To bee or not to bee

an evaluation of management strategies to promote pollinators in private gardens

CLARA JONSSON 2020

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Abstract

Urbanisation has an increasingly negative effect on wild bees and other pollinating insects because it results in land-use change and habitat-loss, leading to population declines. We rely on ecosystem services that bees provide and must ensure their survival. Private gardens constitute a substantial part of green spaces in cities, making them important foraging habitats for pollinators. In 2018 The Swedish Society for Nature Conservation (SSNC) started a nationwide project to engage the Swedish public in helping bees by using different garden management strategies to create "bee-friendly" plantations or meadows. This study aims to evaluate the success of such "bee-friendly" plantations and meadows in terms of pollinator visitations and the project participants' experiences by analysing citizen survey data from the SSNC project.

A literature study and a statistical analysis of survey data were carried out. The results showed that survey respondents' perceived success of meadows or plantations was related to the amount of insects observed. For plantations, perceived success was also related to the age of the plantation and the environment in which it was planted. Older plantations, and plantations implemented in natural environments were perceived as more successful. However, most respondents implemented their strategies in urban or rural gardens, indicating that these spaces are important for providing pollinator habitats in built areas. The literature study validated that meadow implementation through mowing lawns less often and planting "bee-friendly" flowers is beneficial for wild bees. Further, the literature study validated that the flowers that participants observed as best in terms of blooming, are good choices for helping bees and other pollinators. Finally, some suggestions for improving the SSNC project and the survey questions are given.

Keywords: *Bees, pollinators, garden management, flowers, urban*

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1.Introduction

The number of pollinating insects, such as wild bees, are declining on a global level (Potts et al., 2016, Hallmann et al., 2017, Potts et al., 2010). Insect pollination plays a substantial role regarding food production and the international economy (Klein et al., 2007). Humans are thus dependent on the ecosystem services that pollinators provide; therefore, their survival is of huge importance. By 2050, 68 % of the world's human population is predicted to be urban (UN, 2019). Urbanisation, where green areas, including pollinator habitats are converted into urban fabric is threatening the survival of pollinators (Wenzel et al., 2019).

However, urbanisation does not always result in reduced abundance of wild bees (Hall et al., 2017). For example, green spaces, specifically gardens, can provide beneficial habitats (von Koenigsloew et al., 2019, Hofmann and Renner, 2020, McCune et al., 2020, Lanner et al., 2020, Hall et al., 2017, Dylewski et al., 2019). In many cases, urban areas can contain greater pollinator diversity than agricultural areas (Baldock et al., 2019, Hall et al., 2017). Private gardens make up a considerable amount of the green space in urban environments all over the world (Goddard et al., 2013). How these gardens are designed and managed therefore influences urban biodiversity. Despite extensive research on the fact that green spaces, including gardens, can greatly benefit pollinators in urban environments, knowledge regarding which types of garden management strategies that are best for promoting diversity of pollinating wild insects is still lacking (Rollings and Goulson, 2019).

Engaging citizens in pollinator conservation is of importance to ensure sustainable development of urban areas, including private green spaces (Goddard et al., 2013). The Swedish Society for Nature Conservation (SSNC, in Swedish: *Naturskyddsföreningen*) started a campaign in 2018, called "Operation: Save the bees!" aiming to inform the Swedish population about the decrease in the number of pollinating insects and encouraging citizens to implement measures to benefit pollinators in their private gardens (SSNC, 2020). Data regarding the perceived success of different strategies among participants was collected through online surveys. Survey respondents provided feedback on their perceived success of three different methods of establishing flowering meadow areas in gardens to benefit wild pollinators: converting grass lawns to meadows, sowing meadow plant species seeds, and planting meadow seedlings. Meadow plant species refer to wild plant species. Furthermore, respondents could choose a strategy regarding planting "bee-friendly" plants, which includes native garden plants and exotic species. Different combinations of all methods also occurred.

In the surveys carried out by the SSNC, perceived success of different methods and plant species was recorded, along with which plants flowered best according to respondents, the kind of environment the strategy was implemented in, and respondents' estimations on the amount of pollinators in the flowering patches. Analyses of the survey data can provide insights both into which method(s) and plant species people preferred, and if these benefitted pollinators. Investigating perceived success of methods aids understanding of how well the participants' choices are in line with pollinator flower resource needs, and what causes the perceived success of strategies. Results from this study can be used by the SSNC in guidance for how improve their future recommendations on garden management to benefit pollinators. Feedback to participating citizens can aid in the continuation of the project and maintain the interest of participants (Goddard et al., 2013, MacIvor and Packer, 2015). On a broader level, results from this study could be used to improve urban gardening in both private and public areas and help provide guidelines for pollinator consideration during inevitable future urbanisation.

1.1 Aim and research questions

The aim of this study is to analyse to which degree establishment of garden meadows, (either by sowing seeds of meadow species, mowing grass less often, or planting meadow seedlings) and/or creating plantations with "bee-friendly" flowers, benefit wild pollinating insects, with a special focus on wild bees. The results will be discussed in relation to published literature regarding different garden management strategies and plant species' suitability for pollinating insects.

The study intends to answer the following research questions:

1. Which garden management strategies were most common among respondents (create meadows (three different methods) and planting "bee-friendly" flowers)?
2. Which plant species were the most popular among respondents for meadows and plantations, respectively and can these be validated as beneficial to wild bees and other pollinators by existing literature? Does the number of flower species influence the amount of visiting insects?
3. Does respondent perception of success depend on i) the amount of insects observed, ii) the type of environment in which the strategy was implemented, iii) the age of the meadow or plantation, iv) the chosen implementation strategy?

1.2 Scope

This study is limited to wild insect pollinators in Sweden. This includes solitary bees, bumblebees, butterflies, and hoverflies. In some cases, beetles have been reported in the surveys, but they will be disregarded, as it is unlikely that most participants consider them pollinators. Although this study focuses on wild insect pollinators in Sweden, literature concerning locations outside of Sweden and Europe will be studied when it comes to background information and the success of garden management strategies.

Only survey data provided by the SSNC will be analysed and put into perspective through comparisons with literature. Other survey data has been disregarded, e.g how respondents found out about the “Operation: Save the bees!”, which strategies they would like to implement next year and personal information.

1.3 Ethical reflection

Data provided by the SSNC includes information from individual persons. Private information has been handled with care and has not been shared with others outside this project. Citizens volunteer to participate and SSNC followed GDPR in handling any personal information.

The data provided by the SSNC includes interaction with live insects. However, insects were not harmed during data collection, only observed.

2. Background

2.1 The decline of wild bees

There are over 20,000 bee species worldwide (Potts et al., 2016). Only around 10% of these species are domesticated, including the common *Apis mellifera*, the western honeybee (Danforth et al., 2019). Most bee species are solitary bees or social bumble bees (Danforth et al., 2019). Currently, global bee populations are facing what has been dubbed a "pollinator crisis", with population declines mainly being attributed to rapid agricultural expansion and fragmentation of habitats (Potts et al., 2010, Verboven et al., 2014, Hall et al., 2017, Potter et al., 2019, Pettersson et al., 2004).

Bees are either oligolectic or polylectic (Rocha-Filho et al., 2018). Oligolectic bees are specialists and forage on a limited number of plants, whereas polylectic bees are generalists and have a wider range of pollen-producing plants to choose from (Rocha-Filho et al., 2018). Oligolectic bees are most vulnerable to the ongoing land-use change and habitat loss since plant diversity decreases when areas of agricultural monoculture and urban fabric expand (Lanner et al., 2020). Further, the use of pesticides and herbicides, and urban pollution can have a detrimental effect on fauna diversity (Hall et al., 2017, Martins et al., 2017). Despite this, urban areas can serve as refuges for pollinators as relatively small green spaces can potentially harbour high biodiversity, if they are optimized for it (Baldock, 2020, Baldock et al., 2015, Burr et al., 2018, Ahrne et al., 2009, Bates et al., 2011).

The importance of solitary bees and bumble bees for crop pollination is indisputable. Within the EU at least 150 crop plant species from 60 different families rely on insect visitation for seed production (Pettersson et al., 2004). To support bee species and other pollinating species, an extensive flora is necessary to ensure that the foraging needs of oligolectic, as well as generalist species, are met (Pettersson et al., 2004). Beyond crop pollination, insect pollination ensures the growth of berries and seeds supporting other parts of the ecosystem, such as plant reproduction itself and diets of birds and rodents. Therefore, solitary bees and bumble bees make up important corner stone insect groups that support ecosystems as a whole (Pettersson et al., 2004). In Sweden there are 270 wild bee species. In 2016, 99 of these were threatened (SSNC, 2018).

2.2 The effect of gardens on insect pollinators

Green spaces in urban areas can provide nesting and feeding opportunities for pollinators, as well as function as potential corridors between larger parks and nature areas (Lanner et al., 2020). However, the often homogenous vegetation in urban green spaces is not sufficient to support bees and other pollinators (Hall et al., 2017, Leve et al., 2019, Dylewski et al., 2019). A variety of plant species are necessary to effectively support insects (Campbell et al., 2017, Potts et al., 2016). Parks, cemeteries, golf courses and other public green spaces have substantial potential regarding the provision of habitats for insect pollinators. Yet, conflicts of interest can affect how "bee-friendly" these areas are, e.g. in terms of plant diversity and limiting the use of pesticides (Tasker et al., 2020). On the other hand, private gardens and residential green areas can offer significant plant diversity suitable for bees and other insects, although socio-cultural aspects influence the degree to which citizens are likely to engage in optimizing gardens for pollinators (Burr et al., 2018). Private gardens make up a large part of urban areas; for example, 16% of the total area of Stockholm and 19-27% of UK cities is garden space (Salisbury et al., 2015). Pesticide use may be lower in private gardens than in large public green spaces, which make them better habitats for pollinators (Martins et al., 2017). There is great potential for garden habitats to benefit pollinators. However, many citizens are unaware of the importance of pollinators and lack the knowledge concerning how to manage gardens to best benefit them (Birkin and Goulson, 2015). Efforts to engage garden owners in issues relating to pollinator decline is of importance to optimize and make full use of the urban garden space (Burr et al., 2018, Goddard et al., 2013). Currently, insufficient knowledge regarding bees and pollinators in general means that many gardens are lacking oligolectic bee species because the plant diversity is too low and because a well-kept mowed lawn is aesthetically preferred to allowing plants to grow freely (Salisbury et al., 2015, Lanner et al., 2020, Tonietto et al., 2011, Majewska and Altizer, 2020).

There are different garden management strategies proven to benefit pollinators which can be applied to private gardens. These methods include planting ornamental exotic and/or native flowers in patches (Salisbury et al., 2015, Razanajatovo et al., 2015), sowing meadow seeds (Shwartz et al., 2014), mowing lawns less (Lerman et al., 2018, Wastian et al., 2016). Although these strategies appear to have an overwhelmingly positive effect on pollinators, there are still other points to recognize. In a wider perspective, there may be ecosystem level effects of planting wild or exotic flowers, for example they may cause habitat competition between the introduced plants and remnant wild species (Johnson et al., 2017). The right species need to be planted in terms of benefitting bees, while still considering other aspects of the ecosystem (Harris et al., 2016). Furthermore, to optimize green areas for pollinating insects, structural features such as ponds, a variation of trees and shrubs, and bare earth areas should also be considered (Shwartz et al., 2013). Considering pollinator species with shorter flight and dispersion ranges when choosing which plants to have in gardens is also relevant for urban areas because gardens have positive effects on pollinators on depending on spatial scales (Leve et al., 2019). Further, local spatial garden scale could be considered because the placement of plantations and combinations of flowers within a short distance can influence bee diversity (Plascencia and Philpott, 2017).

3. Method

The following section will address two different methods used for this study, a literature review regarding which management methods and plant types are best for bees and other pollinators in garden environments; and an analysis of the survey data collected by the SSNC regarding the establishment of meadows or plantations by Swedish citizens.

3.1 Literature study

The literature study was based on two different keyword searches to establish a comparative factual basis for the SSNC data analysis. The first search string was selected to obtain literature on insect pollinator flower preferences, limited to European studies to be comparative to Swedish species (Table 1.) The second search string focused on different garden management strategies for pollinating insects, which was not limited to European studies since general management strategies can be applied anywhere (Table 2). Both searches were performed in Web of Science (all databases) in April 2020.

Table 1. Keywords used to research which plant species are suitable for different pollinating insect groups.

	Block 1	Block 2	Block 3	Block 4	Block 5
Concept	Pollinator	Preference	Gardens	Flower	Europe
Alternatives	“wild bee*” OR pollinator* OR “pollinating insect*” OR “native bee	Preference* OR Prefer* OR choice* OR choose* OR visit* OR visitation* OR best*	“urban garden*” OR garden OR “private garden*” OR “residential garden*” OR “residential green space*” OR backyard* OR “green space*”	Flower* OR floral* OR nectar* OR pollen* OR plant* OR bloom*	Europe* OR Sweden* or Scandinavia* OR UK OR United Kingdom* OR Norway OR Denmark OR Finland OR "North Europe*"

Table 2. Keywords used to research which plant species are suitable for different pollinating insect groups.

	Block 1	Block 2	Block 3	Block 4
Concept	Pollinator	Strategies	Gardens	Method examples
Alternatives	"wild bee*" OR pollinator* OR "pollinating insect*" OR "native bee	adaptation* OR solution* OR measure* OR strategy* OR method* OR management*	"urban garden*" OR garden OR "private garden*" OR "residential garden*" OR "residential green space*" OR backyard* OR "green space*"	meadow* OR lawn* OR sow* OR plantation*

The first search string generated a total of 109 articles, and the second search string generated 41 articles. All abstracts were read. Articles with relevant abstracts were subsequently exported to EndNote. In EndNote, search words such as "management/ strategy", "urban" and "bee" were used to determine if the articles were still relevant for the aim of this study. Articles with no access to full text, articles focused on irrelevant main topics, or focused on only honeybees were excluded from the final analysis. Some articles had duplicates due to overlap within the two search strings and were subsequently excluded. The article selection process can be seen in Figure 1. A total of 45 articles were then studied in detail and subject matter categorized to form a framework in Microsoft Excel.

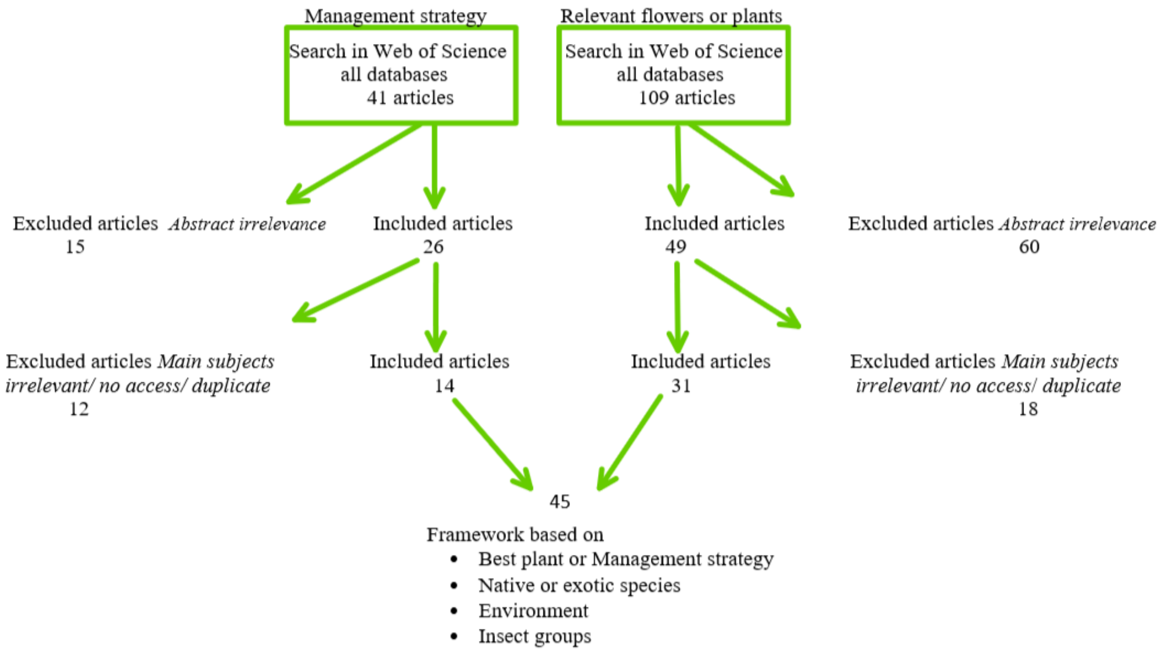

Figure 1. Article selection process to obtain a knowledge basis of plants and management to benefit insect pollinators, focusing on wild bees.

The framework was filled out based on whether the focus of the article regarded plants appropriate for bees and other pollinating insects, or garden management methods to optimize gardens for bees and other pollinating insects, or both. Further, information surrounding the insect species studied, environments where studies were carried out, and the origin of plant species (native or exotic) was included in the framework. Finally, the suitability of plants for pollinators was evaluated by looking at how visited different plant genera were. A list of plant genera was included based on article results for beneficial flowers for bees and other pollinating insects. Results from the literature study were summarized in graphs using Microsoft Excel. Subcategories used to graph the literature results were derived from frequency counts of similar words within the articles. Categories were simplified, hence insects and plants mentioned were only registered to genera for consistency, rather than species since some literature only mentioned genus.

Apart from searching for relevant scientific articles using Web of Science, further information regarding the suitability of different plant species for different insect groups was found in published reports from the Swedish Wild Bee project (*Svenska Vildbiprojektet*)(Pettersson et al., 2004). Although the project mainly concerns the impact of agricultural land-use on bees, extensive lists with suitable flower species and bee species that benefit from them are included in project documents. Successful plant species in terms of pollen and nectar that were reported in the Swedish Wild Bee Project were cross-referenced with the best plants according to respondents in the SSNC survey.

3.2 Survey data

Survey data supplied by the SSNC, was provided in two Microsoft Excel documents; one with 747 participant responses about their establishment of meadows, and one with 785 participant responses about their implementation of bee-friendly plantations. All data analyses were carried out in IBM SPSS Statistics 25, except frequency count for successful plant species which was carried out in Microsoft Excel. A summary of the final selection of data used for statistical analysis to answer the main aim and research questions of this study can be found in Table 3 and 4.

Table 3. The statistical analyses that were carried out and the survey data used for each test from each Excel file. Meadow and Plantation data were analysed separately.

Analysis	Meadow file	Plantation file
Frequency	Successful plant species	
	Number of respondents per strategy and method combinations (Meadows)	
Spearman Rank Correlation	Chosen method/ method combinations × environment	Number of different plantspecies × perceived success. Number of different plantspecies × age
Generalized Linear model	Perceived success of strategy (dependent variable)	
	Amount of insects	
	Environment	
	Age of meadow/ plantation	
	Method used for meadow establishment	

3.2.1 Recoding and computing of variables

Prior to statistical analysis, word string variables were recoded into ordinal or nominal data (Table 4). Values within *Perceived success* were assigned categorical names. Responses of *I don't know* in the variable *Amount of insects* were filtered out as missing data to not skew results. Since the number of responses stating *Allotment*, *farmland* , *forest* and *natural,* as environment type in which the strategy was implemented made up only a small proportion of responses, and were not the focus of this study they were combined into one category named *Natural*. Creation dates for the meadows and plantations were not normally distributed and most of the implemented strategies were established in 2019, hence this dataset was categorized into implementation *During 2019* or *Prior to 2019*. Finally, respondents could choose between different sub-methods for implementing meadows; *Sowing meadow specie seeds on bare soil, Letting grass and flowers grow by mowing less often, Planting meadow seedlings* or *Other.* Respondents could choose more than one method. After an initial frequency count it was apparent that *Mowing less often* was the largest category. Combinations of methods without *Mowing less often* were substantially fewer. Three method categories for meadow establishment were created, focusing on *Mowing less often* (Table 4).

Table 4. Variables that were renamed, coded, or computed using "compute variable" in SPSS.

Variable	Previous categorization	Categorization used in study	Nominal or ordinal
Perceived success of meadow/platation	likert 1-5	1=Very bad, 2=Bad, 3=Average,4=Good, 5=Very good	Ordinal
Amount of insects	None, Yes few, Yes many, Don't know	1=None, 2=Yes few, 3=Yes many	Ordinal
Type of environment	City, urban garden, rural garden, allotment, farmland, forest, natural	1=City, 2=urban garden, 3=rural garden, 4=natural	Nominal
Date created	Dates between 1900 - 2019	1=During 2019, 0=prior to 2019	Nominal
Method (only meadow)	Sowing seeds, mowing less, planting seedlings, other	1=Only mowing less, 2= combination mowing less and others, 3= all other combinations	Nominal

3.2.2 Frequency analysis – Plant species and common meadow methods

Respondents could fill out which plants they thought bloomed the best in their meadows or plantations in an open-ended response. They had the option of giving the first, second and third best flowers and other successful flowers. Manual counting of the first choice for best flowers for meadows and plantations was carried out in Microsoft Excel. The top 10 plant genera were displayed in bar charts. These species were later compared to findings from the literature study and Swedish species brought up as optimal in the Swedish Wild Bee Project. Due to time constraints, the second and third best and other flower responses were not analysed.

A descriptive frequency analysis was carried out on the methods for meadow establishment using the descriptive statistics function in SPSS. All possible method combination frequencies can be found in Appendix A. A frequency analysis was carried out on the recategorized method combinations to establish which types of methods and combinations were most popular. Three categories were established: *Only mowing less*, *Combination of mowing less and all others* and *All other method combinations without mowing less*. 9 respondents did not choose any method and were excluded from further analyses leaving a total number of 738 respondents that established garden meadows. The survey for flower plantation only used one method type so all 785 responses were included in further analysis using a Generalized Linear Model.

3.2.3 Correlation – Amount of insects and Age and number of flower species in the plantations

To test if there was a significant relationship between the *Amount of insects* for plantations and the *Number of flower species* in the plantation (see Table 3), a Spearman's rank order correlation test was carried out. This test was chosen since categorical data was used, thus requiring a non-parametric. The Spearman's test shows the dependency between the rankings of two variables. The number of flower species was not given for meadows and could therefore not be analysed. Similarly, a Spearman's test was used to see if there was a significant relationship between the *Age of the plantation* and the *Number of flower species.*

3.2.3 Generalized Linear Model – Perceived success

The dependent variable (the *Perceived success* of strategy; meadow or plantation) and the independent variables (*Amount of insects*, *Environment type*, *Age of strategy* and *Method*—meadow only) were all nominal or ordinal (Table 3). To investigate which independent variables significantly affected respondents' perceived success of strategies a Generalized Linear Model (GZLM) for ordinal logistic regression was used. This model yields a single set of regression coefficients to estimate the relationship between the dependent and independent variables (Harrell and SpringerLink, 2015). This method was chosen over a regular ordinal regression method after the data was cross-tabulated, revealing that some combinations of the independent variables resulted in 0 values, which violated the assumptions required for proportional outcomes for ordinal regression (Harrell and SpringerLink, 2015). GZLMs produce a generalization of regression and allows for non-normal distribution and independent variables to be nominal or ordinal; no ordered categories are necessary. For every unit increase in an independent variable, the GZLM ordinal logistic predicts the increase in logistic odds of landing at a higher level of the dependent variable. The model output consists of an Omnibus test with a likelihood ratio Chi-Square test, where H_0= the model with no predictors. The Model Effects (predictors) are also tested with a likelihood Chi-Square test. Finally, the model displays the parameter estimates with odds ratios for the independent variable reflecting the multiplicative change in the odds of being in a higher dependent variable category, while the other independent variables are constant.

Two models were made: one to investigate the factors affecting the perceived success of meadows and one for plantations. These datasets could not be combined because some respondents had answered both surveys, in which case there would have been a duplication issue. Independent variables were: *Amount of insects*, *Type of environment*, *Age of strategy* and *Method* (meadows only).

4.Results

4.1 Literature study

A total of 45 articles were read in detailed and categorized to produce frequency data regarding how many articles discussed various points of interest relating to this study.

4.1.1 Focus areas: best plants or management strategies

Out of the 45 articles studied, 28 focused on plant genera or species that were shown to benefit or not benefit pollinators through investigating one or more of the following: the number of pollinator visitations or abundance of pollinators, the phenology of the plants, the quality or amount of pollen/nectar, the effect of native/exotic species on pollinators, or choice of plants via "bee-friendly" labelling plant retailers. 23 articles focused on different management methods that would benefit bees and/or other pollinating insects via any one or more of these concluded methods: planting a variation of plant species, mowing the grass less often, putting different structures, such as ponds in the gardens, creating microhabitats such as patches of bare earth, or increasing the size of pollinator habitats (e.g. meadows). 12 articles focused on plants and garden management methods (Figure 2, 3).

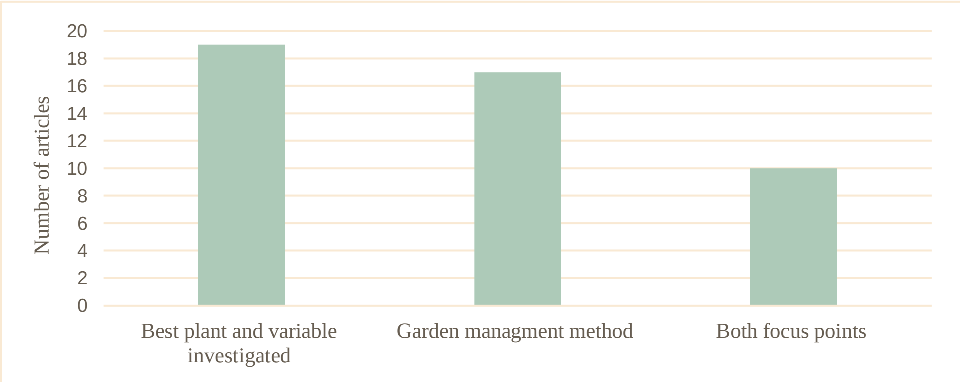

Figure 2. Type of focus area; best plant and the variable (abundance/pheology/nectar,pollen/ native, exotic/labelling) that was investigated to find this, garden managment methods or both focus areas and the number of articals for each category. Total articles = 45.

11 articles (24.4%) investigated benefits of plants via *visitation rate or abundance* of pollinating insects. *Plant phenology* and the management strategy *variation* (increasing the number of plant species) were both mentioned 10 times each (22.2% each). *Mowing less* was mentioned 8 times (17.7%). The least mentioned categories were the *size of pollinator habitats* in gardens (3 articles, 6.6%) using "bee-friendly" *labeling system* (2 articles, 4.4%) (Figure 3).

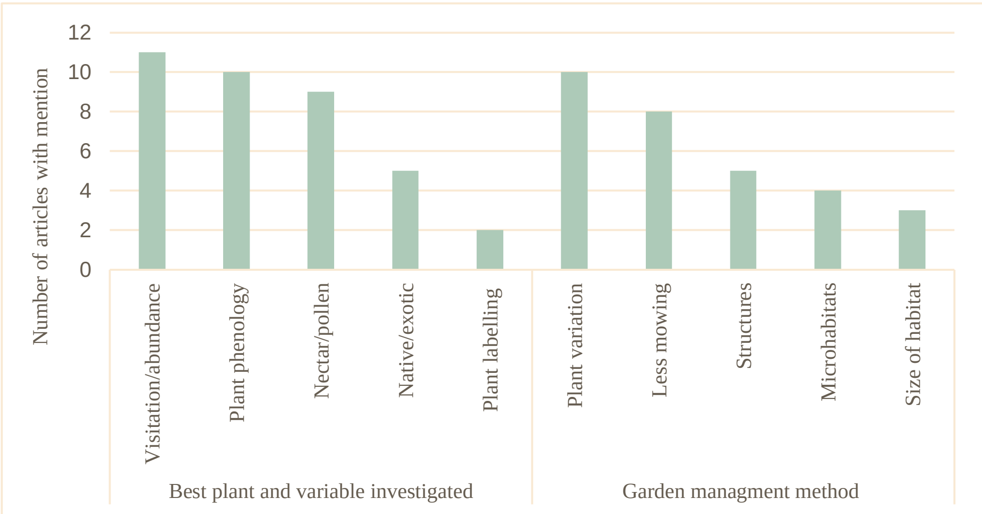

Figure 3. Different focus points, best plant and the variable investigated, or garden managment methods, and sub-categories for the 45 articles. Total = >45 because articles could mention more than one option.

4.1.2 Insect groups

Bumble bees was the most frequently studied insect group (28 articles, 62.2%). Solitary bees made up the second most studied insect group (15 articles, 33.3%). Articles mainly focusing on honeybees, but which mentioned other insects too, accounted for 13 articles (28.8%) (Figure 4).

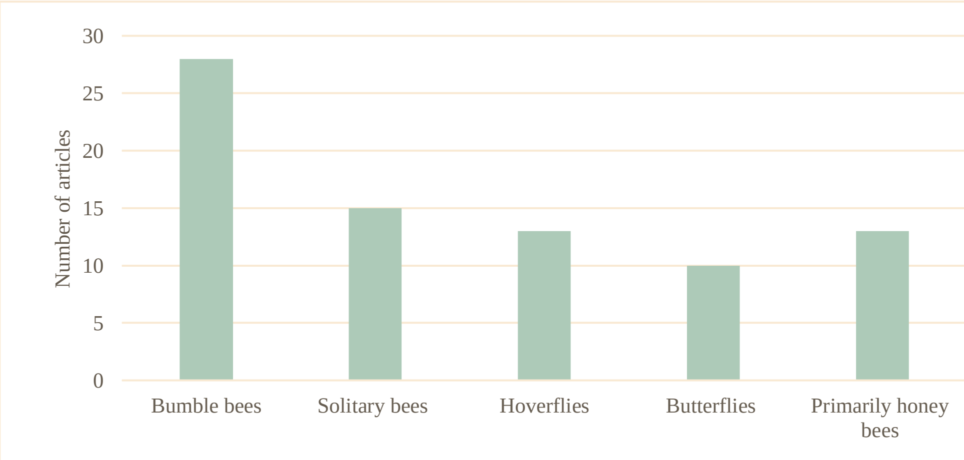

Figure 4. Mentioned insect groups relevant for this study and the number of articles they were mentioned in. Total >45 because each article could mention more than one option.

4.1.3 Environment types

The 45 articles addressed several different environment types in which plants had been tested or management strategies applied. Some articles mentioned more than one environmental type, particularly comparisons between more natural areas and urban green areas. Some experiments were carried out in parks and experimental gardens to simulate private garden habitats. Indeed, the most mentioned environmental category was private gardens and allotments (15 articles, 33.3%). One article was related to farmland close to urban areas (Figure 5).

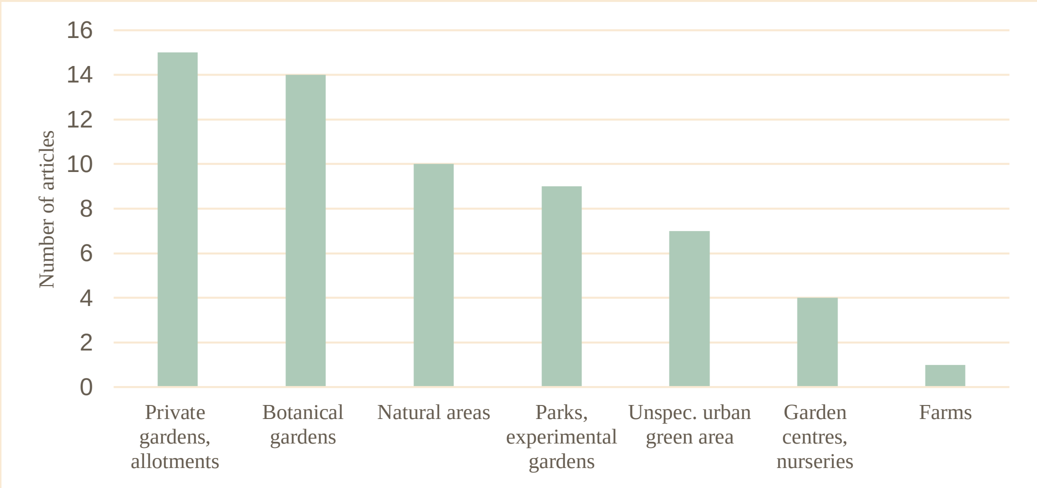

Figure 5. Different environment types in which optimal plants for pollinators or managment strategies were tested and the number of articles that reffered to each environment. Total = >45 since articles could refer to more than one type.

4.1.4 Plant genera

Several articles within the literature study discussed weather native or exotic/ alien plant species are better for bees and other pollinators in terms of pollen and nectar amount and quality. However, only one article concluded that exotic species are better for pollinators, whereas 6 articles concluded that native species are a better option to plant for pollinators. A majority (13 articles), though, reasoned that there was no apparent difference between native and exotic species in terms of benefits for pollinators, although it varies with circumstance.

The literature study revealed a total of 37 plant genera beneficial to bees and or other pollinating insects and appropriate for keeping in gardens (Table 5). All genera can be found in Sweden. 28 genera are wild species, and 9 genera are garden plants that can be purchased (Krok and Almquist, 2013). Cross-comparison with species mentioned in the Swedish Wild Bee Project revealed that 12 genera from the list in Table 5 were mentioned in the documents from the Wild Bee Project.

Table 5.Genera of plants beneficial for pollinating insects found in literature. Includes genus in Latin, vernacular names in Eglish, if genus is native/ exotic to Sweden, and authors of relevant articles.

Genus Latin	Genus English	Native Exotic	Authors
Achillea	Yarrows	Native	(Garbuzov and Ratnieks, 2014b)
Arabis	Rockcress	Native	(Strzalkowska-Abramek et al., 2016b)
Brassica	Brassicas	Native	(Cresswell, 1999), (Schlinkert et al., 2016)
Calamintha	Calamints	Exotic	(Rollings and Goulson, 2019)
Centaurea	Knapweeds	Native	(Denisow et al., 2014)
Conyza	Horseweed	Native	(Lerman and Milam, 2016)
Cytisus	Brooms	Native	(Buchholz and Kowarik, 2019)
Dahlia	Dahlias	Exotic	(Garbuzov et al., 2015)
Digitalis	Foxgloves	Native	(Hanley et al., 2014)
Echium	Echiums	Native	(Garbuzov and Ratnieks, 2014b)
Erigeron	Fleabane	Native	(Lerman and Milam, 2016)
Geranium	Crane's bills	Native	(Masierowska et al., 2018)
Iberis	Candytufts	Exotic	(Strzalkowska-Abramek et al., 2016b)
Lantana	Lantanas	Exotic	(Harris et al., 2016)
Lathyrus	Pea vines	Native	(Micholap et al., 2018)
Lavandula	Lavenders	Native	(Micholap et al., 2018)
Linaria	Toadflax	Native	(Corbet et al., 2001)
Lonicera	Honeysuckles	Native	(Jachula et al., 2019)
Lotus	Bird’s foot trefoils	Native	(Corbet et al., 2001)
Mecanopsis	Mecanopsis	Exotic	(Hanley et al., 2014)
Monarda	Bee balm	Exotic	(Micholap et al., 2018)
Nepeta	Nepetas	Native	(Harris et al., 2016)
Origanum	Oreganos	Native	(Micholap et al., 2018), (Garbuzov and Ratnieks, 2014a), (Garbuzov and Ratnieks, 2014b), (Ahrne et al., 2009)

Oxalis	Wood sorrels	Native	(Lerman and Milam, 2016)
Polygonum	Knotweed	Native	(Lerman and Milam, 2016)
Potentilla	Cinquefoils	Native	(Lerman and Milam, 2016)
Pulsatilla	Pasque flowers	Native	(Strzalkowska-Abramek et al., 2016a)
Rhododendron	Rhododendrons	Native	(Micholap et al., 2018)
Robinia	Locusts	Exotic	(Buchholz and Kowarik, 2019)
Salvia	Sage	Native	(Micholap et al., 2018), (Corbet et al., 2001)
Sedum	Stonecrops	Native	(Garbuzov and Ratnieks, 2014a)
Solidago	Golden rods	Native	(Garbuzov and Ratnieks, 2014a), (Ahrne et al.,2009)
Stachys	Hedge nettle	Native	(Garbuzov and Ratnieks, 2014b), (Corbet et al., 2001)
Symphyotrichum	New york Aster	Exotic	(Garbuzov and Ratnieks, 2015)
Trifolium	Clovers	Native	(Lerman and Milam, 2016)
Vicia	Vetches	Native	(Birkin and Goulson, 2015)
Viola	Violas/ Violets	Native	(Lerman and Milam, 2016)

4.2 Data analysis

4.2.1 Methods chosen by respondents

Respondents have shared information regarding which methods they have used to establish meadows (sowing meadow seeds, mowing or cutting grass less often, planting meadow seedlings, or other). A frequency analysis of each of these methods and combinations of all methods can be seen in Table 6. The most frequently chosen method without combination was to mow grass areas less often (40.2 % of all 738 respondents). The least popular method to use without combination was to plant seedlings (0.3% of all respondents, see Appendix A). Overall, the number of respondents was approximately equal for both meadows and plantations.

Table 6. Main strategies for benefitting bees and the sub-methods for implementing meadows, and the frequency of respondentes that have chosen each combinatino or strategy. Percentages are included for the meadow sub-methods, as well as the percentages for all sub-methods and main strategies.

Strategy	Sub-method	Frequency	Percentage	Percentage of Meadow and Plantation combined
Meadow	Less mowing only	297	40.2	19.5
	Less mowing in combination	266	36.0	17.5
	All other method combinations	175	23.7	11.5
	Total	738	100.0	48.5
Plantation	Only plantation	785	100.0	51.5

A substantial portion of respondents who had responded to one of the surveys had responded to the other as well. However, more people who had established meadows had also implemented plantations (67.3%), rather than vice versa (43.7%).

4.2.2 Popular plant species or plant groups

The plant species that respondents observed as the best plants in terms of blooming varied between the plantation strategy and meadow establishment strategy (Figure 6). No responses and vague responses were removed, giving a total number of 650 responses included for the plantation strategy and 518 for the meadow strategy. Reported successful flower groups for meadows consisted of native wild plant species with less variation in species (94 species) than for the plantation method (136 species). Lavender (Lavandula) strongly dominated the choices in plantations, making up 20 % of responses.

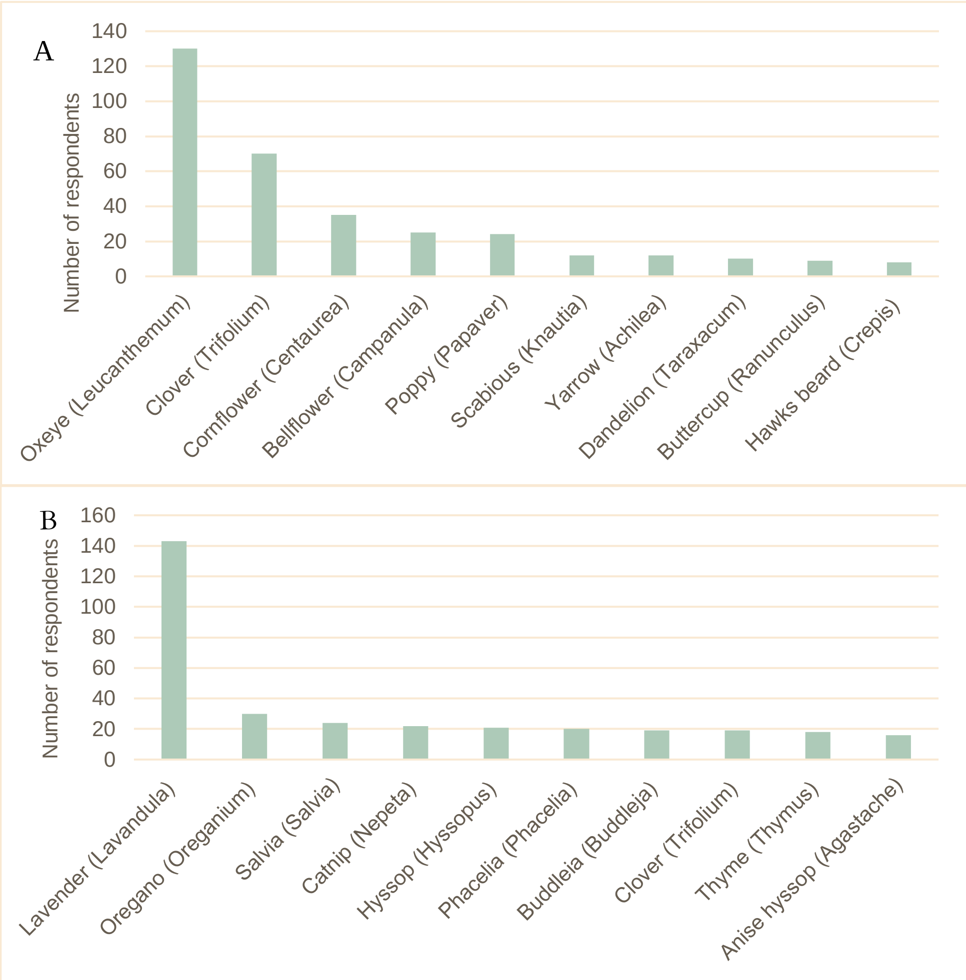

Figure 6. The top ten most popular plant species amon respondents in terms of blooming for A) meadows and B) plantations.

Number of plant species and the amount of insects

According to the results from the Spearman's Rank Correlation there was a strong correlation between the *Amount of insects* in plantations and the *Number of flower species* in the plantations (r_s (770) = 0.136. p<0.001) .

4.2.3 Generalized Linear Model

Perceived success of meadow implementation

The GZLM for Meadow implementation showed that the investigated independent variable factors (*Amount of insects, Type of environment, Age* and *Chosen method*) did have a significant impact on the *Perceived success* (Table 7A). However, the Test of model effects shows that the only independent variable that affected the *perceived success* was the *Amount of insects.* The parameter estimates (Table 8) show that meadows where respondents observed no insects, are 0.002 times as likely to say that they have perceived a high success rate compared to when respondents claim observations of many insects (insects=3). Hence the chances of respondents rating the success of the meadow higher is very unlikely if no insects are observed. Meadows where respondents have observed few insects were 0.117 (insects=2) times as likely to say they have perceived a high success rate compared to respondents who have observed many insects. The *Type of environment, Age of meadow* and *the chosen method* for meadow implementation did not significantly affect the probability of respondents perceiving their meadow as more successful.

Table 7. GZLM results for meadow implementation. A) Omnibus test showing that factors significantly affect model output. B) Tests of model effects showing which factors had a significant effect on the likelihood of perceived success value. (Logit Link used)

A — Omnibus Test

Likelihood Ratio Chi-Square	df	Sig.
160.950	8	0.000

B — Tests of model effects

	Likelihood Ratio Chi-Square	df	Sig.
Type of Environment	2.361	3	0.501
Amount of insects	154.504	2	0.000
Age	3.006	1	0.083
Chosen method	2.575	2	0.276

Table 8. The Parameter Estimates (B), with Exp(B) showing the odds of perceived success being in a higher category for every unit incerease on the factor variables. Significant values are coloured. (Logit link used).

Parameter		B	Std. Error			Exp(B)
				df	Sig.	
Threshold	[Perceived success=1]	-5.694	0.4370	1	0.000	0.003
	[Perceived success=2]	-3.720	0.3065	1	0.000	0.024
	[Perceived success=3]	-1.458	0.2609	1	0.000	0.233
	[Perceived success=4]	0.292	0.2545	1	0.251	1.339
[Type of Environment=1]		-0.079	0.7286	1	0.913	0.924
[Type of Environment=2]		-0.362	0.2520	1	0.151	0.696
[Type of Environment=3]		-0.201	0.2390	1	0.400	0.818
[Type of Environment=4]		0				1
[Amount of insects=1]		-6.213	0.9159	1	0.000	0.002
[Amount of insects=2]		-2.142	0.2131	1	0.000	0.117
[Amount of insects=3]		0				1
[Age=0]		-0.257	0.1483	1	0.083	0.773
[Age=1]		0				1
[Chosen method=1]		-0.140	0.1919	1	0.465	0.869
[Chosen method=2]		-0.305	0.1956	1	0.118	0.737
[Chosen method=3]		0				1

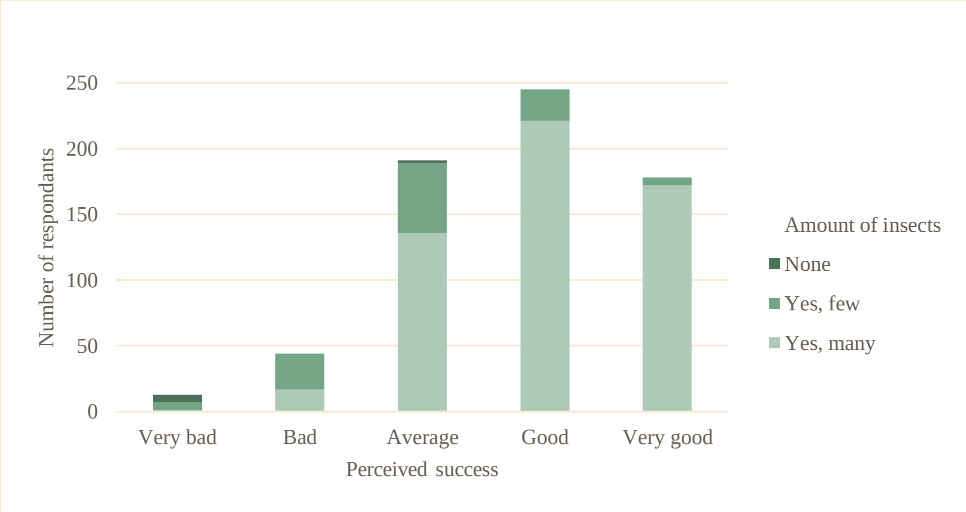

Figure 7. Stacked bar chart showing the number of respondents reported none, few or many insects visiting their meadow for each category of perceived success.

Most respondents who perceived their meadows to be successful also observed many insects on their meadows (Figure 7). Meadows that were perceived to be less successful were more often observed to have few or no insects. Figure 7 visualizes the results from the GZLM.

Perceived success of flower plantations

The GZLM for implemented plantations shows that the investigated factors (*Amount of insects, Type of environment* and *Age of the plantation)* did have a significant effect on the *Perceived success* of the plantation (Table 9A). The Tests of model effects shows that all three factors significantly impacted the probability of respondents perceiving plantations as more successful (Table 9, 10). Respondents who observed no insects, were 0.004 times as likely to say they perceived a high success rate, compared to respondents who observed many insects. Regarding the type of environment, respondents that had a rural garden were 0.573 times as likely to perceive a higher success rate than respondent who had their plantation in a natural environment. Respondents whose plantation was established before 2019 are 1.615 times (61.5%) (p=0.001) more likely to perceive their plantation as more successful, compared to respondents who had a plantation from 2019.

Table 9. GZLM results for meadow implementation. A) Omnibus test showing that factors significantly affect model output. B) Tests of model effects showing which factors had a significant effect on the likelihood of perceived success value. (Logit Link used)

A

Omnibus Testa		
Likelihood Ratio Chi-Square	**df**	**Sig.**
54.046	6	0.000

B

Tests of model effects			
	Likelihood Ratio Chi-Square	**df**	**Sig.**
Amount of insects	31.542	2	0.000
Age	11.557	1	0.001
Type of Environment	7.838	3	0.049

Table 10. The Parameter Estimates (B), with Exp(B) showing the odds of perceived success being in a higher category for every unit incerease on the factor variables. Significant values are coloured. (Logit Link used).

Parameter		B	Std. Error	df	Sig.	Exp(B)
Threshold	[Perceived success=1]	-5.961	0.6327	1	0.000	0.003
	[Perceived success=2]	-4.069	0.3447	1	0.000	0.017
	[Perceived success=3]	-1.792	0.2668	1	0.000	0.167
	[Perceived success=4]	0.162	0.2581	1	0.531	1.176
[Amount of insects=1]		-5.450	1.5273	1	0.000	0.004
[Amount of insects=2]		-1.288	0.2673	1	0.000	0.276
[Amount of insects=3]		0				1
[Age =0]		0.479	0.1414	1	0.001	1.615
[Age =1]		0				1
[Type of Environment=1]		0.031	0.3696	1	0.933	1.031
[Type of Environment=2]		-0.474	0.2657	1	0.075	0.623
[Type of Environment=3]		-0.557	0.2606	1	0.032	0.573
[Type of Environment=4]		0				

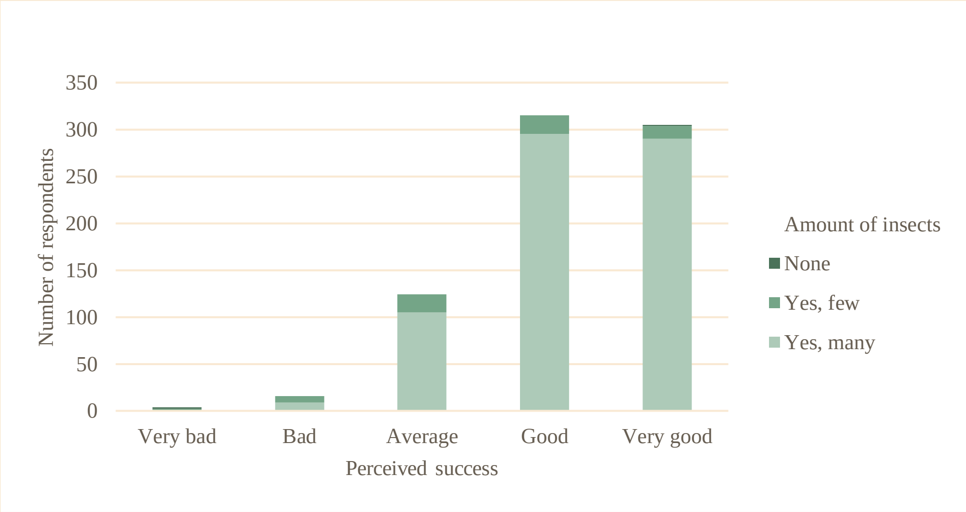

Figure 8. Stacked bar chart showing the number of respondents that have observed none, few or many insects in their plantations for each category of perceived success.

Most respondents for the plantation survey observed many insects, despite how successful they perceived their plantation to be. However, as the rating of plantation success goes down, there is a slightly higher proportion of respondents who say that there are fewer insects (Table 10, Figure 8). Respondents that perceived their plantation to be very unsuccessful observed few or no insects, although this was a very small portion of the entire respondent population.

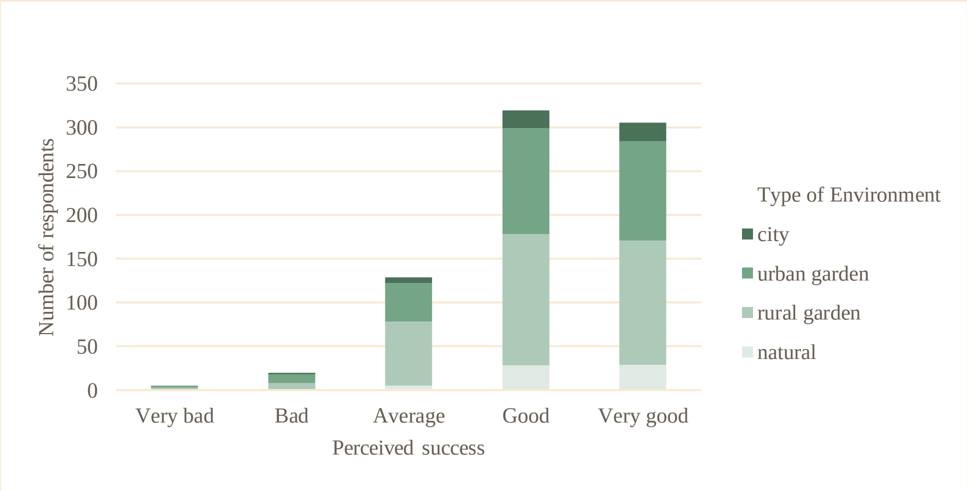

Figure 9. Stacked bar chart showing the number of respondents that have implemented their plantation in a city environment, urban garden, rural garden or natural environment for the perceived success.

There was a significant odds variation between rural gardens and natural areas in relation to the perceived success of plantations (Table 10). Natural areas are only seen as environmental types in the data when the perceived success is “Good” or “Very good”, hence there is a difference between the odds of having higher perceived success if natural environments are involved in the data; which results in higher perception scores according to the GZLM (Table 10, Figure 9). The number of respondents that had plantations in cities (Type of environment =1) generally stated a higher perceived success of plantations, although not significantly affecting the outcome of perceived success (p=0.933) (Figure 9).

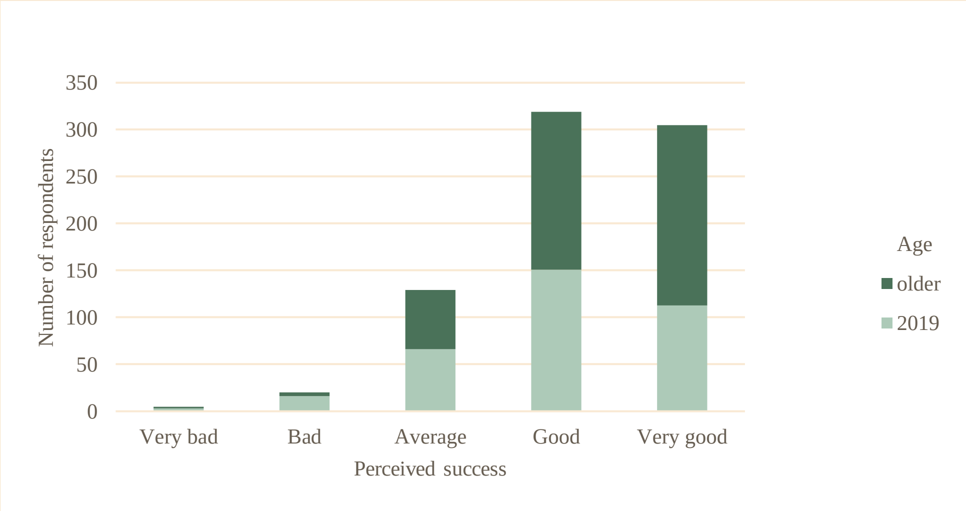

Figure 10. Stacked bar chart showing the number of respondents that have implemented their plantation in 2019 or before for each category of perceived success.

Having an older plantation significantly affected the odds of respondents having a higher perceived success (Table 9, 10). Respondents perceiving their plantation to be less successful, more often have plantations established in 2019 (Figure 10).

A Spearman’s Rank Correlation showed that there was a significant correlation between the *Number of plants* in the plantation and the *Age of the plantation* (r_s(785)= -0.131, p<0.001).

5.Discussion

The aim of this study was to analyse to which degree establishment of garden meadows and creating "bee-friendly" plantations benefit bees and other wild pollinating insects. In addition, the study has focused on what affected the survey respondents' perception of how successful their implemented strategy was, and how effective the methods were in supplying bees with flower resources. The following research questions have been answered.

1. Which management strategies (with sub-methods) were most common among survey respondents?
2. Which were the most popular flowers for meadows or plantations, and how beneficial are these for wild bees?
3. Which factors affected how respondents perceived the success of their chosen management strategy?

5.1 Garden management strategies

5.1.1 Most popular strategies and sub-methods for respondents

The number of respondents who had implemented meadows or plantations was approximately the same (Table 6). People who had implemented meadows often chose to also implement the "bee-friendly" plantations, while the opposite occurred less often. This could be due to meadows being more challenging to implement and maintain, while also requiring more space. It is worth noting that the most popular method used to implement meadows was to mow lawns less. Since the SSNC project "Operation: Save the Bees!" Started only in 2018, some participants may be inexperienced when it comes to meadow implementation and management, particularly with regards to the three methods available (*Sowing meadow species seeds on bare soil, Letting grass and flowers grow by mowing less often, Planting meadow seedlings* or *Other*). 450 of the 747 (original total) had meadows were implemented during 2019, and most participants may have chosen to use the *mowing less* method because it is easier than planting seeds or seedlings.

5.1.2 Legitimacy of survey management strategies in relation to literature

The most frequently mentioned management strategy within the literature study was to simply plant a variety of different plant species (Sikora et al., 2020, Rollings and Goulson, 2019, Micholap et al., 2018, Salisbury et al., 2015, Garbuzov and Ratnieks, 2014b) (Figure 3). 10 articles clearly discussed the importance of plant variation (diversity) in terms of flowering phenology and maintaining this diversity through different seasons (Sikora et al., 2020, Masierowska et al., 2018, Hanley et al., 2014, Garbuzov and Ratnieks, 2014b). Planting several plant species caters to the needs of more pollinator species, thus increasing bee biodiversity (Masierowska et al., 2018).

The second most frequently discussed management strategy was to mow garden lawns less, or in varying degrees to obtain more patches of wild flower abundance (Lerman et al., 2018, Wastian et al., 2016, Tonietto et al., 2011, Banaszak-Cibicka et al., 2018) (Figure 3). To mow lawns less frequently is a simple method that requires no particular prior knowledge, and the strategy is growing in popularity as awareness increases regarding pollinators (Lerman et al., 2018).

These two most discussed literature strategies correspond well to the SSNC survey data where the two studied strategies were meadow implementation (and the most popular method was to mow lawns less) and planting "bee-friendly" flowers. The literature thus validates the use of these methods. The simplicity of planting a variety of appropriate plants for pollinators in gardens can be very useful in the wider scope of helping declining populations (Garbuzov and Ratnieks, 2014b). Mowing lawns less is similarly simple to do, and can also quite easily be implemented in larger public spaces, which could be relevant for the SSNC to promote in the future (Wastian et al., 2016). Strategies that are easier to implement are more likely to be undertaken by citizens (Lerman et al., 2018), which is indeed a key to success.

Other garden management methods discussed in the literature included implementing different structures in gardens such as ponds, large trees, (Ahrne et al., 2009, Lanner et al., 2020) and implementing microhabitats such as leaving patches of bare soil (Lanner et al., 2020, Tonietto et al., 2011). Although these methods were mentioned less often than mowing lawns less, it does not necessarily mean that they are less important, but rather that there might be knowledge gaps regarding the importance of garden structures and microhabitats. It could be interesting to implement such strategies in gardens within the SSNC project in the future. In fact, some respondents in the meadow and plantation surveys had completed other contributions to support pollinators, such as leaving bare sand patches and putting up bee hotels.

5.2 "Bee-friendly" plants

5.2.1 Variation in plant diversity for meadows and plantations

The most popular flowers among respondents differed between meadows and plantations (Figure 7). The meadows had a greater number of different plant genera, whereas the plantations had less variation, and 43% of plantation respondents considered lavender as the best flower. Plantations mainly refer to smaller areas, or potted plants, whereas meadows are larger, hence the higher diversity of meadows is not surprising. Respondents for the plantation survey could choose which plants to have, meaning that the lower plant diversity of the plantations could be attributed to many participants having similar ideas about which plants are both attractive to humans and/or beneficial to pollinators (Lavender). Plants in the meadows more often grew without the factor of the participant's active choice, which seems to have led to higher plant diversity. Only planting meadow seedlings did include choice. One issue with the flowers for both strategies is that the top ten flowers could be in the top ten just because they are very common flowers, such as Oxeye. If certain plants are dominating plantations or meadows (Oxeye, Lavender), it might cause participants to more frequently answer that these are also the "best flowers".

The survey data for meadows did not include umber of flower species in the meadow. However, this was included for plantations, and there was a significant correlation between the *Number of flower species* and the *Amount of insects*. This highlights that higher plant diversity results in a higher abundance of insects. It was not possible to evaluate if the diversity of insects was likewise positively affected by the diversity of flowers, but it is likely to be the case (Sikora et al., 2020, Banaszak-Cibicka et al., 2018)

5.2.2 "Bee-friendly" plants in surveys in relation to literature

All the top ten flower genera for both meadows and plantations, except *Buddleia*, include species native to Sweden (Krok and Almquist, 2013). Furthermore, all top ten genera for meadows, and six of the top ten genera for plantations could be found listed in the Swedish Wild Bee project as flowers suitable for different bee species (Pettersson et al., 2004). The four genera that could not be found in the documents for the Wild Bee Project were *Origanium, Salvia* and *Calamintha* and *Buddleia* though they were discussed in other papers from the literature study (Rollings and Goulson, 2019, Micholap et al., 2018, Garbuzov and Ratnieks, 2014a, Garbuzov and Ratnieks, 2014b, Ahrne et al., 2009, Corbet et al., 2001). 22 out of 30 plant genera found in the literature study include species that are native to Sweden (Table

5) (Krok and Almquist, 2013). While the remaining eight genera can be found in garden centres. The fact that most of the top ten genera that respondents perceived as the best flowers are either mentioned in the Swedish Wild Bee Project in relation to wild bee species, or in remaining literature from the literature study, shows that the respondents have chosen plants that are indeed appropriate for supporting bees and other pollinators. The fact that most plants chosen by respondents are native to Sweden is beneficial oligolectic species that are native to Sweden and are specialized for native species, which leads to a wider variety of pollinators being benefited, rather than greatly benefitting a few polylectic species.

Most studies in the researched literature concluded that there is no important difference between native and exotic plant species regarding how beneficial they are for pollinators. However, there were six articles that concluded that native species are more beneficial and only one article that claimed exotic species to be preferable (Corbet et al., 2001, Razanajatovo et al., 2015, Salisbury et al., 2015, Strzalkowska-Abramek et al., 2016, Buchholz and Kowarik, 2019, Sikora et al., 2020, Banaszak-Cibicka et al., 2018). Even though the *No difference* between native and non-native species category was more frequent, this does not necessarily have to be correct since this study is limited in the assessed literature. The inconsistency of the articles' conclusions about native or not native could indicate a knowledge gap, which needs to be studied further. Most articles did agree that planting a greater number of species was more important than focusing on only native or non-native plant species (Salisbury et al., 2015, Hanley et al., 2014). Native plants could be planted to benefit a wider variety of native, oligolectic pollinators and exotic species could be used to extend flowering seasons. Furthermore, some factors, such as urbanisation, or how close native plant species grew near to invasive species for example, impacted the abundance of bees in several studies, which makes it even more difficult to come to a definite conclusion about whether native or exotic species are preferable (Buchholz and Kowarik, 2019, Corbet et al., 2001).

It is interesting that most articles in the literature study focused on bumble bees (Figure 4). The number of articles focusing on solitary bees was almost equal to the number of articles studying hover flies. The number of articles mainly focusing on honeybees was also high in comparison to solitary bees (and other articles had already been removed regarding honeybees in the article selection process). Wild bees that are not bumble bees, need to be studied more in order to understand how this specific group can be benefitted in the best way.

The list of genera established from the literature (Table 5) includes some genera that are discussed in more than one article, but overall, the genera discussed showed large variation. This is problematic because the compiled list may be less credible if there is less concurrence. Further the list is only on genus level, meaning that species variance within genera is not captured. Despite these issues, the list can bel a good indicator for where to start looking for plants that benefit pollinating insects. Further analysis could be carried out to group insect species and plant genera, to get an overview of which kind of pollinators are benefitted, and if they are oligolectic or polylectic species.

Since the literature studied was focused on garden plants, many articles discussed species not only in terms of attractiveness for pollinators, but also for humans (Burr et al., 2018, Majewska and Altizer, 2020, Hanley et al., 2014). This has resulted in some “weedy” plants, such as dandelions and buttercups being discussed less often, despite potentially being important and attractive to pollinators (Hanley et al., 2014). It would be interesting to take a closer look into these types of flowers in more detail.

Initially, beneficial plants for wild bees and other pollinators were to be evaluated based on pollen amount and nectar quality, however this proved to be difficult and evaluating the flowers that participants deemed to be the best in this way was not possible due to time constraints. An interesting future study would be to look further into which species are best in terms of pollen and nectar, with the list of genera as a starting point.

5.3 Factors that affect perception of success

The GZLM for meadows predicted the odds that *Amount of insects, Type of environment, Age of meadow* and *Type of method* would cause the perceived success of the meadow to be rated higher. *Amount of insects* was the only independent variable that affected the odds, which shows that respondents considered insect amount to be a determinant of whether the meadow was successful or not. This is positive since the main aim of the project is to help bees and pollinators. Figure 7 shows that meadow respondents rated meadows as being less successful if no insects were observed.

Type of environment, Type of method and *Age of meadow* did not have a significant effect on the odds that respondents would perceive the meadows to be more successful. Distribution of these categories did not vary enough between different categories of success to detect any difference. The *Age of* meadow did not vary significantly between success categories. The same was true for the type of method. Hence, none of these factors could be attributed to causing participants to perceive success differently. Most of the respondents implemented their meadows in urban or rural gardens. The criteria for what is an urban or rural garden are not clear, leading to which could have affected the results of the GZLM. The fact that most respondents for meadows had rural or urban gardens as their environment (as well as for plantations) highlights the importance of optimizing these types of spaces.

The general perception of success for meadows was lower than for plantations. This might be due to how the plantations or meadows look, rather than how many insects are present. It is likely easier to maintain plantations and keep flowers blooming, which might cause respondents to rate them as more successful in general than how meadow respondents have rated.

The GZLM for plantations predicted the odds that *Amount of insects*, *Type of environment* and *Age of plantation* would cause the perceived success of the plantation to be higher. All the factors significantly affected the odds. However, for *Amount of insects*, respondents mostly observed many insects (Figure 8) but the variation of the other two categories was still large enough between the success categories for there to be a significant positive effect of *Amount of insects* on *Perceived success.*

The effect that the *Environment type* category *Natural* had on participants rating success higher was positively significant (Table 9, 10, Figure 8). This category included forested areas, agricultural areas, allotments, and conservation areas. The significance of the effect that this category had on participants rating success higher is therefore questionable since it is difficult to discern which of the original categories led to the significance. Investigating the categories separately would not have been feasible since the number of respondents for each was so small.

For plantations, the proportions of created in 2019 compared to older in *Age of plantation* varied significantly within the success categories (Table 9, 10, Figure 9). Higher success categories had a larger portion of older plantations, and lower success categories had a larger portion of newer plantations. There was a significant correlation between the *Age of plantation* and the *Number of flower species* in the plantation, which indicates that the reason for respondents rating older meadows higher in success could be that they have more flower species, which would mean a larger amount of insects (as this was also correlated).

5.4 Limitations and suggestions for the SSNC

Due to the times constraints of this study, it was not possible to study the second, third best and other flowers that respondents had given in the survey data. Furthermore, time constraints did not allow for comparisons and tests between the two files of data: meadows and plantations. This could have given interesting results. For future studies, it would be interesting to investigate what other measures respondents have implemented in their gardens, such as sand areas. In addition, it would be interesting to see if gender and other factors cause variation in responses.

Although meadows and plantations in general were successful in terms of participant responses for best plants and insect amount fitting with success and conclusion from the literature study, the surveys could be improved for future years. More specific data would make it easier to discern if meadows and plantations (or other strategies) are successful in benefitting more specific pollinator groups and on what their success depends.

To simplify data processing, open-ended questions and answers should be avoided in the survey. This will save time and systematize results allowing for easier comparison between different strategies, or surveys from different years, for example. Worded answers could still be submitted, but with instructions for what to write. For example, plant species can be entered as words but would have to adhere to specific spellings to make data sorting easier.

Many questions could be improved by providing more alternatives or by clarifying existing ones. Some data is lost if respondents are not able to adequately understand questions and what is included in alternatives. For example, some respondents in the meadow survey said that they had used the method *Other* to establish their meadow, yet the reasons given for choosing this alternative oftentimes overlapped with the other alternatives. One respondent had not wanted to choose the alternative *let grass and flowers grow by mowing less often* because they had stopped mowing at all. Clarifications regarding what is included in each alternative is necessary. Having too many alternatives can also be more difficult to analyse and can result in combinations being too complicated when carrying out more complex tests, such as GZLMs, making it difficult to see trends in the data.

However, more alternatives should be added to *Amount of insects* to capture the data between *yes, few* and *yes, many*. In the current surveys, it is difficult to know what the alternatives entail.

The *Number of flower species* is currently only a question in the plantation survey. This should be included in the meadow survey as well, to allow for better comparison between the two surveys, and to see if this is an important factor for meadows. The significance of *Number of flower species* for plantations regarding *Amount of insects* and the *Age of the plantation* highlight the importance of including this variable.

Finally, to gain comparable data, where years can be compared to each other and show clear and reliable results, the whole experimental aspect should be standardized (Birkin and Goulson, 2015). More specific instructions should be given to participants regarding how to perhaps identify insect groups. A counting strategy could be implemented, where insects are counted, for example, for 15 minutes certain days with good weather conditions during the season (Birkin and Goulson, 2015).

Adjusting the way in which respondents observe their strategies and the way in which surveys are carried out can increase the reliability of results and allow for multi-year comparisons, while simplifying he analysis process.

Conclusion

The results from this study show that garden management strategies such as implementing garden meadows or planting “bee-friendly” plantations are beneficial for wild bees and other pollinating insects. The most popular management strategies were to plant “bee-friendly” flowers and to implement meadows by mowing grass less often. Both these methods are frequently mentioned as beneficial for bees in literature. Respondents in the SSNC surveys have generally perceived their implemented strategies as successful. The flowers perceived to be the best in the surveys have been validated as belonging to genera beneficial to pollinators. The amount of insects affected the perception of success for both strategies, and environment and age affected the plantation strategy. Although flower species could not be evaluated, this thesis gives a good indication as to which management methods and flower genera are beneficial to wild bees and other pollinators in gardens and urban areas, which is important to ensure pollinator survival.

Thank you

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Appendix A

Table 1. Combinations of methods for meadow implementation. A) Combinations of two methods and single methods with percentages of total number of respondents. B) Combinations of three methods with percentage of total number of respondents. C) How often each method was given by respondents without combination.

A	Sowing seeds on bare soil	Mowing the lawn less often, letting flowers and grass grow	Planting seedling meadow species	Other
Sowing seeds on bare soil	**14.5**	12.7	2.8	0.3
Mowing the lawn less often, letting flowers and grass grow	12.7	**39.8**	12.0	3.6
Planting seedling meadow species	2.8	12.0	**0.3**	0.4
Other	0.3	3.6	0.4	**5.0**

B Method combination	Number of respondents	Percentage
Sowing x stop mowing x planting	33	4.4
Sowing x stop mowing x other	4	0.5
Sowing x planting x other	2	0.3
Stop mowing x planting x other	9	1.2

C Method	Frequency
Sowing seeds	273
Mowing less often	563
Planting seedlings	168
Other	92

All methods	8	1.1
No methods	9	1.2