Flower visitors in flower strips

– which flower species are the most attractive?

Blombesökare i blomremsor – vilka blomarter är de mest attraktiva?

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Independent project • 30 hec
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Agriculture Programme – Soil and Plant Sciences
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Abstract

Flower strips can be a helpful tool when it comes to increase pollination, pest control and farmland diversity. Different flower species have different attributes such as colour, odours and depth of the corolla tubes and this determines which beneficial organisms will be attracted to that flower species.

In order to discern which are the most attractive flower species for pollinators in Sweden, we surveyed 30 different plant species in a field trial in Uppland. All the pollinators visiting the flowers were observed and collected. In total 264 hoverflies and 484 bumblebees were collected during the season. The most attractive flower species overall were *Phacelia tanacetifolia, Cyanus segetum, Coriandrum sativum* and *Fagopyrum esculentum*. Hoverflies preferred flower species with shorter corolla tubes, such as *Coriandrum sativum* and *Ammi majus*, and bumblebees and honeybees preferred flower species with a bit longer corolla tubes such as *Trifolium* spp. and *Vicia sativa*. Flower strips can benefit the biological diversity by maintaining natural habitats for different pollinators. By using a broad variation of plant species in flower strips one can benefit ecosystem services such as pollination.

Keywords: pollinators, hoverflies, bumblebees, flower strips, honeybees

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1. Introduction

1.1. Agricultural intensification and its consequences

Agriculture is very important, both for us humans but also for species in nature. By growing different crops and maintaining pastures we can provide several different habitats both for plants and animal species. This will in return give us a higher biological diversity and sometimes higher yield and better quality of the crops (Bradbear, 2009). Some issues with agriculture are the increasing intensification, which means that we grow more and more crops and have more of a monoculture to give some examples. In order to maintain a healthy agricultural system that support nature we need to get more sustainable. This by decreasing the usage of pesticides and other chemical sprays and also optimizing crop rotation to avoid different pests (Bowles et al., 2020). Cropping areas are getting bigger at the expense of natural habitats, leaving insects with fewer places to take shelter or over winter (Tscharntke et al., 2015). Grasslands are also getting fewer and fewer (Goverde et al., 2002; Michiel, 2012). Currently, agriculture is highly dependent on external inputs such as pesticides and fertilizers, which affects the environment and the biological diversity. Pesticides can also affect pollinators and natural enemies, leading to a less effective biocontrol and pollinating service (FAO, 2018). We need to conserve and enhance the biodiversity that is already existing, and the ecosystem services it provides, like biological control and pollination. Pollination is another ecosystem service of great importance as the majority of plants need pollination to reproduce and give fruit. Crops being pollinated with the help of insects tend to get a higher yield and a better quality, showing the benefits of pollination (FAO, 2018).

Biological control is the management of pests with the help of beneficial organisms such as insects, other plants and microorganisms. Invertebrate natural enemies include spiders, parasitioids and larvae from different predatory insects that feed on for example aphids (Harris et al., 2016).

To benefit these insects, it is important to supply them with habitats and suitable resources. In order to do this, farmers can plant flower strips, grass or lay on the side of the field that can provide shelter and food resources (pollen, nectar and alternative prey (Holloway, 1976).

1.2. Pollinators and pollinator diversity

Approximately 80% of the plants that give flowers are dependent on insects to pollinate them and 1/3 of the crops that we use as food resources need bees to pollinate them (Bradbear, 2009). Flowers comes in a variety of shapes and sizes with different depth of the corolla tubes. That is why diversity in pollinators are of importance, so that each flower can get pollinated and each pollinator can get food resources (Kevan, 1999).

1.2.1. Bees

Bumblebees (Apidae: Bombus) have over 255 globally species and have annual colonies where the queen hibernates and creates a nest during spring and then workers die, whereas, in honeybees, the workers overwinter with the queen. However, many bumblebee species are adapted to a colder climate and the climate change is a threat that could be problematic (Rasmont et al., 2015). Other challenging factors are the usage of pesticides, especially the ones containing certain neonicotinoids (Goulson, et al., 2005). Bumblebees exposed to pesticides do not collect pollen as often and do not visit flowers as often as bumblebees without exposure to such pesticides (Stanley, 2015). Other threats are, as for most pollinators, the lack of grasslands and natural habitats as a result of monoculture as well as a more intense agricultural usage (Goulson, 2005).
As the bumblebee life cycle is longer than those in honeybees and other pollinators, they can provide pollination during the entire season (Westphal, et al., 2009). Bumblebees can be short-tongued or long-tongued and that gives them access to different food resources. Long-tongued bumblebees usually visit flowers with deep corolla tubes for example *Trifolium* spp., while short-tongued bumblebees are more generalized when it comes to the tube-length (Wermuth, 2010). Climate change might lead to a reduction in availability of flowers, short-tongued bumblebees might adapt easier to reduce flower availability since they are more generalised (Miller-Struttmann, 2015). Bumblebees can pollinate by buzzing, where they vibrate their wing muscles close to the flower making the poricidal anthers release the pollen. Flowers with poricidal anthers do not have pollen available, and only release pollen when being vibrated in a specific frequency (Fischer & Moriarty, 2015).
Honeybees (*Apis mellifera)* are social and live in a nest with one queen, the males will die during autumn while the females will overwinter in the nest. Honeybees stand for the pollination of approximately one third of all the crops used for food and can use flower species with both shorter and deeper corolla tubes. Honeybees are used all over the world and are effective pollinators. However, they can be problematic as they can out-compete other wild pollinators, such as solitary bees (Bradbear, 2009).

1.2.2. Hoverflies

Hoverflies (Diptera: Syrphidae) are one of the largest families in Diptera with approximately 6000 species described globally. In Sweden there are about 300 species out of which approximately 150 are predatory hoverflies (Bartsch, 2009). Some have bright colours and different patterns on their abdomen and thorax, whereas other species are rather small and. Hoverflies often mimic other species such as bumblebees, wasps and honeybees to repel any predators (Allaby, 2014).

There are three subfamilies and two types of hoverflies: predatory (Syrphinae) and non-predatory (Eristalinae and Microdontinae). Syrphinae feed of nectar which supply them with carbohydrates and pollen which supply them with proteins, minerals and lipids. They can also feed of the honeydew of aphids (Haslett, 1989). Traits that attracts the hoverflies are shape, size and colour of the flowers. Yellow coloured flowers seem to be the most attractive colour as it can even trigger the proboscis extension response, which is a taste behavioural reflex. This might be because they feed on mostly yellow pollen and yellow flowers mimic and tricks the hoverflies into believing they have food resources. What kind of food sources they have access to has an impact on their fitness, survival and nutrition. Different plant species have various impacts on the hoverflies, for example did access to *Coriandrum sativum* increase the fertile female proportion (Amorós-Jiménez et al., 2014). Other known plant species that are attractive to hoverflies are *Fagopyrum esculentum* and *Phacelia tanacetifolia* (Laubertie, et al., 2012). However, which plants that will be visited depend on numerous factors such as the presence of other flowers, competition with other pollinators or plant structure.

The hoverfly larvae can be scavengers and detritus feeders, feeding on dead plant material, carnivore feeding of aphids or phytophage, feeding on living roots (Allaby, 2014). During the larvae development the larva can consume up to 1000 aphids, making hoverflies a good predator on aphids (Tenhumberg, 1995). Although predatory larvae seem to be able to live solely on pollen and honey for a while, they will not pupate or develop any further without animal prey (Volsteen et al., 2018). As hoverflies can hover and are strong at flying, they can more easily locate aphid colonies and female hoverflies tend to oviposit based on the size of the aphid colony (Bugg et al., 2008).

Harsh agricultural management during winter could potentially lead to a decrease in places to hibernate in. If the hoverflies have places to hide and enough food resources the population have a higher chance of survival and leads to an increase in biocontrol the following spring (Raymond et al., 2014).

1.2.3. Other pollinators

Other wild pollinators such as solitary bees and butterflies are important pollinators. They can also pollinate different plant species and variation is needed. Butterflies (*Lepidoptera*) are effective pollinators and attracted to different types of flowers such as clover and *Cirsium arvense* (Janz, 2005; Eriksson & Rundlöf, 2012). There are about 180.000 species of *Lepidoptera* but about 10% are the butterflies most people think about (Hahn & Brul, 2016). Butterflies do also benefit from flower strips as they get more food resources (nectar, pollen) and shelter (Haaland, et al., 2010). Butterflies are also affected by agricultural intensification in a negative aspect and can lead to a homogenization of *Lepidoptera* populations (Ekroos, et al., 2010). Just like with honeybees and bumblebees, other wild pollinators are affected negatively by pesticides, that might lead to a decrease in wild pollinators (Main, et al., 2020).

1.3. Flower strips

Flower strips are one way to increase biodiversity in agricultural landscapes and attract pollinators and natural enemies by providing nutrition, shelter, and overwintering prospects (Ouvard, et al., 2018). Flower strips are usually sown on the edge of a field with a variety of different plant species and should be easy for the farmer to deal with. In Sweden species like *Phacelia tanacetifolia*, *Fagopyrum esculentum* and *Coriandrum sativum* are some examples of plant species (Jordbruksverket, 2020). However, different plant species will attract different species of insects so it is important to think through what the purpose of the flower strip is. It should also be considered if the plant species have different growth-cycles and are going to out compete each other (Korpela et al., 2013). Planted species could have an impact on how the local plant species will thrive and compete. Flower species planted might become invasive and disturb the natural habitat (Hobbs, et al., 2009). However, there is still in need of research on this topic as some studies are critical to the invasion claims (Richardson, & Riccardi, 2013). Research about how plant species and flower strips can be adapted in Nordic conditions is also needed.

Flower strips can be annual or perennial or include a mixture of both. Both have their advantages and disadvantages depending on what kind of crops that is sown. In orchards perennial flower strips tend to be of more usage as they can remain a steady food resource and shelter for a longer time (Pfiffner et al., 2018). In annual crops, such as cereals, there seems to be both annual and perennial flower strips. However, according to one study annual flower strips gave a higher abundance in parasitoids in the later part of the growing season (Pellissier et al., 2018). Perennial flower strips gave a steadier abundance and supported different parasitoid communities than the annual one (Pellissier et al., 2018).

1.4. Aim

There is a gap of knowledge of which flower species in flower strips attract what kind of insects. To know which composition the strip should have is important so you know if you promote biocontrol or pollinators. The objective of this study was to evaluate the relative attractiveness of selected flowering plants to different pollinator groups (hoverflies, bumblebees and honey bees) to promote biological control and pollination in agricultural fields.

2. Method

2.1. Study site and design

The study was conducted on a at Lövsta close to Uppsala during the summer of 2020. A total of 30 plant species (Table 1). All plant species were sown on the 2^{nd} of June of 2020 in 10 m2 plots (2m x 5m) in complete randomized-block design with four replications. All the plots were visited weekly from the 17^{th} of July to the 2^{nd} of September to record flower visitation.

To evaluate the attractiveness of the plant species to pollinators every week the plant species that were in bloom were observed, and the pollinators visiting the flowers were counted for one minute in the mornings and one in the afternoon. Pollinator observations were only done under good weather conditions (not be too windy or rainy), otherwise the observation was postponed to another day. The visiting pollinators that could not be identified in the field were collected with a sweep-net and put in a tube with ethyl acetate and were transferred to a plastic tube, labelled and put in a freezer. Some plots never flowered and were therefore excluded from the study. Identification was made with the help of a key for Nordic hoverflies and bumblebees (Bartsch, 2019).

Table 1. The plant species used in the experiment, what family they belong to, life cycle and if they were excluded due to low ground cover.

Bloom	Flower Species	Family	Type	Excluded
Never	Leucanthemum vulgare	Asteraceae	Perennial	Yes
August	Echium plantagineum	Boraginaceae	Annual	Yes
August	Vicia sativa	Fabaceae	Annual	Yes
August	Cuminum cyminum	Apiaceae	Annual	Yes
August	Lotus corniculatus	Fabaceae	Perennial	Yes
Never	Anthriscus cerefolium	Apiaceae	Annual	Yes
August	Trifolium hybridum	Fabaceae	Annual	Yes
August	Tripleurospermum inodorur	Asteraceae	Annual	Yes
August	Centaurea jacea	Asteraceae	Perennial	Yes
August	Medicago sativa	Fabaceae	Perennial	Yes
August	Cota tinctoria	Asteraceae	Perennial	Yes
September	Foeniculum vulgare	Apiaceae	Annual	Yes
Never	Sinapis alba	Brassicaceae	Annual	Yes
Never	Cichorium intybus	Asteraceae	Perennial	Yes
August	Fagopyrum tataricum	Polygonaceae	Annual	Yes
August	Ammi majusa	Apiaceae	Annual	No
July	Borago officinalis	Boraginaceae	Annual	No
July	Coriandrum sativum	Apiaceae	Annual	No
July	Cosmos bipinnatus	Asteraceae	Annual	No
July	Cyanus segetum	Asteraceae	Annual	No
July	Fagopyrum esculentum	Polygonaceae	Annual	No
August	Helianthus annuus	Asteraceae	Annual	No
August	Melilotus officinalis	Fabaceae	Biennial	No
July	Phacelia tanacetifolia	Boraginaceae	Annual	No
August	Plantago lanceolata	Plantaginaceae	Perennial	No
August	Trifolium alexandrinum	Fabaceae	Annual	No
August	Trifolium incarnatum	Fabaceae	Annual	No
August	Trifolium pratense	Fabaceae	Perennial	No
July	Trifolium resupinatum	Fabaceae	Annual	No
August	Vicia villosa	Fabaceae	Biennial	No

2.2. Statistical analyses

Plant species: the groundcover data of each week was used as an exclusion criterion for the sown species. Only plant species that had bloomed during the season and had a ground cover above 50% in 3 plots and 3 weeks were included in the analysis. This resulted in the inclusion and exclusion of some flower species (Table 1).

This selection was made to ensure that the resulting data about the attracted pollinators would be due to the presence of the sown species.

Flower visitors: only the data about hoverflies, bumblebees and honeybees was considered for the statistical analysis since other insect species were not found. The different hoverfly species were grouped in non-predatory and predatory for the analysis. The bumblebee species were grouped in short-tongued and long-tongued.

The average of observations for each group of species per day were calculated. Then the average of all weeks in which the plant was observed (after excluding the data with the blooming and groundcover criteria) was calculated in order to make a overall average. Linear fixed models were fitted to test the attractiveness of the sown flower species to hoverflies, bumblebees and honeybees. A linear mixed effect model (with block as a random factor) using the the lmer function of the LmerTest package in R (R Core Team 2011). The P-values correspond to the anova test performed with the lmerTest package. Thus, the significance (P-values) only state that there are statistical differences between plants, but not which plants are statistically different form each other.

3. Results

3.1. Pollinator diversity found

In total 264 hoverflies were observed and 484 bumblebees. As seen in figure 1 bumblebees stood for more than half of the total number of insects, hoverflies for about one third, honeybees about one fifth and wasps and butterflies were scarce.

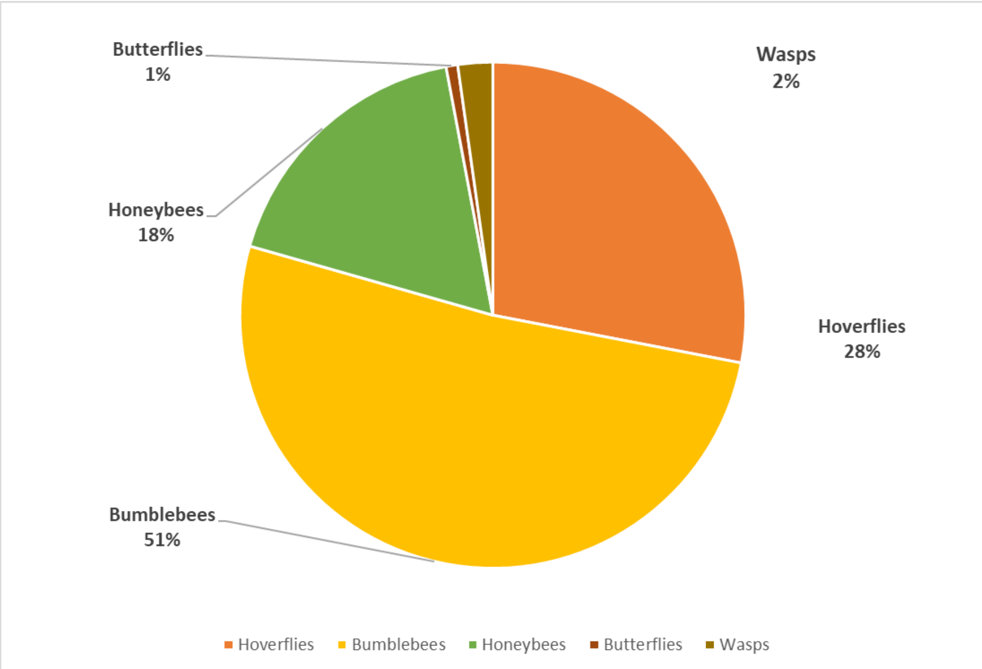

Figure 1. Proportion of the different flower visitors groups found.

3.1.1. Hoverflies

In total 21 hoverfly species were collected among which 7 species were predatory, and 14 species were non-predatory. The most commonly found hoverfly genus was *Eristalis* (48%), consisting of *E. arbostorum, E. pertinax, E. tenax, E. abusivae, E. lineata, E. intricaria and E. interrrupta* (Figure 2). The most common tribe was Eristalini with 13 species and the majority of the hoverflies were non-predatory (Table 3 and Figure 2).

Table 2. The hoverfly species collected, their feeding mode and tribe they belong to..

Hoverfly Species	Predatory	Tribe
Syritta pipiens	No	Eristalini
Eristalis arbustorum	No	Eristalini
Eristalis pertinax	No	Eristalini
Eristaliz tenax	No	Eristalini
Eristalis abusiva	No	Eristalini
Eristalis luneata	No	Eristalini
Eristalis intricaria	No	Eristalini
Eristalis interrupta	No	Eristalini
Cherlosia scutellata	No	Rhingiini
Sericomyia silentis	No	Sericomyiini
Myatropha florea	No	Eristalini
Xylota sylvarum	No	Xylotini
Helophilus hybridus	No	Eristalini
Helophilus pendulus	No	Eristalini
Melanstoma scalare	Yes	Eristalini
Melanstoma mellinun	Yes	Eristalini
Sphaerophoria scripta	Yes	Syrphini
Scaeva pyrastri	Yes	Syrphini
Episyrphus balteatus	Yes	Syrphini
Syrphus vitripennis	Yes	Syrphini
Syrphus torvus	Yes	Syrphini

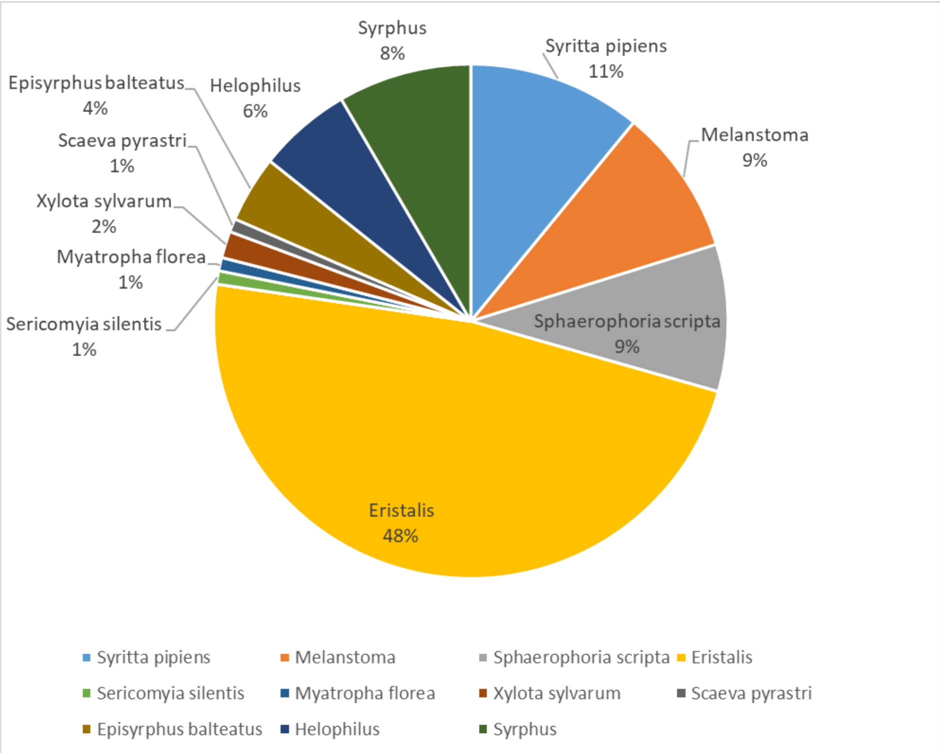

Figure 2. Percentage of the different hoverfly taxa observed visiting flowering plants.

3.1.2. Bumblebees

In total 9 bumblebee species were collected during the experiment, 5 short-tongued and 4 long-tongued (Table 4). Long-tongued bumblebees stood for 79% of the total sum whereas short-tongued stood for 21 % as seen in Figure 3.

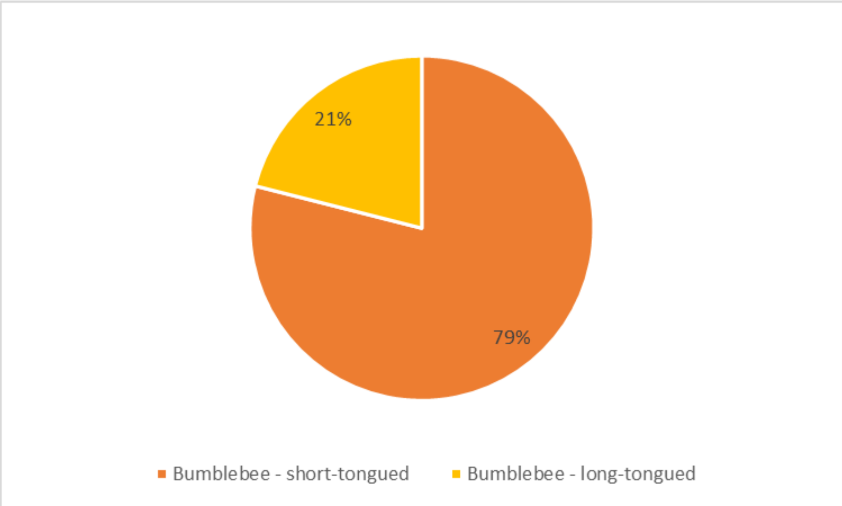

Figure 3. The percentage of collected long-tongued and short-tongued bumblebees.

Table 3. The collected bumblebee species in the experiment and if they were long-tongued or short-tongued.

Bumblebee Species	Long-tongued
Bombus pratorum	No
Bombus ruderarius	No
Bombus lucorum agg.	No
Bombus lapidarius	No
Bombus ruteratus	No
Bombus sylvarum	Yes
Bombus pascuorum	Yes
Bombus hortorum	Yes
Bombus subterraneus	Yes

3.2. Attractiveness

3.2.1. Hoverflies

There were significant differences for the attractiveness of the different flower species to non-predatory hoverflies (F = 5,0587, P <0.001) and predatory hoverflies (F = 8,8355, P <0.001). *Ammi majus, Coriandrum sativum, Cyanus segetum, Fagopyrum esculentum, Helianthus annuus and Phacelia tanacetifolia* were the most attractive flower species for non-predatory hoverflies, while *Ammi majus, Coriandrum sativum* and *Fagopyrum esculentum* attracted the most predatory hoverflies. Between these flower species you can't tell any significant differences. The less visited flower species were *Vicia villosa*, *Trifolium* spp and *Cosmos bipinnatus* (Figure 5).

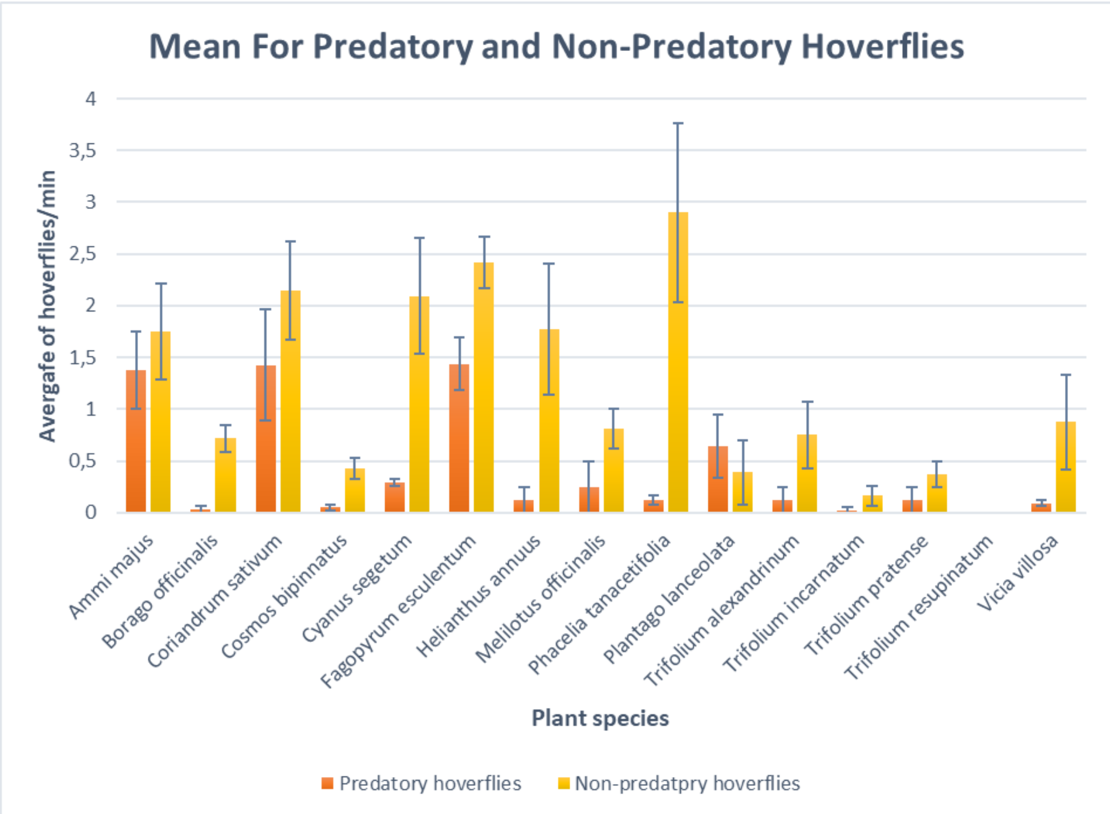

Figure 4. Mean number of predatory and non-predatory hoverflies observed visiting flowering plants per 1 min. Vertical bars show standard error.

3.2.2. Bumblebees

There were significant differences for the attractiveness of the different flower species to short-tongued (F = 8,0592, P = $7{,}722e^{-8}$) and long-tongued bumblebees (F = 3,5303, P = 0,000811). The most attractive flower species amongst short-tongued bumblebees were *Phacelia tanacetifolia, Melilotus officinalis* and *Cyanus segetum.* Amongst long-tongued bumblebees *Vicia villosa, Trifolium alexandrium* and *Helianthus annuus* were the most attractive ones. The significant difference between flower species is between the mentioned species and *Borago officinalis, Cosmos bipinnatus* and *Fagopyrum esculentum* (Figure 6).

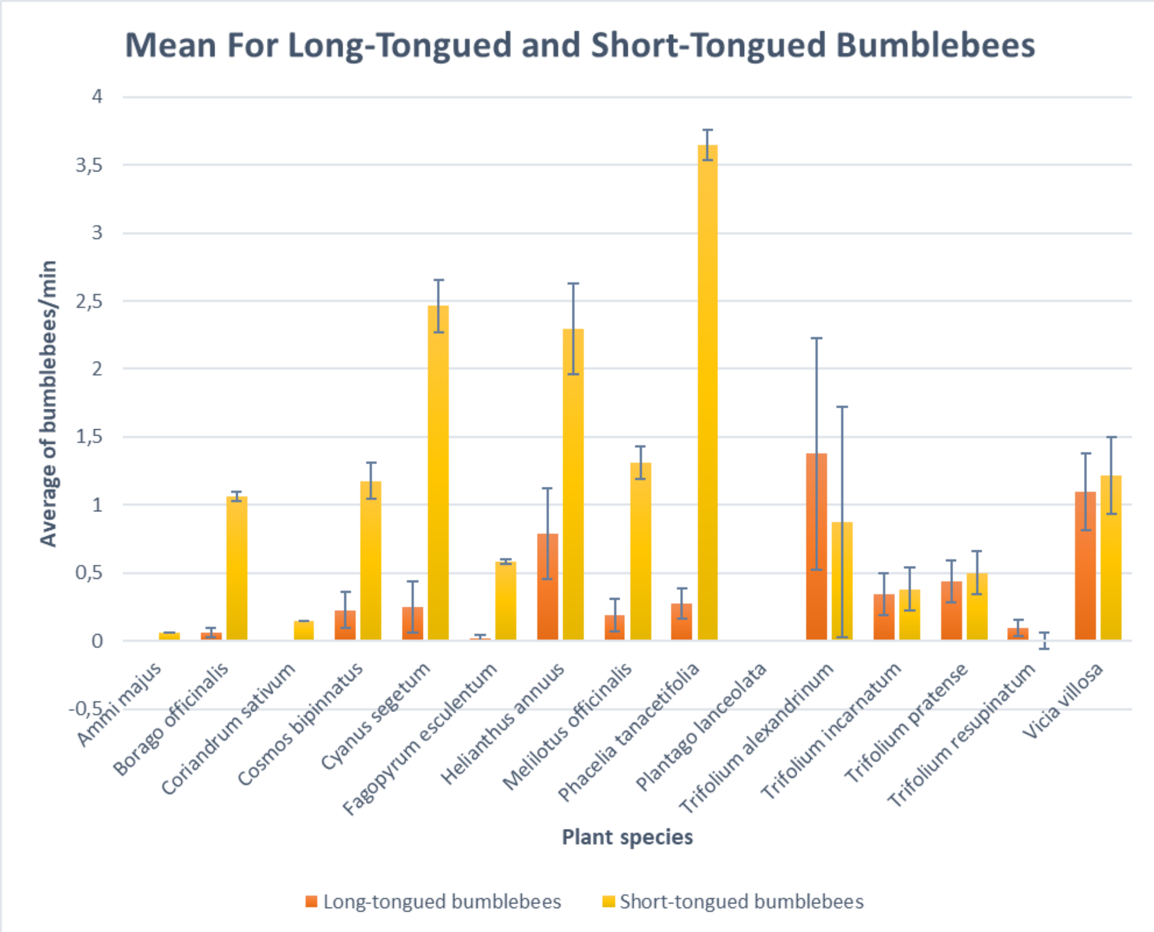

Figure 5. Mean number of long-tongued and short-tongued bumblebees observed visiting flowering plants per 1 min. Vertical bars show standard error

3.2.3. Honeybees

There were significant differences for the attractiveness of the different flower species to honeybees (F = 11,24, P <0.00). *Borago officinalis, Coriandrum sativum, Cyanus segetum, Fagopyrum esculentum* and *Phacelia tanacetifolia* were the flower species most visited by the honeybees. The significant difference was between *Borago officinalis, Coriandrum sativum, Cyanus segetum, Fagopyrum esculentum*, *Phacelia tanacetifolia* and *Ammi majus, Coriandrum segetum, Fagopyrum esculentum* and *Trifolium* spp., which were less visited (Figure 7).

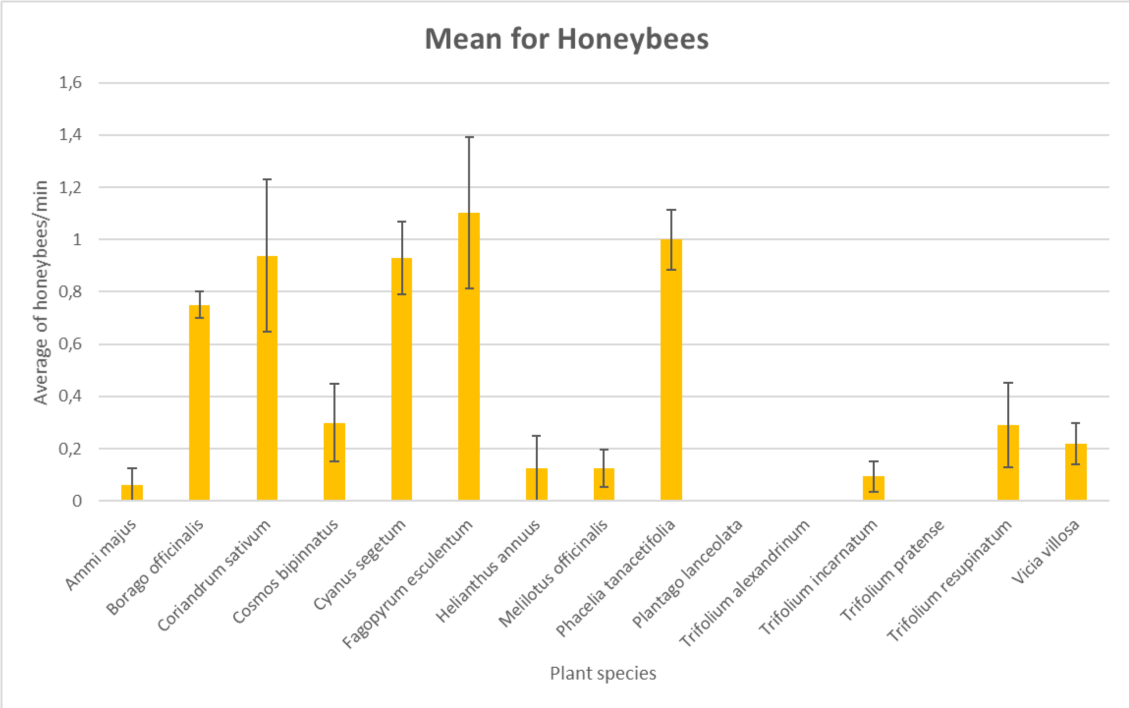

Figure 6. Mean number of honeybees observed visiting flowering plants per 1 min. Vertical bars show standard error

4. Discussion

4.1. Plant species establishment

During the experiment some of the flower species did not establish properly (*Leucanthemum vulgare, Echium plantagineum, Vicia sativa, Cuminum cyminum, Lotus corniculatus, Anthriscus cerefolium, Trifolium hybridum, Tripleurospermum inodorum, Centaurea jacea, Medicago sativa, Cota tinctoria, Foeniculum vulgare, Sinapis alba, Cichorium intybus, Fagopyrum tataricum*), showing low percentage of ground cover as well as delayed or inhibited blooming. Some flower species (*Sinapis alba* and *Tripleurospermum inodorum*) showed particularly low growth. However, sowing was quite late in the experiment, and if everything had been sown in time, the planted species would probably have been better able to compete with weeds. A plant that is sown later will not have the growth time to be able to match the growth of the weeds. In addition, the plant species does not have the time to germinate properly leading to bad germination and inhibited growth. It was clear that bumblebees, butterflies, honeybees and hoverflies were visiting *Cirsium arvense* and *Galeopsis speciosaI,* which are common weeds in Sweden. This is relevant since the presence of both these weeds were high in several plots in the experiment. It is a possibility that some insects prefer weeds, such as *C. arvense* and *G. speciosa* over the planted flower species. This is supported by Janz (2005) and Eriksson & Rundlöf (2012) that showed that butterflies are attracted to *C. arvense*.

Because some plots had so much weed in relationship to the planted species it was decided that some plots would be excluded as they did have more weeds than flowers. This was done by excluding the species with a percentage of 60% or higher of weeds. If similar experiments will be done in the future, it would be recommended to discuss and consider clearing the plots of weeds in order to remove this factor. However, in natural habitats there will be weeds, in fields and ditches, so keeping them in the experiment would give a more realistic environment. Kishinevsky (2017) suggested that local plants are better for biological control than planted flowers, as the local ones attract more natural enemies such as parasitoids. Planted and human introduced species could become invasive and compete with the wild, local species**.** Several studies, such as Hobbs et al (2009) and Richardson & Riccardi (2013) has discussed whether they have a negative impact on local species or not. It is possible that flower strips could decrease the habitats for some natural enemies as they are planted by humans and might therefore disturb the preferred flower species for the natural enemies. However, it will always be important to keep natural habitats.

4.2. Attractiveness of the flower species to pollinators

The most attractive flower species for hoverflies were the ones with easily accessible pollen and nectar which is as expected as hoverflies have very short feeding proboscis. Unlike honeybees and bumblebees, they have a hard time finding food in flowers with deeper corolla tubes (Allaby, 2014). The most attractive flower species, among both predatory and non-predatory hoverflies, were *Phacelia tanacetifolia, Helianthus annuus, Fagopyrum esculentum, Cyanus segetum, Coriandrum sativum* and *Ammi majus*. That several plant species were attractive can be explained by the fact that hoverflies are generalists. This was expected as hoverflies tend to prefer yellow and white flowers due to the mimicking of pollen and the trigger of the taste behavioural reflex, just like Amorós-Jiménez (2014) discussed. The visited plants all had pollen that was easily accessible and/or small flowers such as *C. sativum* and *P. tanacetifolia*. It would be interesting to see more research on if there are any differences in preferences when it comes to choosing flower species among predatory and non-predatory hoverflies. If there is, that could be another deciding factor when composing flower strips. As different species of hoverflies are attracted to different plant species that can be used when composing flower strips. Strips containing flowers more attractive to predatory hoverflies will naturally lead to more biocontrol as according to Tenhumberg (1995) they will prey on alternative prey, whereas flower strips containing flower species attractive to non-predatory hoverflies will become more of a pollinating ecosystem service. In fields with pest problems but efficient pollination a flower strip attracting predatory hoverflies would be the best suggestion. Especially if one has problems with aphids as you will give both the adult hoverfly and the larva food resources and shelter.
Also some of the weeds had aphids on them, which according to Haslett (1999) makes a flower attractive, as hoverflies feed of the honeydew. As there were a lot of weed present and some of them did have aphids it remains unclear if it were the flower species or the weeds that attracted to hoverflies. Another possibility is that the hoverflies were attracted to the flowers of the weeds. Could more hoverflies have been collected if the plots had less weeds in them?

Bumblebees shared some preferences in flower species with the hoverflies such as *H. annuus, C. segetum* and *P. tanacetifolia*. Other flower species that seemed attractive to bumblebees were the ones with deeper corolla tubes such as *Trifolium alexandrium* and *Vicia villosa*. Those flower species would be useful around greenhouses, strawberry fields, lays or fruit fields as they are best pollinated by bumblebees (Velthuis, 2006). As Wermuth (2010) discussed, this is an expected result as both clover and vetch have deeper corolla tubes, which suits bumblebees. Flower species with many small flowers have not been as attractive and are not suited in flower strips where the goal is to increase the bumblebee population. Although there were different types of bumblebees (short-tongued and long-tongued) there were not significant differences between the two groups when it came to attractiveness to flower species. This can be explained as there were a higher number of short-tongued species collected than long-tongued. However, *P. tanacetifolia* has quite accessible pollen and nectar and might be a more common food source for the short-tongued bumblebees. As short-tongued adapt more easily to new climates and flowers, just as Miller-Struttmann (2015) discuss, and they have more feeding resources. This makes it important to adept the flower strips depending on what purpose they have, making sure that you use flower species with deeper corolla suits long-tongued bumblebees better as Wermuth (2010) stated.

Honeybees showed similar preference to the same flower species as bumblebees and hoverflies, such as *C. sativum, P. tanacetifolia and F. esculentum* as well as they were attracted to *Borago officinalis*. As they have a shorter tongue than long-tongued bumblebees they will also have more feeding resources. This implies that you will most likely have flower species that will be beneficial to honeybees in flower strips, as they can feed of a broad variety of flowers, both with deeper and shallower corolla tubes just as according to Bradbear (2009).

Other pollinator groups, such as butterflies were not as attracted by the sown flower species. As butterflies are quite big and have a longer wing span, they will need more space to land on so flower species that are big, open and easily accessible would be more attractive Corbet (2000). This might explain why pollen rich *Phacelia tanacetifolia* were not visited, as that flower species are too small to land on. However, they were common guests to the experimental field, and they seemed very attracted to *C. arvense*, a theory which is supported by Janz (2005) and Eriksson & Rundlöf (2012). If similar projects would be done it would be interesting to focus a bit more on butterflies and see where they landed, as they were quite active during the season. Flower strips containing species with deeper corolla tubes, such as clover, would be beneficial for butterflies and bumblebees and suited next to fruits or lays as Velthuis (2006) suggests. Flower strips do not only attract pollinators but other insects as well, both pests and useful ones. This study did not consider these insects and more research on this topic would be a good complement to optimize flower strips.

5. Conclusion

The most attractive flower species amongst all three categories of collected insects were *Phacelia tanacetifolia, Cyanus segetum, Coriandrum sativum* and *Fagopyrum esculentum.* These would be suitable in a flower strip wanting to attract a range of different pollinators and not only a specific species for conservation purposes. If the desire is to attract mainly hoverflies to promote biological control, flower species with many small flowers, preferably white or yellow would be contributing to that goal, such as *C. sativum* and *A. majus*. Flower species with deeper corolla tubes are a better suggestion to preserve bumblebees as well as butterflies. This would be preferable as they will help increase the biological diversity as well as the pollination of the surrounding crop and pest control. A combination of these different factors will contribute to preserving and maintaining the pollinator populations in agriculture. Although, more research is needed in this subject and it would be remarkably interesting to see more research on this.

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