JHR 75: 87–95 (2020)
doi: 10.3897/jhr.75.47507
http://jhr.pensoft.net

SHORT COMMUNICATION

JOURNAL OF Hymenoptera RESEARCH
A peer-reviewed open-access journal
The International Society of Hymenopterists

One-year-old flower strips already support a quarter of a city's bee species

Michaela M. Hofmann[1], Susanne S. Renner[1]

1 *Systematic Botany and Mycology, Department of Biology, University of Munich (LMU), Menzinger Straße 67, Munich 80638, Germany*

Corresponding author: Susanne S. Renner (renner@lmu.de)

Academic editor: Jack Neff | Received 22 October 2019 | Accepted 15 December 2019 | Published 27 February 2020

http://zoobank.org/C3F78D31-0DC8-4897-B12D-AFD3F3CDB914

Citation: Hofmann MM, Renner SS (2020) One-year-old flower strips already support a quarter of a city's bee species. Journal of Hymenoptera Research 75: 87–95. https://doi.org/10.3897/jhr.75.47507

Abstract

To combat the loss of flower-rich meadows, many cities are supporting greening measures, including the creation of flower strips. To assess the effectiveness of these measures in supporting flower-visiting insects, their faunas need to be compared to the background fauna at various distances from the flower strips. To meet this goal, we quantified the bee faunas of nine 1000 m^2-large and newly established flower strips in the city of Munich, all planted with a regional seed mix, and compared them to the fauna recorded between 1997 and 2017 within 500, 1000, and 1500 m from the respective strip. The 68 species recorded during the flower strips' first season represent 21% of the 324 species recorded for Munich since 1795 and 29% of the 232 species recorded between 1997 and 2017. Non-threatened species are statistically over-represented in the strips, but pollen generalists are not. These findings illustrate the conservation value of urban flower strips for common species that apparently quickly discover this food source. To our knowledge, this is the first quantitative assessment of the speed and distance over which urban flower strips attract wild bees.

Keywords

Urban ecosystem, attraction effect, flower strips, wild bees

Introduction

Insects that rely on a mix of floral resources for their survival, such as bees and many butterflies and flies, are rapidly decreasing in diversity and abundance (Mandery et al. 2003, Potts et al. 2010, Westrich et al. 2011). One reason for this is the loss of flower-rich meadows, which are becoming increasingly rare. In Germany, for example, meadows covered 5.3 Million hectares (Mio. ha) in 1991, but only 4.7 Mio. ha in 2019 (Statistisches Bundesamt, accessed May 2019). To address the loss of flower-rich areas, the European Union is supporting 'greening' measures, which include the creation of flower strips (European Commission 2011). Flower strips are man-made patches of flowering plants that provide foraging resources for flower-visiting insects, especially bees, butterflies, and flies. Monitoring and experiments have shown that such strips enhance the local plant and insect diversity in agricultural landscapes (e.g. Scheper et al. 2015, Jönsson et al. 2015, Buhk et al. 2018, Dicks et al. 2017 review 80 studies of flower strips).

Despite the work demonstrating the diversity-enhancing effects of flower strips near crops, it is unclear what proportion of bee diversity these usually small, young, and artificial plantings may be 'capturing' and how strongly their faunas may be biased towards common insect species. From first principles, the success of flower strips in maintaining populations of solitary bees will depend on their floristic composition, distance from suitable nesting sites, and distance from other habitats that maintain stable populations. To study the attractiveness of flower strips in an urban landscape, we took advantage of nine 1000 m^2-large flower strips newly established in Munich, all with autochthonous seed mixtures selected by the Bavarian bird protection society (Landesbund für Vogelschutz, acronym LBV) and Munich's Department of Horticulture (Gartenbaureferat München). We identified and counted the bees visiting flowers on each strip and then related these numbers to the total diversity of Munich's bee fauna and to the diversity at different distances from the strips. Our expectation was that newly planted flowers strips would attract a small subset of mostly generalist, non-threatened species and that oligolectic species (species using pollen from a taxonomically restricted set of plants) would be underrepresented compared to the city's overall species pool.

Material and methods

Study sites and plant species inventories

In April 2017, the Regional Society for the Protection of Birds (LBV) and the Department of Horticulture of the city of Munich created eight 1000 m^2-large flower strips; besides these eight strips, we included another 1000 m^2-strip established by the same group in 2015 (Fig. 1). All strips, which initially were covered by lawn or roadside greenery, were ploughed by machine and then sown with regional seeds from the seed

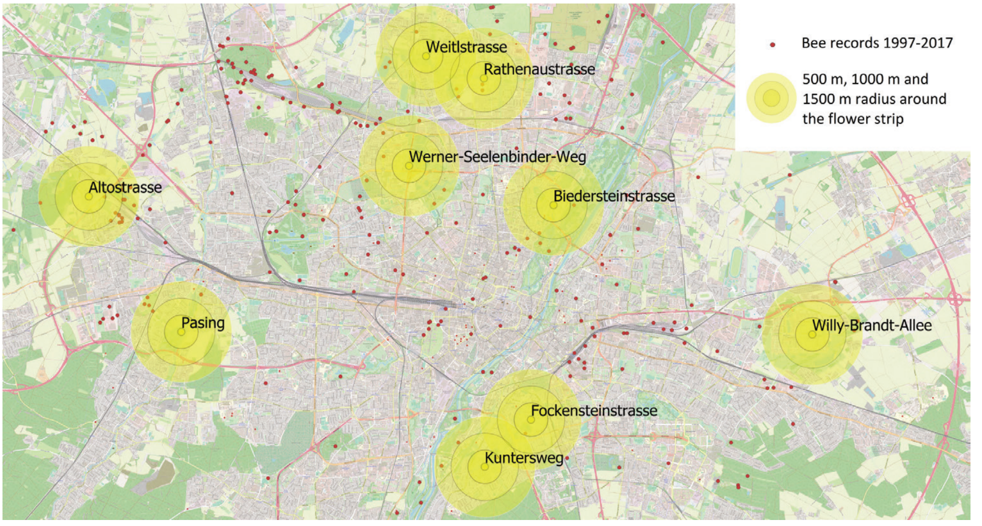

Figure 1. The nine flower strips monitored for this study (modified from https://www.openstreetmap.org, using QGIS 3.8.2 (QGIS Development Team 2019) and Munich's bee records (sightings and/or specimens) between 1997 and 2017.

supplier Kirmer (http://www.krimmer-naturnahes-gruen.de), adapted either for nutrient-rich or nutrient-poor sites, and the LBV also provided man-made nesting sites for cavity-breeding bees at the sites. They therefore all started from bare soil. Flowering plants present after the initial sowing were identified in randomly placed plots of one square-meter per strip at the strips Fockensteinstraße (established in 2015), Willy-Brandt-Allee and Rathenaustraße (nutrient-poor sites established in 2017), and Pasing Stadtpark, and Werner-Seelenbinder-Weg (nutrient-rich sites established in 2017). Plant species found on each strip are listed in Suppl. material 1, Table S1, along with information on herbarium voucher specimens deposited in the Munich herbarium (Botanische Staatssammlung, international acronym M).

Bee species inventories

From March to August in 2017 and 2018, each flower strip was visited four to five times. Visits were made between 10 a.m. and 4 p.m. on sunny, warm days with little or no wind. Where possible, bee species were identified directly in the field and were documented via macro-photography in a standardized setup: for close-up pictures, the bees were caught with an insect net and cooled down for 10 minutes in an Eppendorf screw-capped plastic vial stored on ice in a cooled box. When they fell into rigor of cold, they were transferred onto scale paper (using a small box lined with millimetre paper on its bottom) and photographed from all sides (SLR camera: Pentax K-x; Lens: Sigma DG 17-70 mm, 1:2.8, macro). Within one to two minutes, bees warmed up again and were released at the location where they had been caught. For species that are difficult to identify by morphology alone, such as species of *Sphecodes*, *Lasioglossum* or *Halictus*, voucher specimens, preferably males (for re-identification by genitalia preparations), were collected and identified morphologically and via DNA barcoding (methods and primers as described in Hofmann et al. 2018). The voucher specimens are deposited in the Zoologische Staatssammlung Munich (ZSM). Photo vouchers are accessible at the Diversity Workbench server (DWB; https://diversityworkbench.net/Portal/Diversity_Workbench), and DNA barcodes at NCBI GenBank (https://www.ncbi.nlm.nih.gov/genbank). Suppl. material 2, Table S2 in the Online Supporting Material shows all GenBank and DWB accession numbers. Additionally, Suppl. material 2, Table S2 shows each species' Red List status based on Westrich et al. (2011) as well as foraging and nesting preferences based on Scheuchl and Willner (2016).

To investigate the catchment area of each flower strip, we analysed 7589 records with Gauß-Krüger coordinates made between 1997 and 2017 of single bees or populations and documented either by specimens stored at the Zoological Collections in Munich and/or by taxonomic assessments in Munich's red lists. We focused on the area within a radius of 500, 1000, and 1500 m from each strip using QGIS 3.8.2 (QGIS Development Team 2019). For species that were recorded on a flower strip, but not within the 1500 m radius from the strip, we measured the distance from the strip to the nearest sighting of the respective species (Suppl. material 3, Table S3). For Fockensteinstraße and Willy-Brandt-Allee, we increased the radius to 1600 m, as there were too few records within the 1500 m radius, while a 1600 m radius yielded comparable numbers of records to those of the other sites.

Results

Oligolecty and Red List status of the species on the flower strips compared to the total Munich species pool

On the nine 1000 m²-large flower strips, we found 83 species of flowering plants, 35 of them coming from the regional seed mix *(Materials and Methods*) and 17 self-sown at Fockensteinstraße (Fig. 2), 27 from the seed mix and 28 self-sown at Rathenaustraße and Willy-Brandt-Allee, and all 23 from the seed mix at Pasinger Stadtpark and Werner-Seelenbinder-Weg (see Suppl. material 1, Table S1 for species lists for each site). The flowers of these plants were visited by honey bees and 68 species of wild bees, that is 21% of the 324 species recorded for Munich since 1795 and 29% of the 232 re-observed or newly observed species over the last twenty years (1997–2017).

Of the 68 species, 62 (91%) have the Red List category 'not threatened,' three (4%) are listed on the pre-warning-list, and three are 'threatened' (Suppl. material 2, Table S2). The respective percentages for the 324-species-pool are 54% (n = 174) not threatened, 11% (n = 35) on the pre-warning list, and 27% (n = 89) threatened. Twenty-two

Figure 2. The flower strip at Fockensteinstraße as an example of the urban context of the flower strips studied here.

of the 324 species are not Red-listed due to a lack of data, and three are considered locally extinct. There are thus significantly more non-threatened species on the flower strips than in Munich overall (chi-square test with 2 df, $\chi^2 = 26.4$, $P = 1.8 \times 10^{-6}$). Of the 232-species-pool recorded for 1997–2017, 156 (67%) species are non-threatened, 29 (13%) on the pre-warning list, 38 (16%) threatened, and 9 (4%) of unknown status. With these numbers, too, the flower strip fauna includes a disproportionate number of non-threatened species (chi-square test with 2 df, $\chi^2 = 12.5$, $P = 0.002$).

Of the 68 species found on the strips, 63% (n = 43) are polylectic and 15% (n = 10) oligolectic. Some 22% (n = 15) parasitize other bee species (Suppl. material 2, Table S2). The respective percentages for the 324 species pool are 51% (n = 165) polylectic, 22% (n = 72) oligolectic, and 27% (n = 87) parasitic (Hofmann and Renner, in review), while in the 232 species pool of the last 20 years, 50% (n = 118) of species are polylectic, 25% (n = 59) oligolectic, and 24% (n = 55) parasitic. Of the oligolectic flower strip visitors, seven specialized on Asteraceae, two on *Campanula* (Campanulaceae), one on *Echium* (Boraginaceae), and one on Fabaceae. There is thus no significant difference in the frequencies of polylectic, oligolectic, or parasitic species among the flower strips and the remainder of Munich either for the larger pool (chi-square test with 2 df, $\chi^2 = 3.62$, $P = 0.164$) or the smaller 1997–2017 pool (2df, $\chi^2 = 4.19$, $P = 0.123$).

'Catchment areas' of the flower strips

Our quantification of species recorded between 1997 and 2017 within a radius of 500, 1000, or 1500 m around each of the nine flower strips revealed that the strips at Altostraße (400 records of 105 different species) and Pasinger Stadtpark (329 records of 156 species) were richest in bees within a radius of 1500 m around them, while Weitlstraße and Willy-Brandt-Allee (19 records of 15 species each) have the fewest records within 1500/1600 m around them (Fig. 3; Suppl. material 3, Table S3).

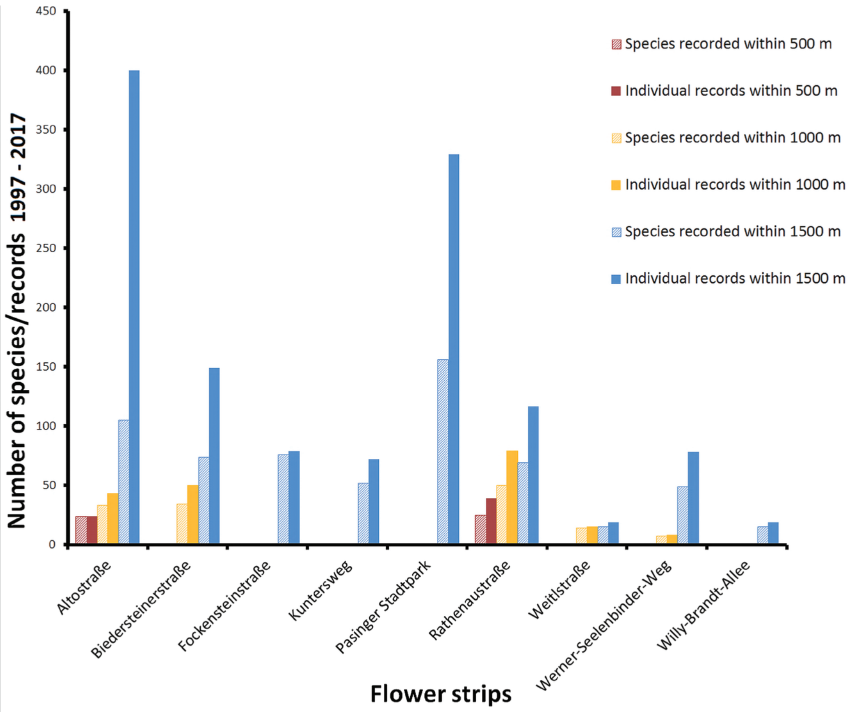

Figure 3. Numbers of species and individuals recorded between 1997 and 2017 within a radius of 500, 1000, and 1500 m from the centre of the respective flower strip (compare Fig. 1). For details of how past recordings were made see Materials and Methods.

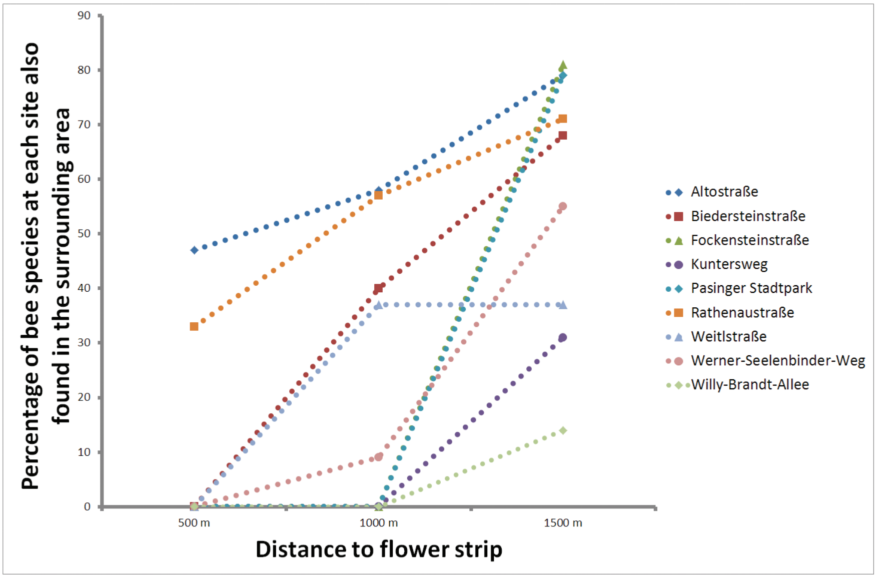

Figure 4. The percentage of bee species recorded at each flower strip that is also found in the surrounding area at distances of 500, 1000, and 1500 m.

Discussion

Bees need time to discover newly created habitat, but Munich's common species did so in just one year, so that the 1000 m^2-small and young flower strips studied here attracted 68 (21%) of the 324 species ever recorded for Munich and 29% of the 232 species recorded during 1997–2017. These percentages are similar to those found for much larger protected sites in Munich. Thus, 105 species (32% of the 324 species pool) were recorded in 2017/2018 in the 21 ha-large Munich botanical garden and 44 species (14% of 324) in a 20 ha-large protected city biotope called 'Virginia Depot' (Hofmann & Renner, in review). Surprisingly, the flower strips attracted a random subset of Munich's bee species in terms of pollen specialization, although as expected, the first-year flower-strip visitors mostly belong to common, non-threatened species. To demonstrate positive effects of flower strips on pollinator populations it would be necessary to show increased abundances of pollinators at the urban landscape scale, which was not part of this study. Still, our data strongly support that flower strip planting in cities helps ensure the availability of foraging resources for pollinators and that this simple conservation measure is effective. We therefore agree with Buhk et al.'s (2018) call that flower strip networks should be implemented much more in the upcoming Common Agricultural Policy (CAP) reform in the European Union.

Acknowledgements

We thank the biology students Pia Schumann, Nadine Dasch, and Thomas Greindl for support with field work, Markus Bräu, Munich city Department of Health and Environment, for sharing bee occurrence data for Munich, and Jack Neff and an anonymous reviewer for their comments on the manuscript.

References

Buhk C, Oppermann R, Schanowski A, Bleil R, Lüdemann J,Maus C (2018) Flower strip networks offer promising long-term effects on pollinator species richness in intensively cultivated agricultural areas. BMC Ecology 18: 55. https://doi.org/10.1186/s12898-018-0210-z

Dicks LV, Ashpole JE, Dänhardt J, James K, Jönsson A, Randall N, Showler D, Smith RK, Turpie S, Williams DR, Sutherland WJ (2017) Farmland Conservation. In: Sutherland WJ, Dicks LV, Ockendon N, Smith RK (Eds) What Works in Conservation 2017. Open Book Publishers, Cambridge, 245–284 . https://doi.org/10.11647/OBP.0131.04

European Commission (2011) CAP Reform – an explanation of the main elements MEMO/11/685. http://www.ala.org.uk/sites/default/files/ExplanatoryMemo.pdf

Hofmann MM, Fleischmann A, Renner SS (2018) Changes in the bee fauna of a German botanical garden between 1997 and 2017, attributable to climate warming, not other parameters. Oecologia 187: 701–706. https://doi.org/10.1007/s00442-018-4110-x

Hofmann MM, Renner SS (in review) Bee species persistence and increase in urban protected sites between 1990 and 2018. Journal of Insect Conservation.

Jönsson AM, Ekroos J, Dänhardt J, Andersson GK, Olsson O, Smith HG (2015) Sown flower strips in southern Sweden increase abundances of wild bees and hoverflies in the wider landscape. Biological Conservation 184: 51–58. https://doi.org/10.1016/j.biocon.2014.12.027

Mandery K, Voith J, Kraus M, Weber K, Wickl K (2003) Rote Liste gefährdeter Bienen (Hymenoptera: Apidae) Bayerns. Bayerisches Landesamt für Umweltschutz 166: 198–207.

Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE (2010) Global pollinator declines: trends, impacts and drivers. Trends in Ecology & Evolution 25: 345–353. https://doi.org/10.1016/j.tree.2010.01.007

QGIS Development Team (2019) QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.osgeo.org

Scheper J, Bommarco R, Holzschuh A, Potts SG, Riedinger V, Roberts SP, Rundlöf M, Smith HG, Steffan-Dewenter I, Wickens JB, Wickens VJ (2015) Local and landscape-level floral resources explain effects of wildflower strips on wild bees across four European countries. Journal of Applied Ecology 52: 1165–1175. https://doi.org/10.1111/1365-2664.12479

Scheuchl E, Willner W (2016) Taschenlexikon der Wildbienen Mitteleuropas: Alle Arten im Porträt. Quelle et Meyer Verlag. Wiebelsheim, 917 pp.

Statistisches Bundesamt (2019) Statistisches Bundesamt. https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Feldfruechte-Gruenland/Tabellen/zeitreihe-dauergruenland-nach-nutzung.html

Westrich P, Frommer U, Mandery K, Riemann H, Ruhnke H, Saure C, Voith J (2011) Rote Liste und Gesamtartenliste der Bienen (Hymenoptera, Apidae) Deutschlands. In: Binot-Hafke M, Balzer S, Becker N, Gruttke H, Haupt H, Hofbauer N, Ludwig G, Matzke-Hajek G, Strauch M (Eds) Rote Liste gefährdeter Tiere, Pflanzen und Pilze Deutschlands. Band 3: Wirbellose Tiere (Teil 1). – Münster (Landwirtschaftsverlag). Naturschutz und Biologische Vielfalt 70: 373–416. https://www.wildbienen.info/downloads/rote_liste_bienen_fassung_5.pdf

Supplementary material 1

Table S1. Lists of plant species and voucher specimens for the nine flower strips

Authors: Michaela M. Hofmann, Susanne S. Renner

Data type: species data

Link: https://doi.org/10.3897/jhr.75.47507.suppl1

Supplementary material 2

Table S2. GenBank and Diversity Workbench accession numbers of the bee voucher specimens

Authors: Michaela M. Hofmann, Susanne S. Renner

Data type: accession numbers

Explanation note: GenBank (https://www.ncbi.nlm.nih.gov/genbank) and Diversity Workbench (https://diversityworkbench.net/Portal/Diversity_Workbench) accession numbers of the bee voucher specimens. Diversity Work Bench accession numbers start with three letters referring to the respective flower strip site. The remaining numbers are GenBank accession numbers for the DNA barcode sequences. Physical vouchers have been deposited in the Zoologische Staatssammlung München.

Link: https://doi.org/10.3897/jhr.75.47507.suppl2

Supplementary material 3

Table S3. List of bee species records at different radii around the nine flower strips (1997–2017)

Authors: Michaela M. Hofmann, Susanne S. Renner

Data type: species data

Explanation note: Species recorded within the last twenty years at 500, 1000, and 1500 m distance from the respective flower strip

Link: https://doi.org/10.3897/jhr.75.47507.suppl3