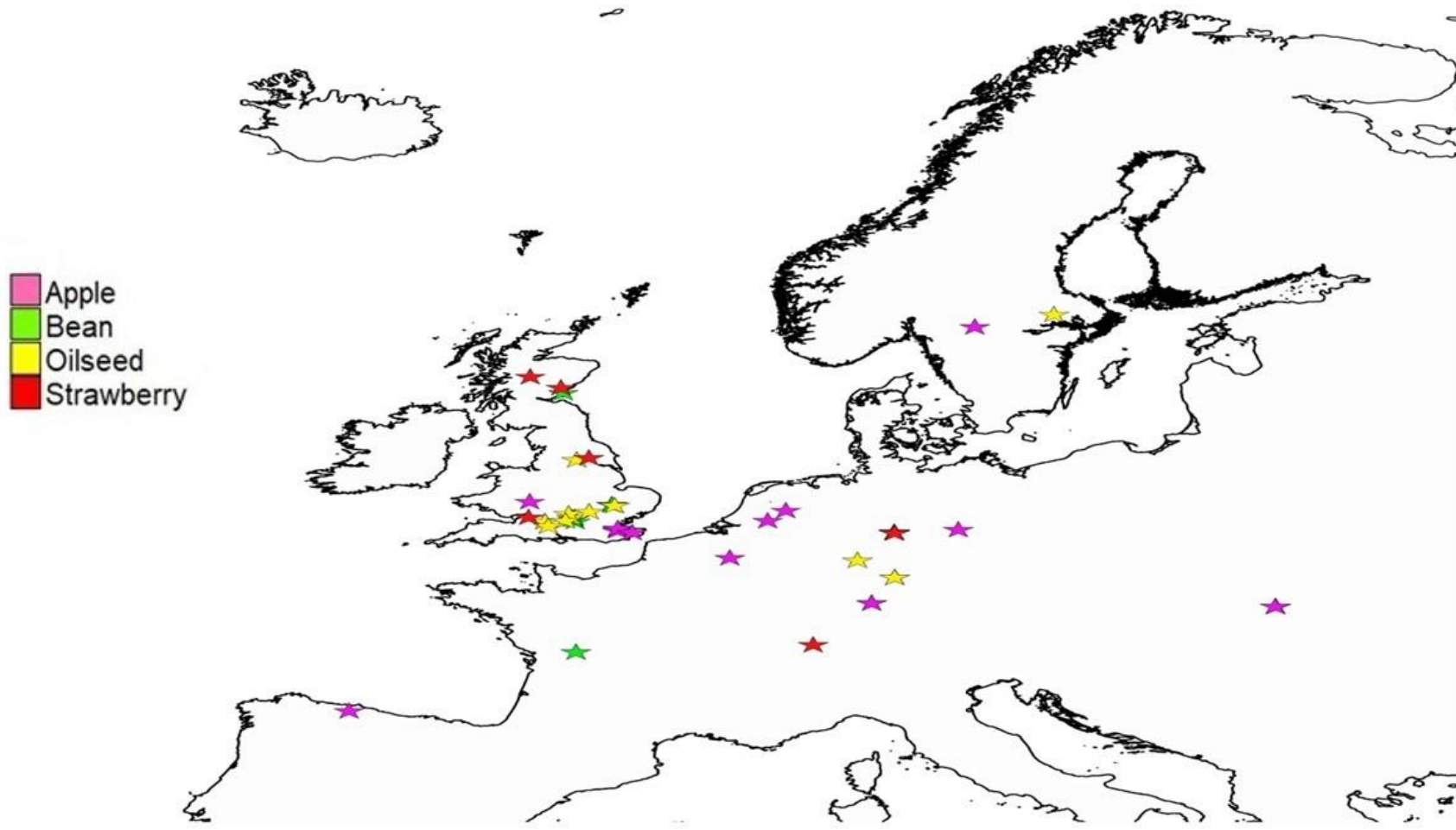
2. Materials and Methods

2.1 Potential crop pollinators.

First, a species database of all extant, resident wild bee species in Great Britain was established using the most recent checklist of UK species (Else et al., 2016). For each species, data on the following were collated: flight period (months); sociality (cleptoparasite, eusocial or solitary); lecty (oligolectic or polylectic, including if any of the target crop plant families are visited for pollen and/or nectar), tongue length (short/long), geographic coverage (distribution and habitat) (based on trait information compiled by Stuart Roberts for the EU- FP6 ALARM-project and BWARS, 2020) and conservation status (Webb et al., 2018). Potential crop pollinators, as defined here, are those bee species which, based upon these ecological traits, such as flight period, lecty, sociality and tongue length, could pollinate our target crops. Habitat specialists that are not coincident with cropland were initially excluded i.e., primarily coastal, heathland species. The known floral ecology of each species was then used to refine lists for each crop. Cleptoparasitic species, species that are oligolectic on plant families other than the target crop or polylectic, but not documented as foraging on the relevant plant family for pollen or nectar and species whose flight period does not overlap with the relevant crops flowering period were excluded. For field bean, only 'long-tongued' species (Michener, 2000) were considered as its flowers have deep corollas and most visits by 'short-tongued' species involve nectar robbing rather than legitimate visitation (Garratt et al., 2014a).

2.2 Field survey data

Field studies were sourced through literature searches in google scholar and existing datasets held by the authors. Fifty-seven datasets from across England, Scotland and eight other European countries were available to combine with the potential crop pollinator lists in order to establish shortlists of crop flower visitors (Figure 1 and Table S3).



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Figure 1: Map of Europe, showing the countries from which field studies were sourced for each crop.

4 Lists of bee species recorded in crop fields were compiled using three types of survey data:

5 i) British flower visitation studies (e.g. transect walks, observation plots).

6 ii) British pan trap studies in crop fields.

7 iii) Other European flower visitation studies (used to validate crop flower visitation for
8 species sampled in British pan traps only).

9 For every bee species the total number of reported legitimate flower visits and number of
10 studies recorded in were calculated for each crop. If studies did not include quantitative data
11 then a conservative approach was taken whereby each bee species listed was taken as
12 representing a single crop flower visit. As pan trap catches do not provide information on floral
13 associations (Westphal et al., 2008), these data were only used, in combination with trait data,
14 to generate the list of possible pollinators.

15 **2.3 Crop flower visitors**

16 The lists of potential crop pollinators were combined with the field survey data to categorize
17 bee species into one of three flower visitor categories (Figure 2; Full details in Supplementary
18 Methods 1):

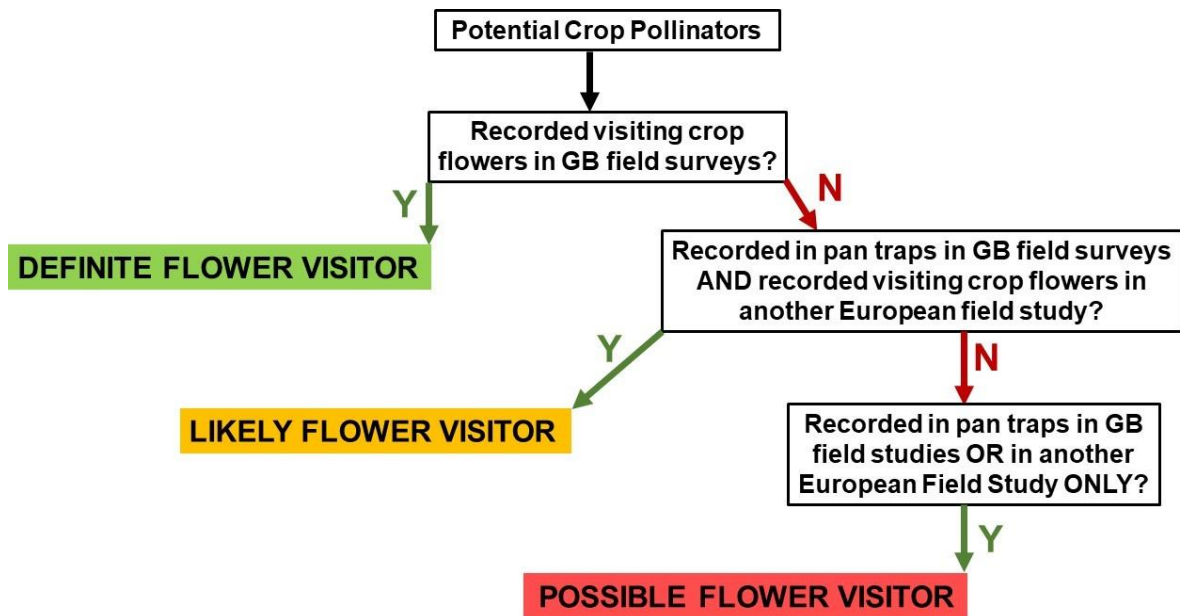
19 i) Definite Flower Visitors – Species recorded visiting crop flowers in British flower
20 visitation studies.

21 ii) Likely Flower Visitors - Species recorded in British pan trap crop studies and
22 recorded as making at least two flower visits in other European studies.

23 iii) Possible Flower Visitors - Species only recorded in British pan trap studies, or in
24 other European flower visitor studies only, and classified as a potential crop
25 flower visitor.

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29 Figure 2: Methodology by which bee species were categorised as definite, likely and
 30 possible flower visitors.

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32

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34 2.4 Dominant crop flowers visitors

35 As visitation rate to crop flowers is a good proxy of relative contribution to pollination service
 36 delivery (Vazquez et al., 2005), we identified the dominant British flower visiting bee species
 37 per crop by approximating the species attributed with a combined total of 80% of flower visits,
 38 the proportion identified as corresponding to the dominant flower visitors by Kleijn et al. (2015).
 39 Only British flower visitation datasets where bee species were either all identified to species
 40 or genus were included in the analysis (Supplementary Methods 2). Additionally, we calculated
 41 the average proportion of visits to crop flowers attributed to wild bees compared to honey bees
 42 for all crops (Supplementary Methods 2).

43

44 **3. Results**

45 **3.1 Potential crop pollinators**

46 A preliminary list of 229 extant, resident British wild bee species was compiled. Of those 132
47 species were excluded due to ecological and lecty traits that were deemed incompatible with
48 these bees being present in crop fields and/or crop flower visitors (Table S1). Four species
49 were treated as an aggregate – *Bombus terrestris* aggregate – due to the difficulties of
50 separating their workers in the field (Wolf et al., 2010; Bossert, 2015). Therefore, a total of 97
51 species were initially identified as potential crop pollinators. Accounting for their documented
52 foraging ecology and flight period, the following number of species were considered as
53 potential pollinators per crop: apple- 83, bean- 30, oilseed- 60, and strawberry – 90 (Table
54 S2).

55 **3.2 Field survey data**

56 The total number of studies sourced per crop were as follows: apple – 17; bean – 10; oilseed
57 – 19; strawberry – 11. The number of studies per survey type for each crop is provided in
58 Figure S1.

59 **3.3 Crop flower visitors**

60 Seventy-three species from ten genera were categorised as flower visitors of one or more
61 crops, 63 of which were recorded in British crop field studies (Table 1, Figure 3). Fourteen
62 species were included in flower visitor categories that were not initially identified as potential
63 crop pollinators. Ten of those were widely polylectic *Bombus* or *Lasioglossum* species, all
64 recorded in oilseed datasets, but not documented in the literature as foraging on
65 *Brassicaceae*. The remaining species were three short-tongued *Andrena* species recorded
66 visiting bean flowers, two of which are oligolectic on Fabaceae and a *Colletes* species,
67 recorded in a single strawberry dataset, that is documented as being oligolectic on another
68 plant family. The majority of species identified as potential pollinators, but not recorded in crop
69 field surveys were either rare species or polylectic species documented as having distinct

70 preferences for plant families other than the target crop. The remaining species were
 71 overwhelmingly smaller species from the genera *Hylaeus* and *Lasioglossum* or cavity nesting
 72 *Megachilidae*. Most species identified as crop flower visitors were geographically widespread
 73 (BWARS, 2020) and polylectic species. However, a quarter (n=18) of species included in
 74 flower visitor categories, currently have a designated conservation status in Britain. Full details
 75 of all species in crop flower visitor categories are given in tables S4a-d and S5a – S8d.

76

77 Table 1: Number of bee species, based upon field datasets and trait information, that were
 78 assigned to each category of flower visitor per crop

Crop	Flower Visitor Category			Total
	Definite	Likely	Possible	
Apple	19	13	25	57
Field Bean	11	0	3	14
Oilseed Rape	37	11	3	51
Strawberry	9	6	18	33

79

80 *Apple*

81 All five British apple flower visitor studies recorded every bee to species level. *Andrena* were
 82 the most speciose genus of flower visitor, both overall (n=22) and in the definite flower visitor
 83 category (n=10). *Bombus* species were the next most commonly represented genus in the
 84 latter category (n=6), but were less frequent overall (n=9) than *Lasioglossum* species (n=16).
 85 Within the definite flower visitor category 80% of flower visits were attributed to eight species,
 86 only half of which were recorded in all studies. Most likely and possible flower visitors were
 87 *Andrena* or *Lasioglossum* species.

88 *Bean*

89 Three of the five British bean flower visitor studies recorded all bee to species level, the
 90 remainder only recorded *Bombus* to species, which was both the most common genus overall
 91 (n=9) and in the definite flower visitor category (n=7). Three short-tongued *Andrena* sp. were
 92 identified as definite flower visitors, but all were recorded as very low numbers of flower visits

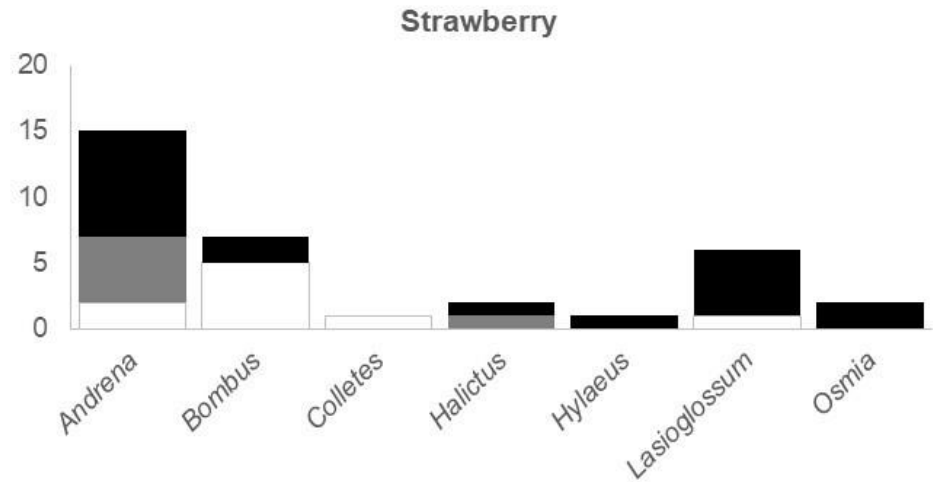
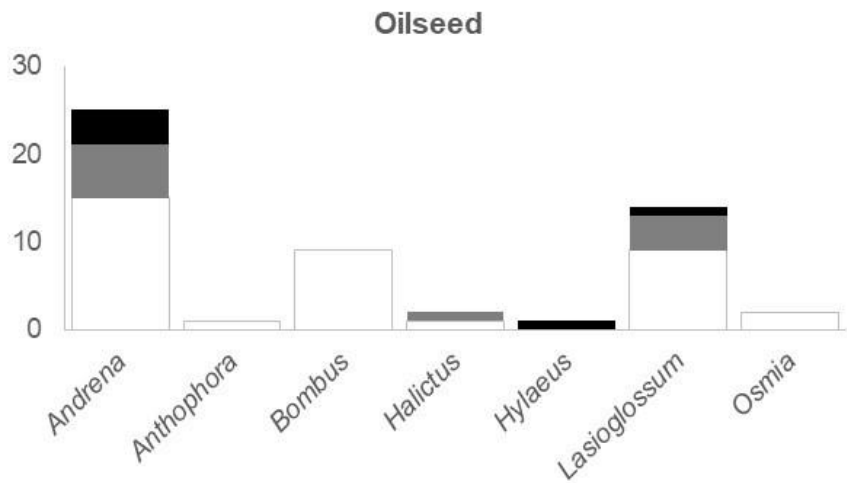
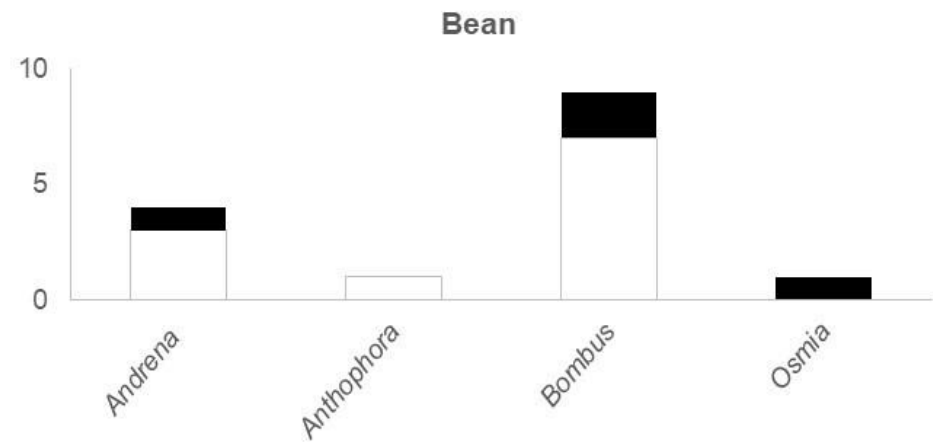
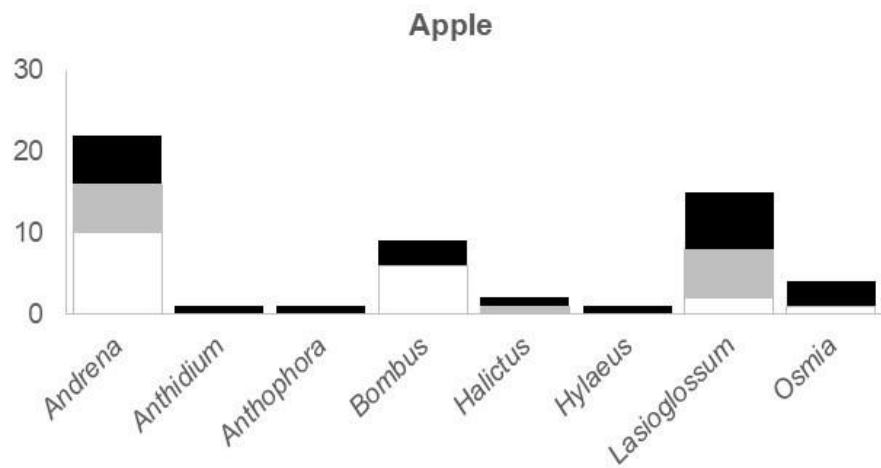
93 (≤ 10). Four *Bombus* species and *Anthophora plumipes* accounted for 95% of all visits
94 recorded in British flower visitation studies. However, all the *A. plumipes* records derived from
95 one study (Bond and Kirby, 1999) carried out at a single site. The four *Bombus* were the only
96 species recorded in four or more studies. No species met the criteria for the likely flower visitor
97 category. The possible flower visitor category included two *Bombus* and one *Osmia* species.

98 *Oilseed*

99 Six of the nine British oilseed flower visitor studies recorded bees to species level, but only
100 two included quantitative data on all bee species. *Andrena* was the most speciose genus of
101 bee, both overall ($n=27$) and within the definite flower visitor category ($n=15$). *Bombus* and
102 *Lasioglossum* species were equally represented in the definite flower visitor category ($n=9$),
103 but *Lasioglossum* were more frequent overall ($n=14$). Within the definite flower visitor category
104 80% of recorded flower visits were attributed to six species, only two of which were recorded
105 in all nine studies, with the remainder only recorded in between five and eight studies, despite
106 all being large *Andrena* or *Bombus* species, generally identified and quantified in all field
107 studies. The likely and possible visitor categories were entirely comprised of *Andrena* or
108 *Halictidae* species, two of which are oligolectic on *Brassicaceae*.

109 *Strawberry*

110 Two British strawberry flower visitor studies recorded all bees to species level. The remaining
111 three only recorded a group of large *Andrena* and *Bombus* to species. *Bombus* species were
112 the most common genus of bee within the definite flower visitor category ($n=5$), but joint
113 second as the most frequent genus overall, alongside *Lasioglossum* ($n=7$), with *Andrena*
114 species being the most prevalent genus across all categories ($n=14$). Within the definite flower
115 visitor category 80% of recorded flower visits were attributed to just two *Bombus* species,
116 which along with two other *Bombus*, were the only species recorded in more than two studies.
117 The likely visitor category was almost exclusively represented by *Andrena* species. The
118 possible visitor category was largely comprised of solitary bees from five different genera.



119

120 Figure 3: The number of bee species from each genus which were categorised as definite likely or possible flower visitors per crop

121 **3.4 Dominant crop flower visitors**

122 Ten bee species were attributed with 80% of flower visits across the four crops (Figure S2;
123 Figure 4). There were differences however in the number and composition of those species
124 making up the 80% of flower visits on a per crop basis. Differences in crop communities were
125 even more distinct when considering the entire suite of bee species included in the
126 characterisation of each crops' total flower visiting community (Figure 3; Figure 4). Wild bees
127 were attributed with an average of between 63 and 83 percent of crop flower visits compared
128 to honey bees (Apple: solitary bee visits = 68%; Bean: solitary bee visits = 83%; Oilseed:
129 solitary bee visits = 63%; Strawberry: solitary bee = 77%).

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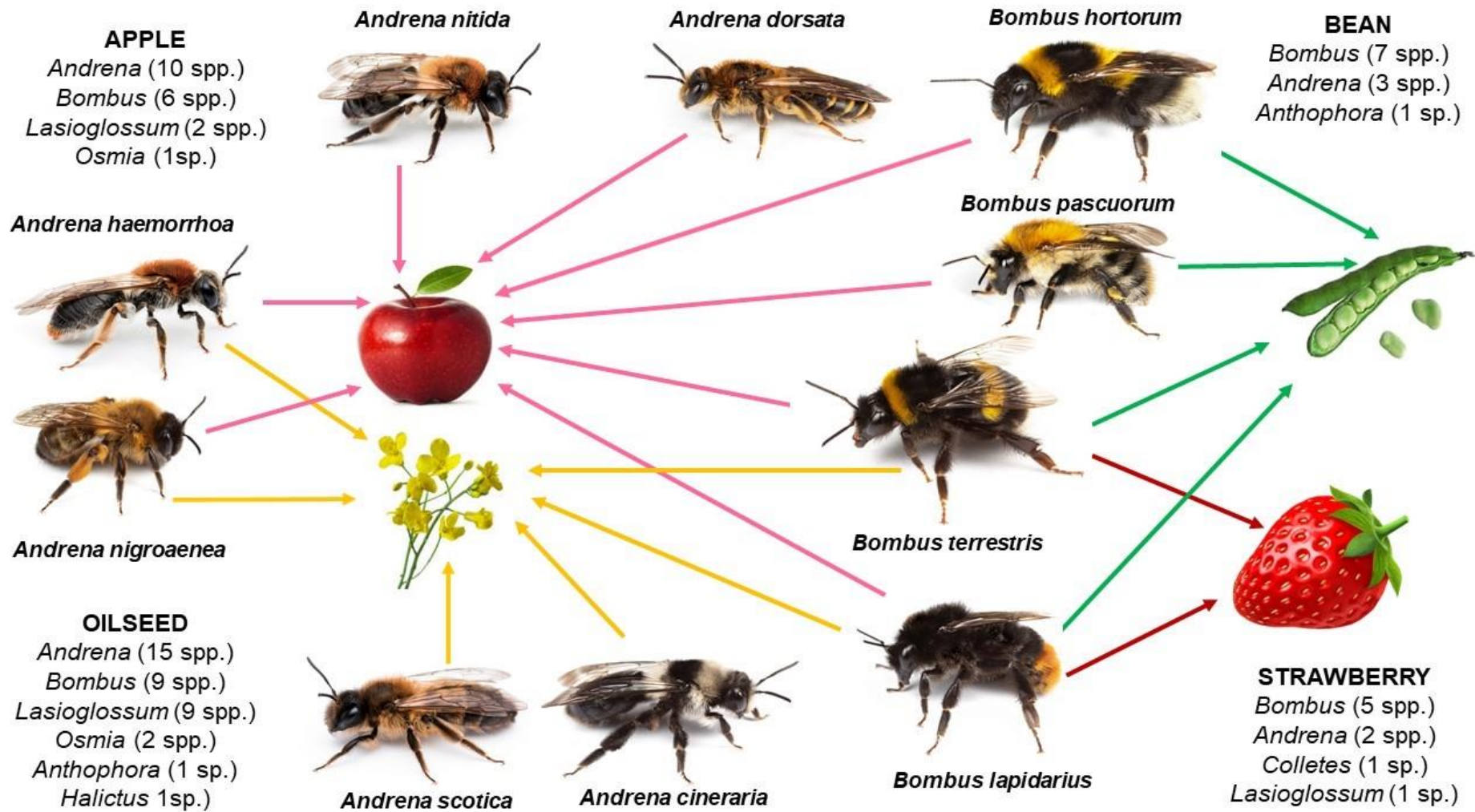
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145 Figure 4: Dominant crop visiting bee species (attributed with ~80% of flower visits in field studies per crop) shown as photographs, with

146 number of bee species in each genus that are 'definite' flower visitors for each crop.

147 **4. Discussion**

148 **4.1 Crop pollinator species**

149 Our study is the one of the first to evaluate the entire wild bee community of multiple crops on
150 a national basis and can be used as model approach for other countries, crops and pollinators.
151 With the identification of bee species important for pollinating crops we build the basis to better
152 sustainably manage services with changing climate and land use. Whilst in accordance with
153 other studies (Rader et al., 2012; Kleijn et al., 2015) our results indicate that a small proportion
154 of common, generalist bee species do make the majority of crop flower visits, many more
155 species were evidenced as crop flower visitors. Additionally, our results suggest that the
156 contribution of wild bee species to crop flower visitation may be even greater than previously
157 thought. Whereas previous estimates indicate that wild bees make a similar overall
158 contribution to honey bees (Kleijn et al. 2015), when considering the entire suite of flower
159 visiting species our results indicate that wild bees make on average between 63 and 83% of
160 flower visits to our target crops. Given the benefits of biodiverse communities for current and
161 future crop pollination services (Kremen et al., 2002; Hoehn et al., 2008; Garibaldi et al., 2011;
162 Rader et al., 2012), interventions to support crop pollinators should target a more significant
163 proportion of the bee fauna than at present (Wood et al., 2015b, 2016a; Gresty et al., 2018).
164 Establishing a list of currently important, but also potentially relevant crop pollinators, is
165 necessary to help target monitoring and conservation (Carvell et al., 2017).

166 Our results also support prior evidence of distinct differences in individual crop pollinator
167 communities (Garratt et al., 2014a). The overwhelming majority of field bean and strawberry
168 flower visits were attributed to bumblebees. However, whereas field bean was visited by the
169 three longest tongued species in Britain, strawberry crops were almost exclusively visited by
170 two other bumblebee species, with relatively shorter tongues. This supports a link between
171 trait matching of bees and flowers in crop pollination (Garibaldi et al., 2015). *Bombus* species
172 were also recorded visiting apple and oilseed rape. However, due to their low abundance in
173 early spring during apple flowering (Martins et al., 2015), and lower rate of pollen transfer

174 when visiting oilseed flowers (Woodcock et al., 2013) they are less important pollinators of
175 these crops compared to solitary species. *Andrena* and *Lasioglossum* species were prevalent
176 across both apple and oilseed flower visitor categories. *Andrena* are known to be highly
177 efficient pollinators of both crops (Martins et al., 2015; Woodcock et al., 2013), especially apple
178 (Russo et al., 2017). Most *Lasioglossum*, species however, generally emerge later than many
179 *Andrena* species, and peak after apple flowering, whereas oilseed tends to flower later and
180 longer, and *Lasioglossum* are likely important pollinators of this crop (Perrot et al., 2018;
181 Catarino et al., 2019). Furthermore, we almost certainly significantly underestimated the
182 diversity and abundance of *Lasioglossum* bees visiting oilseed rape, given that many studies
183 did not include detailed quantitative data on this genus.

184 Our datasets also indicate that rare and specialist species may visit crop flowers when they
185 are locally abundant or are especially attracted to crop flowers (MacLeod et al., 2020). Several
186 rare species recorded in apple orchards are most common in south-east England, Britain's
187 principal apple growing region, and bee species that are oligolectic on Brassicaceae were
188 recorded in oilseed rape studies. Given that biodiversity benefits pollination (Dainese et al.,
189 2019), strategies to support biodiverse crop communities may prove critical to sustain
190 ecosystem service provision. Yet current agri-environment schemes options rarely consider
191 rare species (Senapathi et al., 2015). There is however, a significant overlap in the floral
192 resources used by common and rare crop pollinators (Sutter et al., 2017; MacLeod et al.,
193 2020), and thus there are opportunities to promote both biodiversity and conservation in
194 agricultural landscapes.

195 Our findings also offer an opportunity to anticipate potentially important future crop pollinators.
196 For example, whilst a number of European crop flower visitors not presently recorded in British
197 crop fields are currently geographically restricted, should they expand their range in the future,
198 they could ameliorate the threat of ecological mismatches between current pollinators and
199 crops due to climate change (Polce et al., 2013; Polce et al., 2014; Settele et al., 2016). Taken
200 further, this information could be used to refine existing models of bee populations used to

201 project pollinator populations at large spatial scales (e.g. Gardner et al., 2020), which can
202 assist in larger scale planning of pollinator management.

203 Identifying specific bee crop pollinating species, as we have done, can inform refinements to
204 agri-environment schemes to promote more biodiverse communities in agricultural
205 landscapes. For example, *Andrena* were the most speciose genus of bees identified across
206 flower visitor categories in three of the crops. Currently European agri-environment measures
207 to boost pollinator populations have focused on the creation of flower-rich habitats, including
208 wildflower buffer strips (Wratten et al., 2012). Yet evidence suggests these are primarily visited
209 by bumblebees, with solitary bees preferring non-sown, wild plants (Wood et al., 2015). In
210 apple orchards for example, early-flying *Andrena* species have been positively associated with
211 dandelions (*Taraxacum* agg.) rather than sown species, which often bloom later than apple
212 flowers (Campbell et al., 2017). Reduced mowing regimes in orchards, and other crop areas,
213 particularly in early spring could boost *Andrena* numbers and hence pollination. Such
214 interventions are also likely to benefit early flying *Lasioglossum*, many species of which are
215 known be attracted to yellow flowers in the family *Asteraceae*. *Osmia* species have also been
216 demonstrated as efficient pollinators of apple, oilseed and strawberry crops (Abel et al., 2003;
217 Garratt et al., 2016; Horth and Campbell, 2018), but as in this study, are frequently recorded
218 in low numbers, likely due to a lack of suitable nesting and floral resources in agricultural
219 landscapes for cavity nesting species (Gardner and Ascher, 2006; Blitzer et al., 2016).
220 Incorporating hedgerow species such as Dog Rose and Bramble, alongside, areas of old and
221 dead wood, around crop areas would provide both forage and nesting resources (Eise and
222 Edwards 2018; Gresty et al., 2018) for these and other cavity nesting bees. Future
223 management to support long-tongued solitary bees could benefit field bean pollination.
224 *Anthophora plumipes*, for example, prefers to nest in vertical soil profiles, which are not
225 currently a common feature in agricultural landscapes.

226 **4.2 Data constraints and limitations**

227 There are caveats to using foraging ecology to identify potential bee pollinators, as done here
228 and elsewhere (Ahrenfeldt et al., 2015). There is a lack of published data for many bee species
229 and others visit a wider range of flowers than can be realistically documented (Else and
230 Edwards, 2018). As such, determining the status of bee species as crop flower visitors
231 requires field survey data for confirmation. Yet comprehensive crop pollinator data is currently
232 lacking as sampling is irregular, undertaken almost exclusively as part of bespoke research
233 projects rather than systematic monitoring (Breeze et al., 2020). Furthermore, whilst census
234 methods can provide information on floral associations, they require experienced surveyors to
235 comprehensively record species richness (O'Connor et al., 2019). Across all four crops the
236 only bees which were consistently identified to species level were large, conspicuous ones
237 from the genera *Bombus* and *Andrena*. Small and inconspicuous species, particularly from
238 the genus *Lasioglossum*, were often only extensively sampled in the pan trap surveys.
239 Additionally, whilst the visitation rate of dominant species is strongly correlated to pollination
240 service delivery (Winfree et al., 2015; Fijen et al., 2018), the assumption here and elsewhere
241 that quantitative visitation data can be used to infer pollination (Kleijn et al., 2015), neglects to
242 factor in that flower visitation alone is not a perfect proxy for pollination (King et al., 2013;
243 Senapathi et al., 2015; Ollerton, 2017). Certain physiological and behavioural traits also
244 influence pollination service delivery (Martins et al., 2015). Further detailed data and research
245 is required before any definitive conclusions can be made about the contributions of individual
246 bee species to crop pollination.

247 **5. Conclusions**

248 Given the importance of wild pollinators and the detrimental impacts of conventional
249 agriculture on their populations it is unsurprising that the management of wild and managed
250 pollinating insects is considered a critical step for future food security (Garibaldi et al., 2019;
251 Kleijn et al., 2019; Rollin and Garibaldi et al., 2019; Reilly et al., 2020). Yet information on
252 which species contribute most to ecosystem service delivery has long been elusive (Kremen
253 and Chaplin-Kramer, 2007) despite its critical importance for both monitoring and conservation

254 measures. Here we combine ecological and field data to provide a uniquely comprehensive
255 overview of the crop pollinating bees of a single region, Great Britain. Whilst we have focused
256 on Great Britain, a similar approach would be applicable across Europe, and could also be
257 applied to non-bee species that have been identified as important crop pollinators (Rader et
258 al., 2016). Our research bolsters evidence that many wild bee species, including rare and
259 specialised ones, may contribute to crop pollination (Klein et al., 2003; Sutter et al., 2017;
260 Winfree et al., 2018; MacLeod et al., 2020), thus it can be argued that agri-environment
261 scheme options should not focus solely on dominant crop pollinators.

262 Future climatic changes threaten to further deplete already impoverished bee populations
263 (Soroye et al., 2020) and create spatial mismatches between crops and their pollinators, which
264 could exacerbate existing pollination deficits (Polce et al., 2014). To that end, the species
265 identified as possible crop pollinators could represent an as yet untapped pollinator resource.
266 Whilst some species may not currently visit crops due to ecological or environmental
267 constraints, they could be assisted to expand by dedicated conservation measures in
268 agricultural landscapes, allowing them to compensate for any declines in current crop
269 pollinating species. Many such species are solitary, which presently benefit much less from
270 agri-environment schemes than social species (Wood et al., 2015b, 2016a, 2016b; Gresty et
271 al., 2018). As such land managers may need to re-evaluate existing pollinator management
272 interventions and consider a broader range of species to safeguard the ecosystem service of
273 crop pollination in an uncertain future.

274 **Declaration of Competing Interest**

275 The authors declare that they have no known competing financial interests or personal
276 relationships that could have appeared to influence the work reported in this paper.

277 **Authors' contributions**

278 LH conceived the ideas, analysed the data and wrote the manuscript. MG, TB and TO
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320

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