**Bee-friendly Interventions: The Barriers and Opportunities Affecting Urban Residents’ Conservation of Wild Bees in Gardens**

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**Abstract**

Wild bees are experiencing population declines globally. Despite urbanisation replacing habitat and forage with synthetic materials, urban residential gardens have the potential to become pollinator hotspots, increasing bee diversity and abundance. We explored public knowledge and attitudes towards bees, and ‘bee-friendly’ interventions (BFIs) conducted by urban residents. We reviewed the motivations and barriers which influence or prevent this, using the town of Woking, England, as a case study. An online questionnaire was distributed in 2023 to residents with gardens or balconies. Results from 286 surveys showed 98.3% of respondents performed ≥1 BFI and the most common action was planting “pollinator-friendly” plants (75.9%). Sentiment towards bees positively correlated to the number of BFIs performed, and 94.8% of respondents felt positively about bees. Most participants indicated altruistic motivations behind their performance of BFIs.

Implications for insect conservation: Though the public are altruistically motivated to undertake conservation for wild bees, and most are performing at least one BFI, lack of knowledge and understanding is the biggest barrier preventing conservation action. Governments, policymakers, and plant retailers should direct citizens to wild bee conservation organisations to engage and inform the public about bee ecology and improve habitat provision within neighbourhoods.

**Key words:** wild bees, conservation interventions, planting for pollinators, wild bee decline, urban residents, public engagement

**Statements and Declarations**

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All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Lauren Wiseman. The first draft of the manuscript was written by Lauren Wiseman and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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**Introduction**

The United Kingdom (UK) is one of the world’s most nature-depleted countries, with a Biodiversity Intactness Index score of around 40% (Natural History Museum 2023). One group which is being significantly affected is insects. Recording and monitoring insect populations is challenging (Montgomery et al. 2020) as their size and life cycles are comparatively more difficult to track than large mammals, potentially meaning that the rate of decline is more significant than currently understood. Research estimates that in the coming decades 40% of all insect species are at risk of extinction, with Hymenoptera (including bees) listed as one of the most affected Orders (Sánchez-Bayo and Wyckhuys 2019). In Europe 37% of bee populations were reported as declining in the most recent pollination assessment from the IPBES (2016).

Bees have global importance, but their true value is unquantifiable (Wratten et al. 2012; Goulson 2019). Anthropocentric estimates attempt to calculate the value to the food system as an argument in favour of preserving bees and other pollinators. For example, 91 of the 107 leading global crop types are dependent on animal pollination (IPBES 2016). However, bees provide other essential services beyond the pollination of food crops. Bees are keystone species for many ecosystems (Senapathi et al. 2015; Hall and Martins 2020; Schatz et al. 2021; Colla 2022) as they pollinate plants which other species depend on. Bees provide value to Indigenous cultures and traditions (Quezada-Euán et al. 2018), in various forms including tool making, medicine, jewellery, mythology, and cosmology. Further, bees assist with achieving multiple United Nations (UN) Sustainable Development Goals (SDGs), with one study suggesting they contribute to as many as 15 of the 17 Goals (Patel et al. 2021). Global bee decline jeopardises this value.

The Western honeybee *(Apis mellifera),* which is farmed, is just one of the 275 different bee species found in the UK (Falk 2016). This paper focuses on conservation of wild bee species (hereafter referred to as ‘bees’), rather than honeybees which are managed via human-made and owned hives (‘beekeeping’). Many studies investigate honeybees as they are easier to manage, compared with bees which nest freely, and have anthropocentric value as crop pollinators (Senapathi et al, 2017). However, focus on honeybees, and crop pollinators, detracts from the plight of bees and misplaces conservation efforts (Hall and Martins, 2020; Colla, 2022). Between 1980-2013, crop pollinator species increased by 12% in Great Britain, but upland species declined 55% (Powney et al. 2019). While efforts are made to conserve agricultural pollinators, including honeybees, bees continue to decline.

Threats to bee populations include habitat loss, climate change, loss of forage, invasive species, and pesticides (Schatz et al. 2021; Colla 2022; Griffiths-Lee et al. 2022; Siviter et al. 2023). In the UK, between 1930-1984, 97% of wildflower meadows were lost (Fuller 1987) and today gardens make way for artificial lawns, concrete and tarmac (Aviva 2022). In England, the most densely populated of the nations within the UK, 82.9% of the population live in urban areas (Government Office for Science 2021). There is a risk that biodiversity loss will continue as urbanisation grows, with green infrastructure cleared for human-dominated landscapes. There are, however, advantages provided by urban areas for bees compared with rural environments. Whilst pesticides are still present in urban residential gardens, exposure rates are lower for bees compared to rural areas (Botías et al. 2017; Hall et al. 2017; Šlachta et al. 2020). The increased temperatures in urban areas can also prolong the flowering season to the benefit of bees (Baldock 2020). There is, however, a paucity of research on the impact of urban residential gardens (hereafter referred to as gardens) on bee species. From the research available, gardens have potential as pollinator hotspots (Baldock et al. 2019; Banaszak-Cibicka and Żmihorski 2020; Theodorou et al. 2020; Tew et al. 2021) yet there is a distinct lack of studies on small-scale interventions in gardens.

Bee decline has become part of public consciousness (Schatz et al. 2021), emphasised through campaigns linking food security with pollinator status (Colla 2022). There is public sentiment for bees, awareness of their decline and the causes (Wignall et al. 2019; Burns et al. 2021), and desire to ‘help’ or ‘save’ them (Wignall et al. 2019; Hall and Martins 2020; Persson et al. 2023). However, the public are largely uninformed about bees (Wilson et al. 2017) and therefore conservation interventions may be rooted in misinformation, as knowledge is gathered from secondary sources without scientific evidence, distributed through channels such as social media (Bergman et al. 2022). The prevalence of such misinformation has contributed to a phenomenon known as ‘bee-washing’, first coined by MacIvor and Packer (2015) to describe misleading claims made by retailers of bee hotels despite a lack of evidence that they support wild bee populations. ‘Bee-washing’ misinforms conservation actions and misdirects resources to solutions without scientific research (Wignall et al. 2019; Hall and Martins 2020; Burns et al. 2021; Ford et al. 2021; Colla 2022). For example, businesses may install rooftop beehives as part of their work on biodiversity, yet research suggests that urban honeybees pose a risk to wild bee health and diversity (Hausmann et al. 2016; Baldock 2020; Stevenson et al. 2020; MacInnis et al. 2023, Page and Williams 2023). The application of conservation interventions rooted in misinformation may be counterproductive.

Keen gardeners are more likely to conduct pro-wildlife behaviours (Larson et al. 2022), have positive feelings towards insects (Silva and Minor 2017; Vanderstock et al. 2022), and have greater knowledge of invertebrates (Silva and Minor 2017). However perceived risk to humans and pets (Larson et al. 2021), concerns over wildness and neighbourhood social conventions (Burr et al. 2021), and lack of knowledge and information (Lindemann-Matthis et al. 2021) have all been shown to deter pro-pollinator action. Fear of danger (Ojija and Leweri 2022) and negative experiences such as stings (Silva and Minor 2017) can also contribute to negative attitudes towards bees, which may prevent conservation action. Hall and Martins (2020) however, emphasise that a stronger focus on sociocultural research is needed to understand how people interact with pollinators. This paucity in research was acknowledged by Knapp et al. (2020) who employed sociopsychology to understand behaviours towards pollinator conservation in the UK and found that the extent to which an individual interacts with nature and their perceived ability to help were two dimensions that most influenced pro-pollinator action. Further, Silvert et al. (2020) explored how socioeconomic indicators influenced pro-pollinator gardening in the United States (US) and determined that both understanding pro-pollinator gardening techniques and being afforded opportunities to see best practice were positively correlated with conservation efforts.

To discover how urban residents in England feel about bees, what influences both their sentiment and any associated pro-pollinator actions, and what their knowledge and level of misinformation is, this study uses the town of Woking, England, as a case study. In this study we survey urban residents with gardens (or balconies) to determine attitudes to bees and whether this is influenced by interest in gardening, if attitude corresponds to the number of actions undertaken, and what the most common actions are. We review the challenges that prevent action, examine the motivations to act, and explore why residents want to either increase or decrease bees in their garden, to identify opportunities that could be utilised by organisations to promote bee conservation in urban areas. While using the number of installed bee-hotels as an indicator of bee-washing, this research also analyses the level of knowledge of residents and the sources of information they use, to understand if bee-washing is impacting conservation actions.

**METHODS**

**Location**

Woking is a large commuter town, classified as a ‘major urban conurbation’ (DEFRA 2021) within proximity to London. Woking is densely populated but has a high number of urban gardens; in the town centre 72% of households have a private or shared garden (ONS 2020). As this study sought to explore the attitudes of urban residents towards bees, a location with a high percentage of urban residential gardens was chosen as this signifies an area with potential to improve bee populations.

**Survey design**

Residents of Woking with a garden or balcony were asked to complete an online questionnaire (Online Resource 1) which asked about their awareness, knowledge, and sentiments towards bees, current actions taken in their outdoor spaces and motivating and demotivating factors to action. The questionnaire collected minimal demographic information (age, garden size, location of garden). To explore connections between gardening interest, size of garden, and floral abundance, against action and attitudes towards bees, participants were asked to rank their level of interest using a 4-point Likert item from smallest (1) to largest (4). To assess attitudes towards pollinators and bees, a 5-point Likert item was used which asked participants to rank sentiment from “strongly dislike” (1) to “love” (5). To analyse awareness and understanding of bees, participants were asked to rank issues that affect bee populations using a 5-point Likert scale, then to select whether they think bee populations are “declining”, “increasing”, “remaining steady” or “unsure”. Participants were asked multiple-choice questions regarding activities they have carried out for bees, what factors would restrict them when deciding whether to encourage bees into their garden, and what would motivate them. Participants were asked if they wanted to increase bees in their garden, and then asked a subsequent open-ended question to detail their reasoning behind their answer. Perceived knowledge about bees was self-reported using a 4-point Likert item from ‘none’ (1) to ‘excellent’ (4) and, to evaluate participants’ actual knowledge of bees, a pollinator identification quiz was used. The quiz asked respondents to select which type of pollinator was shown in the picture, with responses limited to either flies, wasps, bees, honeybees, or bumblebees. Pollinators selected for this quiz included species found within Woking; honeybee (*Apis mellifera*), White-tailed bumblebee (*Bombus lucorum*), Greater bee fly (*Bombylius major*), Common wasp (*Vespa vulgaris*), Willughby’s leafcutter bee (*Megachile willughbiella*), Flavous nomad bee (*Nomada flava*), and the Red-tailed bumblebee (*Bombus lapidarius*).The questionnaire ran from 1st April – 30th June 2023.

**Sample size**

The sample for this study was residents of Woking who live within the ‘major urban conurbation’, excluding those in less populated, rural areas. Participants must live in a home with a garden or balcony, but do not need to own their home. A map was provided at the beginning of the questionnaire and respondents were asked for the road name they live on to enable data mapping and exclusion of results outside of the urban area. There are 41,439 households in Woking (Woking Borough Council 2021). Applying the urban average (taken from the town centre) of 72% of households having access to a private or shared garden (ONS 2020), this makes 29,836 households. Using the Qualtrics sample size calculator, a minimum sample size of 269 people was required to ensure that the sample was representative of the population, using a 90% confidence level and a 5% margin of error.

**Survey distribution**

The questionnaire was hosted on Microsoft Forms and posted on social media sites and neighbourhood WhatsApp groups, encouraging sharing by local organisations and participants. 5000 leaflets were also printed and posted to urban residents with gardens or balconies as well as distributed within a garden centre in Woking.

**Ethical approval and permissions**

Ethical approval was granted by the University of Derby DELETED FOR PEER REVIEW: ETH2223-3849. For confidentiality, all responses were collected anonymously, and participants assigned a unique identifier should they wish to remove their responses.

**Statistical analysis**

Questionnaire responses were mapped using road names provided by respondents. Data cleaning removed any invalid responses. Statistical analysis was conducted using the DATATab online software package. Ordinal variables included: demographic information such as *age group*; garden information including *garden size* and *floral abundance*; attitude variables including *gardening interest*, *attitude towards pollinators*, and *attitude towards bees*; and *perceived knowledge about bees*. Ordinal categories were assigned numerical value using Likert items for data analysis, for example from ‘love’ (1) to ‘strongly dislike’ (5). To compare categorical variables including *‘bee-friendly’ interventions*, *motivating factors*, and *barriers*, with other variables, the total number of categories selected by each respondent per variable was used. To test relationships between variables, comparing *‘bee-friendly’ interventions* with *attitudes towards bees*, *floral abundance*, *garden size*, and *quiz score*, as well as *attitudes towards bees* with *gardening interest,* Spearman rank correlations were used with a significance level of 5% (0.05) and a null hypothesis tested. *Age group* was plotted against the *source of bee-related information* to show what the most common sources were by age group. To compare knowledge of participants (not to be confused with *perceived knowledge*) with other variables, scores from the pollinator identification quiz were converted into a *quiz score,* and to correlate *quiz score* with *perceived knowledge of bees* a Spearman rank correlation was used, as above.

**Thematic analysis**

Reflexive thematic analysis (Braun and Clarke 2022) was deployed on the qualitative data obtained from open ended questions. Three rounds of the six-step approach were conducted to reevaluate the data considering constructed themes, simplifying codes, and merging themes where possible.

**RESULTS**

**Survey respondents**

317 people responded to the questionnaire and 286 responses were valid after data cleaning. Age of respondents ranged from 18-24 (n=3) to 75+ (n=12), and the mode was 45-54 (31.8%). The average (mode) *garden size* was “medium” (50-200m2) (48.3% of respondents, n=138) and “small” (5-50m2) to “medium” size gardens accounted for 80.4% of responses (n=230). Equally, 80.4% of respondents (n=230) were “somewhat interested” to “interested” in gardening (*gardening interest*). Only 5% (n=13) of respondents had “no flowers or flowering plants” in their garden (*floral abundance*).

**Attitudes towards bees**

Most respondents indicated positive (“like” or “love”) *attitudes towards pollinators* (n=277, 96.9%) and *attitudes towards bees* (n=271, 94.8%). A Spearman correlation test showed a high positive correlation between *attitude towards pollinators* and towards *bees* (*r*(284) = 0.63, *p* = <0.001). Of those who selected “dislike” or “strongly dislike” (n=5), two selected “fear of bees”, one reported an allergy, and two people “dislike bees”. There was a positive correlation between both *gardening interest* and *attitudes towards pollinators* (*r*(284) = 0.32, *p* = <0.001), and between *gardening interest* and *attitude towards bees* (*r*(284) = 0.25, *p* = <0.001). A Spearman correlation test showed a positive correlation between *perceived knowledge of bees* and *attitude towards bees* (*r*(284) = 0.26, *p* = <.001).

**Knowledge of bees**

Most respondents (86.0%, n=246) describe bee populations as “declining”, 4.9% describe them as “increasing” or “remaining steady” (n=14), and 9.1% (n=26) were “unsure”. The mode for respondent’s *perceived knowledge of bees* was “limited” (n=184, 64.3%). Pollinator identification *quiz score* returned a mode of 4 (27.6%, n=79), 60.8% (n=174) scored ≥4, and four respondents correctly identified all seven pictures (1.4%). Figure 1 shows the percentage of respondents that correctly identified each picture. The most correctly identified picture was a wasp (97%, n=278). There was a low positive correlation between *perceived knowledge of bees* and *quiz score* (Spearman correlation *r*(284) = 0.14, *p* = 0.015). Most respondents reported they received ‘none’ to a ‘small amount’ of information about bees (n=224, 78.3%).

**Fig. 1** Percentage of respondents that correctly identified each picture (n=286)

A graph of bees and bees

Description automatically generated

**‘Bee-friendly’ interventions (BFIs)**

A multiple-choice question asked respondents to select any actions they conduct for bees (*‘bee-friendly interventions (BFIs)*). The number of selected BFIs ranged from 0-11, and 98.3% of respondents reported carrying out at least one BFI (n=281). Table 1 shows the three most frequent BFIs were “planted “pollinator-friendly” plants”, “’rescued’ a bee”, and “sown wildflowers”. The least frequent BFI was “drilled holes in logs/wood”. Of the “other” selections, five respondents mentioned interventions for honeybees including “I’m an apiarist”, “kept honeybees”, and “considered putting beehives in garden but unsure of whether this would support UK native bees”. Spearman correlation tests determined positive correlations between number of *BFIs* performed against *attitude towards bees* (*r*(284) = 0.43, *p* = 0.<0.001), *gardening interest* (*r*(284) = 0.41, *p* = <0.001), and *garden size* (*r*(284) = 0.24 *p* = 0.<0.001). There was no statistically significant Spearman correlation between respondents’ *quiz score* and number of *BFIs* (*r*(284) = 0.05, *p* = 0.445). Table 2 shows the mean number of BFIs performed was highest in *garden size* ‘large’ (200m2+) (mean ± SD = 6.38 ± 2.7 BFIs, range=9), followed by 'medium’ (50-200m2) gardens (mean ± SD = 4.94 ± 2.58 BFIs, range=10). Notably, of the five respondents who “dislike” or “strongly dislike” bees, three carried out at least one BFI.

**Table 1** Responses to the question “Have you ever carried out any of the following activities for bees (tick all that apply)”

|  |  |  |
| --- | --- | --- |
| **Bee-friendly intervention (BFI)** | **Number of respondents** | **Percentage (n=286)** |
| Planted “pollinator-friendly” plants | 217 | 75.9% |
| ‘Rescued’ a bee (from drowning, or revived with sugar syrup) | 181 | 63.3% |
| Sown wildflowers | 174 | 60.8% |
| Stopped using weedkiller, insecticide, and/or pesticides | 160 | 55.9% |
| Left “weeds” (such as dandelions) to grow | 160 | 55.9% |
| Reduced/stopped mowing your lawn (or a patch of lawn) | 136 | 47.6% |
| Looked up how to help pollinators | 125 | 43.7% |
| Installed a bee hotel | 103 | 36.0% |
| Placed stones in water (bee watering station/similar) | 91 | 31.8% |
| Drilled holes in logs/wood | 41 | 14.3% |
| Other | 18 | 6.3% |
| No activities conducted | 5 | 1.7% |

**Table 2** *Garden size* and *number of ‘bee-friendly’ interventions* (BFIs) including mean, standard deviation, and confidence interval

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Size of Garden** | **Frequency** | **Total number of BFIs per garden size** | **Mean** | **Standard Deviation** | **Minimum** | **Maximum** | **95% Confidence Interval of Mean** |
| **Micro (balcony – 5m2) (1-50 sq. ft)** | 14 | 41 | 2.93 | 1.44 | 1 | 5 | 2.1-3.76 |
| **Small (5 – 50m2) (50-540 sq. ft)** | 92 | 415 | 4.51 | 2.72 | 0 | 10 | 3.95-5.07 |
| **Medium (50 – 200m2)** (**540-2150 sq. ft)** | 138 | 682 | 4.94 | 2.58 | 1 | 11 | 4.51-5.38 |
| **Large (200m2+)** (**2150 sq. ft+)** | 42 | 268 | 6.38 | 2.7 | 2 | 11 | 5.54-7.22 |

**Barriers**

Participants were asked to select potential barriers that would impact their decision to encourage bees into their garden. Number of *barriers* selected ranged from 0-5 and the mode value (as shown in Table 3) was “lack of information or knowledge about bees” (n=82, 28.7%). No *barriers* category was selected by more than 30% of respondents, 16.8% reported that none apply (n=48) via the “other” option, and three respondents (1%) mentioned “time” as a limitation in “other”. A Spearman correlation test determined a low, negative correlation between *attitudes towards bees* and the number of *barriers* selected (*r*(284) = -0.25, *p* = <0.001).

**Table 3** Responses to the question “Would any of the following restrict you when deciding whether to encourage bees into your garden? (Tick all that apply)”

|  |  |  |
| --- | --- | --- |
| **Limitation** | **Number of respondents** | **Percentage (n=286)** |
| Lack of information or knowledge about bees | 82 | 28.7% |
| Concern about being stung (personal/children/pets) | 68 | 23.8% |
| Limited space | 58 | 20.3% |
| Financial constraints | 57 | 19.9% |
| None apply | 48 | 16.8% |
| Preference or need for lawn over plants | 39 | 13.6% |
| Gardening for wildlife may make garden untidy | 34 | 11.9% |
| Preference for ornamental plants / shrubs | 15 | 5.2% |
| Other | 7 | 2.4% |
| Fear of bees | 6 | 2.1% |
| Dislike of bees | 2 | 0.7% |

**Opportunities**

As shown in Table 4, the two *motivating factors* selected by >75% of respondents were “interest in nature” and to “help pollinate other plants, fruits, vegetables”. The number of factors selected ranged from 0-9, and two of five respondents mentioned “honey” in their “other” response. Less than half of respondents stated that “receiving information and advice on bees” would motivate them to encourage bees into their garden (n=118, 41.3%).

**Table 4** Responses to the question “Would any of the following motivate you when deciding whether to encourage bees into your garden? (Tick all that apply)”

|  |  |  |
| --- | --- | --- |
| **Motivating factors** | **Number of respondents** | **Percentage (n=286)** |
| Interest in nature | 226 | 79.0% |
| Help pollinate other plants, fruits, vegetables | 223 | 78.0% |
| Concerns about biodiversity | 184 | 64.3% |
| Enjoyment of watching/listening to bees | 180 | 62.9% |
| Restoring the local food chain (birds eat bees, mammals eat the birds etc) | 179 | 62.6% |
| Concerns about climate change | 151 | 52.8% |
| Receiving free seeds or plants | 144 | 50.3% |
| Receiving information and advice on bees | 118 | 41.3% |
| Other | 5 | 1.7% |
| None apply | 4 | 1.4% |

In total, 81.8% of respondents want to increase bees in their outdoor space (n=234), and 75.5% (n=216) want more information about bees. Participants were asked an open-ended question to provide reasoning behind their response to whether they wanted to increase bees in their outdoor space. Reflexive thematic analysis of the 257 qualitative responses to this constructed 2 themes, containing 12 codes (Table 5). Themes were constructed by ecological motivations and concerns, such as biodiversity or bee populations, and anthropocentric concerns and motivations, including safety, personal enjoyment, and the need for crop pollination. Most responses showed ecological coding (62.6%, n=161), and the most popular code was concern for bee populations. Table 6 shows respondents’ primary *source of bee-related information* compared to *age group.* The most common source of information (mode) was “online articles” (22.0%) and was the source chosen by the mode *age group* (45-54). Social media was the most popular source of information for the age group 18-24 (n=2). Of the qualitative answers given, 23 respondents mentioned the Royal Horticultural Society (RHS) (8.0%).

**Table 5** Thematic analysis of qualitative responses to question 16 (which asked respondents to explain their reasoning to question 15 “Do you want to increase bees in your outdoor space?”)

|  |  |  |
| --- | --- | --- |
| **Theme and codes** | **Number of respondents** | **Percentage of respondents (n=257)** |
| Ecological motivations and concerns | 161 | 62.6% |
| Concern for bee population | 57 | 22.3% |
| Ecosystem concerns | 43 | 16.8% |
| Pollination services (excluding food) | 34 | 13.3% |
| Biodiversity concerns | 27 | 10.5% |
| Anthropocentric concerns and motivations | 96 | 37.4% |
| Participant likes bees | 25 | 9.8% |
| Food pollination | 20 | 7.8% |
| Safety or phobia | 15 | 5.9% |
| Self-satisfaction and enjoyment | 14 | 5.5% |
| Perception there are enough/too many bees | 9 | 3.5% |
| Honey/honeybees | 6 | 2.3% |
| Personal concerns | 5 | 2.0% |
| Dislike gardening | 2 | 0.8% |

**Table 6** Source of information about bees plotted against age group

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **18-24** | **25-34** | **35-44** | **45-54** | **55-64** | **65-74** | **75+** | **Prefer to not say** | **Total** | **Percentage of respondents** |
| **Online articles** | 0 | 11 | 14 | 20 | 8 | 7 | 1 | 2 | 63 | 22.0% |
| **Web searches** | 0 | 9 | 14 | 15 | 7 | 6 | 3 | 2 | 56 | 19.6% |
| **TV programmes** | 1 | 4 | 7 | 19 | 6 | 5 | 3 | 0 | 45 | 15.7% |
| **Social media** | 2 | 6 | 10 | 7 | 6 | 0 | 1 | 0 | 32 | 11.2% |
| **Through specific organisations** | 0 | 2 | 3 | 11 | 8 | 4 | 1 | 2 | 31 | 10.8% |
| **Friends and family** | 0 | 1 | 3 | 5 | 3 | 3 | 0 | 1 | 16 | 5.6% |
| **Other** | 0 | 1 | 2 | 7 | 4 | 0 | 0 | 0 | 14 | 4.9% |
| **Magazines** | 0 | 0 | 1 | 2 | 3 | 3 | 3 | 1 | 13 | 4.5% |
| **Books** | 0 | 1 | 1 | 1 | 3 | 1 | 0 | 0 | 7 | 2.4% |
| **Newspaper** | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 4 | 1.4% |
| **None** | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 3 | 1.0% |
| **Radio** | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0.7% |

**Discussion**

This study aimed to identify the barriers and opportunities to increasing bees in urban residential gardens by exploring residents’ perceptions, knowledge and understanding of bees, their performance of BFIs, and the motivating or demotivating factors behind these. It should be noted that there may be a bias in the responses received as only citizens interested in this topic were likely to have completed the questionnaire.

The results indicate that almost all respondents carried out at least one BFI. This concurs with the findings from previous research of public actions for insects in Ireland (Burns et al. 2021) and England (Wignall et al. 2019). However, this is the first paper exploring public actions for bees in England. Although feelings towards bees positively correlated with the number of BFIs undertaken, three out of the five people who reported negative attitudes towards bees still performed at least one BFI. This suggests that even though people may dislike bees they may still act altruistically to support them. It is proposed that this altruism is rooted in a perception of the importance of bees. For example, Ojija and Leweri (2022) found that, despite a much higher incidence of fear of bees (74% of participants), 84% considered bees to be important. Participants were asked whether they wanted to increase bees in their outdoor space and why, and qualitative responses were thematically analysed. Two themes were constructed: 1) ecological or 2) anthropocentric concerns. Most responses were ecological, indicating a motivation and awareness of bees’ value outside of human-centred benefits such as personal enjoyment or crop pollination, and instead prioritising benefits to biodiversity, ecosystems, or pollination of (non-crop) plants. This concurs with Sturm et al. (2021) who categorised motivations behind participation in citizen science activities as ‘altruistic’ or ‘egoistic’. In both the present study and Sturm et al. (2021), participants were strongly motivated by an interest in nature. In this study, “interest in nature” was the most frequent motivating factor selected by participants. The prevalence of altruistic (‘ecological’) responses and high incidence of BFIs undertaken both indicate public engagement in bee conservation. One of the key factors essential for conservation success is engagement (Washington et al. 2015) and this would suggest that conservation organisations have been somewhat effective in engaging the public, but there are other areas for improvement.

As the number of BFIs positively correlated to garden size, this suggests that limited space deters BFIs, but as space increases citizens are able to take more action for bees. Although research suggests that urban residential gardens have potential to assist with conservation of invertebrate species including pollinators (Martins et al. 2017; Braschler et al. 2020; Šlachta et al. 2020) there has been no exploration of what actions urban residents are currently undertaking for bees and why. This finding supports the argument that the public are acting altruistically and will dedicate some portion of their outside space to helping nature. However, these actions were self-reported, and the validity cannot be verified. Consideration should also be given to the scale and impact of various BFIs depending on the size of the respondent’s garden. For example, reducing pesticide use or planting for pollinators in gardens <5m2 may have less impact on bees and biodiversity compared to large gardens (≥200m2).

The most common BFI performed by urban residents in Woking was “planting ‘pollinator-friendly’ plants”. This aligns with garden centre visitors in Sussex (Wignall et al. 2019) but contrasts with Burns et al. (2021) who found the most popular self-reported action amongst the Irish public was reduced fertiliser and pesticide use. In both this study and Wignall et al. (2019), a high proportion of the respondents indicated positive attitudes to gardening and can therefore be assumed to be gardeners. Interest in gardening may mean people are more likely to carefully consider plants for their gardens, whereas Burns et al (2021) may represent more of the non-gardening public who could still require pesticide or weedkiller despite no other gardening activity. The incidence of gardening interest is an important factor as gardeners show greater appreciation of insects (Sturm et al. 2021; Larson et al. 2022; Vanderstock et al. 2022). Our results support this notion, as gardening interest positively correlated to both the attitudes towards pollinators, and the number of BFIs undertaken. Most respondents showed positive attitudes (“like” or “love”) towards bees, and many wanted to increase bees in their outdoor space. This may be attributable to the presence of ‘biophilia’ (feeling connected to nature) which positively influences attitudes towards pollinators. Those who spend more time in nature (such as gardening) are more likely to have positive attitudes to nature and want to conserve it (Vanderstock et al. 2022). As shown in Wignall et al. (2019), gardeners are a key demographic for pollinator conservation and there are opportunities for garden centres and conservation organisations to collaborate, particularly with regards to bees.

One of the intentions of this research was to determine whether interventions performed by residents were aligned with what research suggests is the most effective, or if ‘bee-washing’ was apparent. Research shows that increasing floral resources positively impacts bee abundance and diversity (Bennett and Lovell 2019; Lanner et al. 2020; Griffiths-Lee et al. 2022; Baldock et al. 2020; Kanduth et al. 2021; Felderhoff et al. 2023). The four most common BFIs (selected by over 50% of participants in this study) align with what research shows to be most effective, by addressing major threats to bee populations – planting for pollinators, sowing wildflowers, reducing pesticides, and leaving weeds to grow. This finding suggests that the public have awareness of effective BFIs and are engaged and motivated to perform these interventions. This may be attributable to the ‘pollinator-friendly’ logos on plant packaging which can motivate purchases (Wignall et al. 2019). These logos make it easy to support bees, without specialist knowledge or additional research required. However, such logos may also constitute ‘bee-washing’ if greater regulation is not enforced to ensure a knowledgeable body, such as the RHS, has verified ‘pollinator-friendly’ claims, and if commercially grown plants labelled ‘bee-friendly’ are still found to contain high levels of pesticides harmful to bees (Porseryd et al 2024).

Planting for pollinators also allows residents to retain control of their garden by choosing plants and planting locations, compared to sowing wildflowers or leaving weeds to grow which were less popular, perhaps because they may spread or become unsightly. Although in the US ‘unwelcome wildness’ is a significant barrier to residential planting for wildlife (Burr et al. 2021), few respondents in this study stated that untidiness would be a barrier preventing BFIs. In the US, Homeowners’ Associations have the power to influence landscaping and planting in yards (Burr et al. 2018; Burr et al. 2021; Larson et al. 2022), and residents feel pressure to comply with neighbourhood aesthetic conventions (Burr et al. 2021; Silvert et al. 2020). In England such legal restrictions on planting, or social pressures, may be less common but were not analysed as part of this study.

Improving habitats was less popular; concurring with the findings of Burns et al. (2021). Though research emphasises the importance of nesting resources in residential gardens (Fortel et al. 2016; Felderhoff et al. 2023), lack of knowledge regarding bee ecology and confusion with honeybees may mean people are unaware of habitat requirements. For example, one respondent “*considered putting beehives in [their] garden but [was] unsure of whether this would support UK native bees*”. Like ‘pollinator-friendly’ plants, bee hotels offer an off-the-shelf solution for consumers to support bees, and they can choose the installation location in their garden. Neither the questionnaire nor the respondents mentioned bare soil, an important habitat for ground-nesting bees such as *Adrena* (mining bees). Encouraging residents to leave patches of bare soil may be less convenient to the logistics of life, or unsightly. Bee hotels can be harmful to bee populations if not properly cared for (Bumblebee Conservation Trust 2019), increase parasitism (MacIvor and Packer 2015), or remain ineffective (Rahimi et al, 2021). Due to the phenomenon of ‘bee-washing’, it was thought that more than half of respondents would have installed bee hotels. It is somewhat positive that <40% of respondents had selected this option, however, this still suggests that ‘bee-washing’ is influencing urban residents’ actions for bees, however, there is an opportunity to explore this in further research by assessing the impact of ‘bee-washing’ on knowledge and understanding. The lack of habitat interventions also indicates less education and awareness (another of the key factors for conservation success, Washington et al. (2015)) particularly regarding ground-nesting bees, and engagement with conservation actions to assist them.

Respondents were not confident in their self-reported knowledge of bees. Most respondents reported ‘limited’ knowledge, yet over half were able to correctly identify most pollinator pictures. Few people were able to correctly identify all 7 photographs, likely due to the inclusion of less common species in the questions such as the Flavous nomad bee, *Nomada flava*. The average score (4) aligns with previous research (Silva and Minor 2017; Wilson et al. 2017) and shows that the public can correctly identify bee species (or make informed guesses) in more than half of cases, despite a lack of confidence in their knowledge. The low positive correlation between self-reported knowledge and quiz score, indicates that participants were able to somewhat accurately self-report their level of knowledge. In the US by comparison, there was a higher statistical significance between these variables (Wilson et al. 2017), suggesting more accurate, or confident, self-assessment. The most correctly identified picture was the wasp, followed by images of two bumblebees, and the most incorrectly identified were the bee fly and nomad bee. The high percentage of correct identification of wasps and bumblebees aligns with the findings of Burns et al. (2021) and Wilson et al. (2017) (for bumblebees), suggesting that these species are more prominent in the public consciousness compared to lesser-known species such as solitary bees. This may be because of size – bumblebees being significantly larger than solitary bees and thus more noticeable – or fear of being stung, commonly associated with wasps (Sumner et al. 2018). The lower scores for less common species indicate an opportunity to improve public education and awareness, and communication, of these lesser-known species which may be in greater need of conservation.

The identification rate of the honeybee was just over half, lower than anticipated given the rise of ‘bee-washing’ and how often honeybees were discussed in conversations between the public and the researcher when distributing the survey. In the US, identification of honeybees was over 90% (Silva and Minor 2017; Wilson et al. 2017) compared to 50-70% in Ireland (Burns et al. 2021) and Tanzania (Ojija and Leweri 2022). Fear may be a contributing factor to this difference as Africanised honeybees (aka ‘killer bees’, a hybrid of *Apis mellifera* and visually indistinguishable from honeybees) are common in the US. However, these bees are also common in Tanzania. Burns et al. (2021) proposes that if the image used in the question featured a hive this may improve identification, however Wilson et al. (2017) used pictures without backgrounds. Uniformity in imagery would enable further exploration of influencing factors behind identification accuracy.

Where participants source their bee information was also explored. Responses were varied and no option received more than 25% of the participants’ selection. The most popular sources were ‘online articles’ and ‘web searches’, which suggests that the public do not have a specific port of information they seek advice from. Instead, they may read tips or information via articles in news applications or via Search Engine Optimised articles, neither of which necessarily originate from scientific sources. For example, a ‘top tips to save bees’ article via an online publication written by a content creator without referencing scientific advice. The high incidence of web sources selected relates to the online-only nature of this questionnaire and more traditional media may have received higher selections if there was an offline version. Social media was less popular, though this may be attributable to the average age of participants being 45-54. Social media can be harmful for spreading misinformation but can be a useful tool for conservation by inciting change, generating funding, and improving pro-conservation behaviours (Bergman et al. 2022). Ultimately these results indicate an opportunity for bee conservation organisations to improve their communication (a key factor for conservation success, Washington et al. 2015) by creating a stronger online presence, providing content that is optimised to draw the public towards their resources.

The positive correlation between self-reported knowledge and feelings towards bees supports the findings that increasing knowledge and awareness of insects generates positive attitudes towards those insects (Silva and Minor 2017; Sumner et al. 2018; Hall and Martins 2020), and this has the potential to increase pro-pollinator behaviours and support for conservation (Larson et al. 2021; Vanderstock et al. 2022). Most participants reported that they want to increase bees in their outdoor space and to receive more information about bees. As attitudes are already significantly positive, the public are engaged and somewhat knowledgeable, showing demand for additional resources. This suggests organisations and policymakers are somewhat effective in spreading the message about bee conservation, but there are opportunities to provide further information to these residents to inspire conservation action and raise funding.

**Limitations and future research**

There are three main limitations to this research. Firstly, hosting the questionnaire online restricted responses to individuals with internet access and, although it is estimated that 97.8% of the UK population has internet access (DataReportal 2023), this is not representative of the entire population. It is also restricted to Woking residents and findings may not be applicable to all UK urban areas. Secondly, not providing ‘none’ options in three multiple-choice questions could have misled participants towards positive responses. Although respondents could use the ‘other’ box to write ‘not applicable’ (or similar response), few participants did so. Thirdly, sampling bias may be present as those motivated to complete the questionnaire were likely to have an interest in bees and gardening. This may exaggerate BFIs and mask barriers which affect those with less interest. The nature of self-reported answers also means the accuracy and efficacy of BFIs undertaken cannot be verified.

This research explored barriers and opportunities affecting urban residents’ conservation of wild bees in gardens with the intention of identifying areas for future research. It highlights an opportunity for practical fieldwork exploring the outcomes of small-scale interventions. For example, planting wildflower patches in micro and small gardens (using a similar methodology to Griffiths-Lee et al. 2022) to test the impact of floral provision on bee diversity and abundance. This research assessed the knowledge and understanding of respondents and found these to be at a basic level with room for improvement and desire to learn more. Conservation organisations may benefit from further assessment of the public’s knowledge of bees by testing identification of different species, akin to Burns et al. (2021) in Ireland. This would confirm which species are prominent in public consciousness and which are less well-known and require additional publicity.

Though this study explored personal motivations and barriers to action it did not explore the influence of socioeconomic factors such as income, ownership of the property, children, and pets. Further research could be conducted specifically targeting those who have neutral or negative opinions of bees and conduct no BFIs, testing whether biophobia (the loss of connection to nature) (Vanderstock et al. 2022) is a significant barrier and could be ameliorated through initiatives to reconnect people to nature.

**Conclusion and Recommendations**

Through exploring barriers and opportunities to bee conservation in urban residential gardens, this research found that there is support for bees, and evidence of positive feelings towards them combined with a willingness to act altruistically to their benefit. This research highlights opportunities for conservation organisations, policy makers and local governments to utilise urban residents and their gardens, which are unique and beneficial habitats for bees. Information about these benefits, why urban gardens are important compared with rural environments, and how residents can amplify these benefits through the provision of floral and nesting resources, should be made available as the main barrier identified was a lack of information. Campaigns to raise awareness should also focus on the initiatives which bring communities and neighbourhoods together that could increase the effectiveness of these measures, as well as improving the spread of information.

As most residents are already planting for pollinators, there is an opportunity for conservation organisations and local governments to work with garden centres, or plant retailers, to ensure that ‘pollinator-friendly’ labelling is correct (that plants carrying that label are beneficial, not harmful, for pollinators), to promote plants which are specifically beneficial for bees, to provide information and advice, and to engage gardeners on other improvements that could be made in their outdoor spaces. Though residents provide floral resources, there is less action being taken to provide habitat and nesting resources. There is an opportunity to raise awareness about the diversity of bee species found in urban areas, their varied life cycle stages and nesting requirements, what the threats to bee species currently are, and what residents can do to help improve diversity and abundance. This could include organisations demonstrating different options using communal urban greenspace such as parks or gardens.

The research highlighted residents were not using one source of information and instead received information about bees from a diverse array of sources, including web articles. When promoting biodiversity initiatives, policy makers should direct the public to scientific conservation organisations to dispel the spread of misinformation and bee-washing, ensuring residents receive accurate and effective information. ‘Bee-washing’ was apparent and there was confusion between conservation of bees and honeybees. Bees have unquantifiable value within ecosystems, cultures, and for food security, and their decline is a global concern. The findings of this research are internationally applicable - investment in education, awareness, floral resources, and green space within urban areas would benefit bees, and potentially other insects, birds, small mammals, and humans.

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