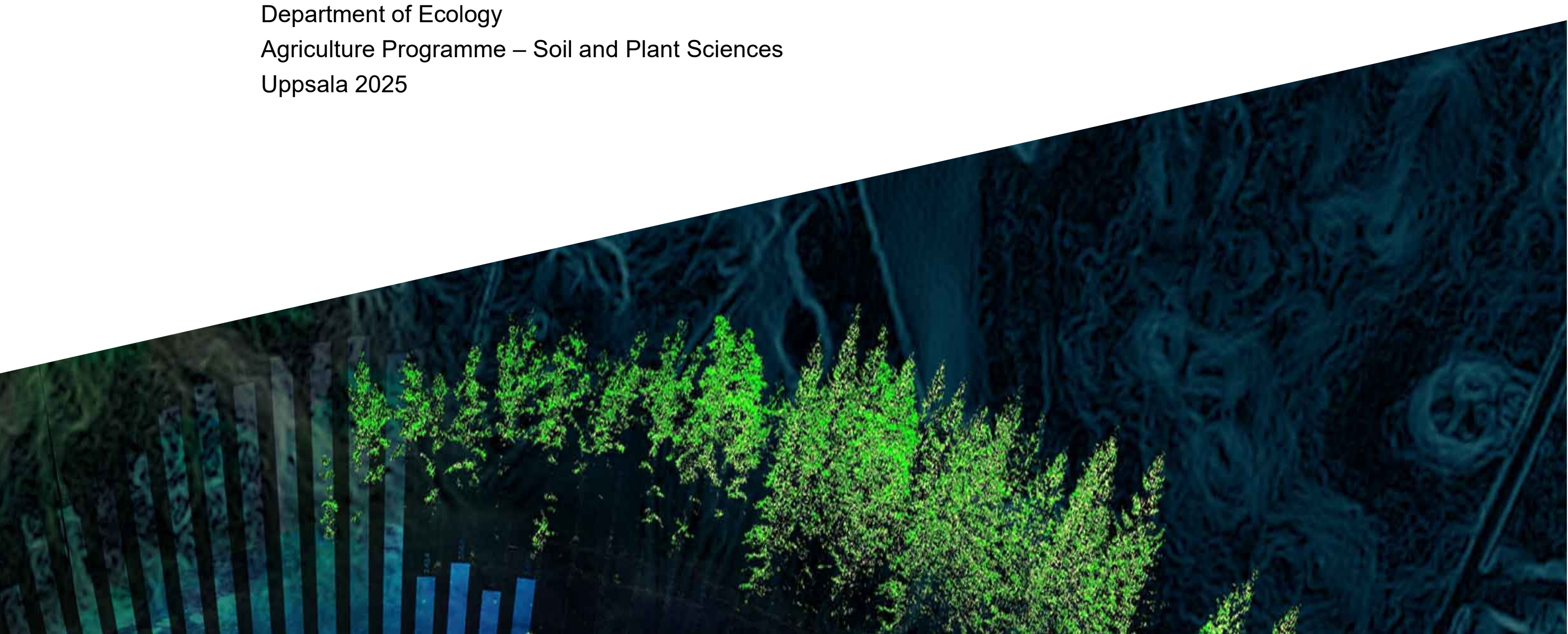
Legacy effects of faba bean cultivation and impact of sowing date on pollinators and pests in faba beans

Elin Tegelid

Master's thesis • 30 credits
Swedish University of Agricultural Sciences, SLU
Faculty of Natural Resources and Agricultural Sciences
Department of Ecology
Agriculture Programme – Soil and Plant Sciences
Uppsala 2025



Legacy effects of faba bean cultivation and impact of sowing date on pollinators and pests in faba beans

Arvseffekter av åkerbönsodling och sådatumets påverkan på pollinatörer och skadedjur i åkerböna

Elin Tegelid

Supervisor:	Ola Lundin, Swedish University of Agricultural Sciences, Department of Ecology
Examiner:	Erik Öckinger, Swedish University of Agricultural Sciences, Department of Ecology

Credits:	30
Level:	A2E
Course title:	Independent project in Biology – Master's thesis
Course code:	EX1026
Programme/education:	Agriculture Programme – Soil and Plant Sciences
Course coordinating dept:	Department of Aquatic sciences and Assessment
Place of publication:	Uppsala, Sweden
Year of publication:	2025
Keywords:	Faba beans, IPPM, pollinators, Bruchus rufimanus, Apis mellifera, Bombus spp.

Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Ecology

Abstract

Pollinating insects and pests are important drivers for both pollination and crop development in agricultural production. Intensified agriculture, crop production, and habitat changes have for a long time created favourable environments for pests, while beneficial insects, such as pollinators, have been negatively impacted. The decline in beneficial insect populations and insufficient pest control are increasing problems for crop health. Integrated Pest and Pollinator Management (IPPM) is a set of principles aimed at simultaneously managing crop pollination and pest control. This preventative management system has the potential to reduce the need for chemical pesticides by, for example, creating agricultural environments that discourage insect pests and support pollinating insects.

The purpose of this project was to investigate how different aspects of faba bean cultivation affects the pollinator densities and pest pressure of *B. rufimanus*. Inventory of pollinators and beetles were performed in 15 fields in to evaluate the legacy effects of faba bean cultivation, cover of arable land and the impact of sowing date. The field study was conducted in the county of Östergötland the growing season 2024. The study was based on data from 2023 year's cropping of faba beans and the fields were selected based on whether faba beans had been cultivated in the area or not. Half of the fields were in areas with a lot of faba beans and half of the fields in areas almost without faba beans previous year. Sowing date and cover of arable land were also som of the factors considered when choosing the fields. Pollinator densities and behaviours were determined with inventory between late June and early August. Pods for egg counting were collected and counted in July and August. The damage was assessed by opening collected pods and looking at the beans for emergence holes by *B. rufimanus*. The pods for damage assessment were collected in the beginning of September to the beginning of October.

Higher cover of arable land in the landscape had significant impacts on both honeybees (*Apis mellifera*) and bumblebees (*Bombus spp.*), where the densities of honeybees increased with higher cover of arable land, while bumblebee densities decreased. Faba bean cropping in the previous year and sowing date had no significant effect on the tested variables. More research is needed to further establish and understand the effects of mass-flowering crops on pests and pollinators in agriculture.

Keywords: Faba beans, IPPM, pollinators, *Bruchus rufimanus, Apis mellifera, Bombus spp*.

Table of contents

List of tables

List of figures

1. Introduction

1.1 Integrated pest management

Use of chemical crop protection are often required in modern agriculture, to reduce pest pressure, weeds and increase yield. Integrated pest management (IPM) is a management system to reduce the pest pressure with as few chemical inputs as possible. It was designed as a response to the over use of pesticides that has had a great impact on insect decline, environmental health and availability of active compounds (Barzman et al. 2015). The basic step for implementation of IPM is to prevent pest and weed infestations. This involves management steps from adjusting sowing date and crop rotation to monitoring thresholds (Biddinger & Rajotte 2015). There are also some strategies within IPM that involves promoting a good environment for beneficial insects in the form of natural enemies (Norrlund 2022).

1.2 Integrated pest and pollinator management

Wild pollinator populations are declining and while managed pollinators can fill the gap they leave to some extent, wild pollinators are needed for many ecosystem services and conservational work are therefore needed (James & Pitts-Singer 2008). IPM is described to be beneficial for biodiversity and pollinators, but there is a gap in the concept that makes it less pollinator friendly than suggested. While the methods in the model are not directly aimed at pollinators, there are many management steps that benefits pollinators. There is, however, a need to have a more direct approach where the goal is to further support and increase the populations of the different pollinator species (Biddinger & Rajotte 2015; Lundin et al. 2021).

IPPM, short for "Integrated pest and pollinator management", is recommeded as an extension of the integrated pest management system. The suggested management steps support pollinators, but reduce pest pressure. Rather than the IPM way of reducing pesticide impact on honeybees, IPPM propose a focus on preventative management actions to protect both managed and wild pollinators. By using mass-flowering crops like oilseed rape and faba beans as break crops in a crop rotation dominated by grains, pollinator densities could be enhanced and pest pressure in the more common crops reduced (Biddinger & Rajotte 2015; Lundin et al. 2021).

1.3 Faba bean (Vicia faba L.)

Faba beans (*Vicia faba L.*) is a common agricultural crop that has been grown all over the world for thousands of years (Singh & Jauhar 2005). In Sweden and some parts of Europe, the faba bean is a spring sown annual crop, grown mainly for animal feed. Further, it is also commonly grown as a catch crop or intercropped with cereals, such as wheat (Kirk 2004; Fogelfors 2017).

Faba beans are, much like oilseed rape a mass-flowering crop and the plant's many flowers are attractive to bees and other pollinators (Marzinzig et al. 2018). At most 20 percent of the flowers becomes a pod and it is common for a plant to have about 5-12 pods. Between 20-80 percent of the flowers are self pollinated, depending on the weather and the wind (Kirk 2004; Fogelfors 2017).

There are many benefits of having faba beans in the crop rotaton. One of its most important benefits is that it is a nitrogen fixing crop, which means that there is a smaller need for mineral fertilizers (Fan et al. 2006). There is often a surplus of nitrogen after faba beans, wich can be used as green manure for subsequent crops (Álvarez-Iglesias et al. 2018). The nitrogen fixating property of faba beans can also lead to reduced carbon dioxide emissions due to reduced transport and spreading of mineral fertilizers (Mínguez & Rubiales 2021). Further, faba bean diversifies the ecological systems in the agricultural landscape due to different phenology than eg. grain crops and creates a better environment for pollinators (Kirk 2004). The beans are rich in protein containing lysine, an essential amino acid, as well as starch, carbohydrates, vitamins and minerals (Macarulla et al. 2001; Dhull et al. 2022). Cultivation of faba beans as an alternative protein source, for both humans and animals, could possibly strengthen the national food security due to decreased need to import meat and other legumes (Crépon et al. 2010; Röös et al. 2020).

With a new focus on climate change and a green wave, new sources of protein are desired and even though faba bean is mainly grown for fodder in Sweden, it is a great protein source for humans (Etemadi et al. 2019). Legumes are often used as a substitute for animal protein, due to its high content of essential amino acids and has been a large part of the diet in many countries, mainly in Asia and Mediterranean regions in Europe (Revilla 2015). It is, however, very susceptible to biotic and abiotic stress, such as pests. One of the most difficult and common insects pests in faba beans is the broad bean beetle (*Bruchus rafimanus*) (Ekbom 2012).

1.4 Broad bean beetle (*Bruchus rufimanus*)

The most common pest to damage the pods of faba- or broad beans is the broad bean beetle (*Bruchus rufimanus*). The beetle appears and cause damage on areas where legumes are cultivated, but the extensive infestations in faba beans is what has given the beetle its common name. It is suggested that the species has been imported with different species of *Vicia*. It can, however, reproduce in Sweden, which means that there is not a need for continuous import for the beetle to increase in abundance (Ekbom 2012; Gailis et al. 2022).

The insect is about 3-5 mm long and ovally shaped. The partly yellow antennas are attached nearby the eyes. The slightly light-haired cover wings does not go over the whole body, but leaves a part in the posterior parts of the body uncovered. The eggs are greenish and the approximately 6 mm long larvae are white- to yellow-ish with a brown head (Andersson 2021; Segers et al. 2021).

The beetle has one generation per year and the adult insect hibernates inside the pods and beans of (mostly) faba beans. Non-crop and semi-natural landscapes that are extensively managed are also common hibernating spots for the beetle, where they can be found in for example litter, leaves on the ground, bark, or holes in the ground (Ekbom 2012). By spring, the beetles leaves the pods or overwintering habitat and they then survive by eating pollen, nectar and leaves of the bean plants (Segers et al. 2021). By the time of reproduction, the female leaves the 2 mm eggs on the pods of the beans, where they stay until they are hatched (Andersson 2021). The larvae then enters the pods by drilling a small hole. This can, however, heal with time so that only a little black mark is showing in the bean. The larvae then pupates and complete the metamorphosis inside the bean (Segers et al. 2021). The adult beetle sometimes leaves the beans from the beginning of September, but can stay in the beans over the winter, which can cause a problem with the seeds following year (Andersson 2021). When leaving the pods, the beetle drills an approximately 3 mm hole in the bean and its pod, which is what causes the largest damage to the beans.

There is currently few options to chemically control *B. rufimanus* in faba beans and if chemically controlled, it should be done in connection to the flowering period of the faba beans. The recommended insecticide from the Board of Agriculture in Sweden is a product containing the neonicotinoid acetamiprid (Jordbruksverket n.d.). The number of neonicotinoid insecticides in the European Union is declining due to the affect they can have on health and behaviours of pollinators (van der Sluijs et al. 2013; IPBES 2016). Restrictions of using neonicotinoids in agriculture makes it more and more difficult to chemically control pests and reduce pest pressure in agricultural landscapes. There is a need to find other more sustainable and practical ways to reduce the damage on faba beans done by *B. rufimanus*. The non-chemical method used today is to make sure that you are using seed that is free from the insect, which can be difficult to control before sowing and it is also not a very effective method due to the fact that some of the beetles overwinter outside the seeds (Ekbom 2012; Andersson 2021).

1.5 Pollinators in faba beans

Even though faba beans are self-pollinating, pollinators are often important for pod production and increased yield in the crop. Pollinators are one of the most important factors for increased harvest and quality of crops (Raderschall et al. 2024). Much to do with the fact that pollinators such as honeybees (*Apis mellifera*) and bumblebees (*Bombus spp.*) have a possible impact to increase harvest with as much as 71 percent, pollinators can not only be seen as a great ecosystem service and biodiversity input, but also strong contributors to world economy (Bartomeus et al. 2014; Khalifa et al. 2021)

However, there is an ongoing decline in pollinator densities in the world (Egan et al. 2020). This does not only lead to a loss in biodiversity, but also reduced quality and yield for crops dependent on pollinators. Because of their enormous value for both ecosystems and world community, there is a great need to find ways to stop or, even better, reverse the population decline of pollinators.

Nesting pollinators, such as bumblebees and honeybees, are shown to travel up to 1.5-2 kilometres from their nesting site to forage and landscapes should be constructed in a matter that enables the foraging for the pollinators (Walther-Hellwig & Frankl 2000; Rands & Whitney 2011).

To help and enable life and foraging for wild pollinators such as bumblebees, there are some steps promoted by the Swedish Board of Agriculture; plant flowering trees or bushes, leave the edge zones free from pesticides, grow flowering edges and have a crop rotation with flowering crops, such as oilseed rape and faba beans. The crop rotations should be organized so that at least some of the fields are covered with flowering crops each year (Risberg 2008). Mass-flowering crops are shown to increase the densities of bumblebees in landscape with high coverage (Beyer et al. 2020).

1.6 Legacy effects on pollinators

Population densities of different pollinators are strongly correlated with the densities of flowering plants in the region. One of the most important factors to successfully enhance the pollinator environment is the length of the flowering season (Kirk 2004). However, the cultivation of mass-flowering crops, despite short growing season, provides a good environment for insects and higher flower resources for pollinators. For example, when faba beans are cultivated, bumblebees have been shown to increase in abundance in the landscape after faba bean flowering (Beyer et al. 2020).

It is stated that faba beans increase pollinators densities the year when they are grown, but new studies suggest that mass-flowering crops leaves a legacy response and that cultivation of the crops does not only enhance pollinator densities the year they are grown, but subsequent growing seasons as well, so-called legacy effects (Riedinger et al. 2015). The term legacy effects have had a few different meanings since it first appeared in modern ecology science, but for this report it refers as the long-term impact of event or interaction, the cultivation of faba beans. The direction of the impact is not stated nor important for the phraseology (Cuddington 2011).

Mass-flowering crops such as faba beans and oilseed rape are often used as break crops between cereals and simplifies the foraging for pollinators. The extensive management of grasslands have, much like mass-flowering crops, a positive effect on the distribution of honeybees in the landscape (Le Féon et al. 2013).

1.7 Legacy effects on pests

The cultivation of agricultural crops creates a habitat that often differs from the natural habitats in the area. A natural landscape is often full of diversity of both plants, animal and insects, which makes it difficult for one species only to be dominant. This balance is, however, altered in an agricultural landscape. Suddenly, there is a whole sea of host plants where some species thrive and some do not. Host crops for certain pest, increases the abundance of this pest when cultivated, the year that they are growing (Fogelfors 2017).

When growing the same crop in a specific landscape area for a longer period of time, there is a legacy effect on the pests with increased pest pressure (Delaune et al. 2021). The landscape composition have an effect on the pest pressure, where cultivation of host plants on fields that are close to fields that have had the same host plant previous year have higher pest pressure of certain pests than fields that are cultivated in areas without the host plant previous year (Boetzl et al. 2023).

Crop rotations are an important part of the modern agriculture and are one of the most influencing management adjustments to reduce pest pressure, root and soil diseases and more (Castellazzi et al. 2008; Zheng et al. 2020). By adjusting and including the whole farm in the crop rotation, the distance between fields with host plants subsequent years could be increased. With an increased distance to previous year's host plant fields, the pest pressure would be reduced (Hausmann et al. 2024). This information can be used to plan crop rotation based on landscape composition as a part of integrated pest management (Schieler et al. 2024)).

1.8 Effects of arable land on pollinators and pests

The intense agriculture of modern days has lead to a huge decline in pollinator populations. The primary driving factors for the losses in species richness and abundences are the reduction of natural habitats, use of disturbing pesticides and climate changes (Winfree et al. 2009; Potts et al. 2010; Williams et al. 2010). Monocultures with winter wheat, spring barley or spring oats were the most common annual cops in Sweden 2024 (Sveriges Officiella Statistik 2024). These crops are mainly grown because of the good harvests and economical values, but they creates a simplification of the landscape diversity (Power & Follett 1987). The landscape fragmentation that arable land creates are shown to have an impact on reproduction and abundance of pollinators (Xiao et al. 2016). Distances to natural habitats have a negative effect on wild bee densities, but honeybee densities are not shown to be affected the same way as wild bees (Potts et al. 2010).

B. rufimanus hibernates in natural environments, such as mulch and holes in the ground (Ekbom 2012). Therefore, it is possible that areas with more arable land could have a negative effect on the infestation in faba bean fields, due to disturbances in the soil.

1.9 Sowing date effects on pollinators and pests

Altering the sowing date to reduce pest pressure is a proven method to reduce pest pressure in different crops. It can be done by either sowing earlier than normally, or later. The effect depends, however, very much on the biology of the pest and the time frame of the maturation of the plants. The goal with an alteration of the sowing date is to make the plant mature in a different time frame than when the infestation usually accurs (Lundin et al. 2020; Pedigo & Zeiss n.d.).

B. rufimanus feeds on pollen and nectar from the faba bean plant, or other host plants, and pollen consumption is an important step for the sexual productivity of the female beetle (Segers et al. 2021). A later sowing date of approximately 10 days in faba beans, delay flowering and could possibly reduce the availability of adequate living conditions and sexual reproduction for *B. rufimanus* (Szafirowska 2012; Ward 2018). A later sowing date have an effect on infestation of the beetle. By postponing the sowing date and delay flowering the impact of the beetle are reduced, but with a reduced yield due to shorter growing season (Szafirowska 2012; Ward 2018).

Pollinator densities and species richness are connected to the sowing date and flowering of the host crop (Toivonen et al. 2019). By delaying the sowing date, flowers will become available at a later time (Ferrise et al. 2010; Eberle et al. 2024). The effect of increased pollination services with later sowing date could possibly be due to availability of attractive flowers for a longer part of the season and greater floral density in peak density of the pollinator colonies (Toivonen et al. 2019; Eberle et al. 2024).

1.10 Aim and objective

The aim of this master thesis is to investigate how the abundance of pollinators and *B. rufimanus* fluctuates depending on whether faba beans (*Vicia faba L.)* have been cultivated in the area the previous year. Further, I investigate how the presence of pollinators and *B. rufimanus* is affected by the sowing date and proportion arable land in the landscape. The hope is that this information can be used to investigate how a landscape can be planned and designed to benefit pollinators and at the same time reduce pest pressure. The research objective to gain an understanding of the influence of faba beans and arable land in the landscape was as follows:

To relate the infestation of *B. rufimanus* and the abundance of pollinators to sowing day, whether faba beans were cultivated in the area or not and the amount of arable land in the area around the fields.

2. Method

2.1 Experimental design

The study was conducted in commercial fields (not in, for example, an experimental field station) and located in 15 different fields spread across the county of Östergötland, Sweden. The fields were organically grown faba beans sown 2024. The locations of the fields were selected based on whether faba beans had been cultivated in that area or not in the previous year. Information and coordinates for 166 fields sown with faba beans in 2024 was obtained from advisors in Östergötland. For 2023 year's agricultural land use in these areas we collected layers from the Integrated Administration and Control System (IACS), compiled by the Swedish Board of Agriculture.

To select 15 fields out of the 166 fields, the crop areas and proportions were calculated by sorting the crops into categories; permanent grassland, ley, faba bean, annual crops, fruits and berries, and other agricultural land. To limit the area calculated, buffers of one kilometre, two kilometres and three kilometres were combined with the IACS blocks and their coordinates in a GIS program. The 15 fields were then selected as extremes in terms of faba bean cropping in 2023, where seven fields where in areas without or almost without faba beans 2023 and eight fields had a lot of faba beans the same year (Table 1). Parameters such as proportion arable land, cultivar, field size and sowing date were also observed and balanced across the faba bean cropping history treatment. The proportion of arable land land was calculated as the proportion of cultivated crops, excluding grassland and ley.

For the analysis the fields were categorized as "Yes" or "No" (Yes>0 and No=0). These categories were dependent on the faba bean proportions (Table 1).

The field design was based on two transects, on two locations in the each field. One that was called "Edge", approximately 10 metres in and the other, called "Center", approximately 50 metres in, or in the center of fields that were less than 100 metres wide.. The two transects were 50 metres long and included to take more samples from a larger part of the fields, compared to only taking the samples from one transect.

Table 1. Table of the experimental sites, their area, cultivar, sowing date and wether or not there was faba bean in the area previous year. The faba bean fields are categorized as either 'Yes' or 'No'. All the sites had organic faba beans and the area is the field area in hectares. Proportion of faba bean and arable land are for the two kilometre buffer. Proportion for one and three kilometres can be found in Appendix (Table A1).

Site	**Area (ha)**	**Cultivar**	**Sowing date**	**Faba beans (%)**	**Arable land (%)**	**Faba beans**
Hästholmen	2.37	Birgit	01-05-24	6	41	Yes
Heda	16.81	Birgit	01-05-24	6	42	Yes
Boxholm	24	Daisy	02-05-24	3	12	Yes
Stigtomta	10	Tiffany	07-05-24	0	21	No
Skeppsås	10.57	Birgit	03-05-24	0	73	No
Vikingstad	25.29	Tiffany	19-05-24	5	41	Yes
Söderköping	4.66	Birgit	28-05-24	2	24	Yes
Kättorp	21	Aurora	20-05-24	9	61	Yes
Askeby	9.75	Birgit	10-05-24	3	44	Yes
Norrköping	36.5	Birgit	26-05-24	3	15	Yes
Skänninge	34	Birgit	03-05-24	0	67	No
Vikbolandet	18.3	Aurora	19-05-24	0	13	No
Finspång	5.36	Fanfar	14-05-24	0	10	No
Orlunda	7.96	Birgit	15-05-24	0	29	No
Ekholmen	4.5	Birgit	13-05-24	0	31	No

2.2 Data collection

2.2.1 Inventory of pollinators

To investigate the abundance and distributions of pollinators, each field was inventoried at least two times and at most five times during the flowering of the faba bean plants. Mean visitation times were 3.4 times between the dates 2024-06-18 and 2024-08-02 (Table A2). Further, in addition to the species, the behaviour of the insects collecting pollen and nectar were observed and noted as following; regular flower visitor (Poll), nectar robbers (Rob) and visitors of extrafloral nectaries (Efn). The regular flower visitors, collect nectar and pollen at the same time, and takes the pollen to the next plant. Nectar robbers steal nectar without collecting pollen, wich affects the reproduction and quality of the plants that they are visiting (Sakhalkar, et al., 2023). Exrafloral nectaries are not a part of the pollination, but the glands excrete nectar that are attractive to many insects. It is, for example, common that ants and honeybees visit plants to collect the sugary liquid (Lanan 2021).

During the inventories, pollinators on faba beans in each transect was observed one meter to each side and for exactly ten minutes. At the time of the inventory, the temperature was always above 15 degrees Celsius, enough sun to discern a shadow, dry vegetation and not more wind than 4 on the Beaufort scale. These weather criteria, combined with a difference in flowering time for the fields, resulted in variations in inventory times, which was included as a factor in the models for the pollinators.

2.2.2 Collecting of eggs from *Bruchus rufimanus*

The assessment of the eggs from *B. rufimanus* were done by collecting 50 pods from each transect. The plants were at crop stage BBCH 75, when 50 percent of the pods were set. The egg collection were done between 2024-07-22 and 2024-08-09 (Table A3). To even the distribution of pods, every third pod was taken from the higher part of the plant, every third from the middle and every third from the lower part of the plant. The pods were carefully placed in a paper bag and inspected in the laboratory to count the densities of eggs within 24 hours.

2.2.3 Damage on the pods by *Bruchus rufimanus*

To evaluate the infestation of *B. rufimanus* in the beans, pods were manually harvested (70 pods from each transect) when at least 70 percent of the pods at the field were matured, at BBCH 87 to 89. Collection of pods were done between 2024-09-03 and 2024-10-02 (Table A4) To even the distribution of pods, every third pod were taken from the higher part of the plant, every third from the middle and every third from the lower part of the plant. The pods were then left in the lab for approximately a month before they were opened and the damage done by *B. rufimanus* were estimated as proportion of beans with emergency holes of all beans counted.

2.3 Statistical analysis

The statistical analysis were performed in R 4.4.1 for Windows (R Development Core Team, 2024). The data were converted from an Excel matrix and organized into data frames from in R using the packages readxl, dplyr, tidyr, ggplot2 and lubridate.

For the statistical analysis the transects edge and center were named 'Position'. The inventoried pollinator numbers, 'Apis' and 'Bombus', were summarized over the transects within each 'Position' (edge or center) across the season and grouped as honeybees (*Apis mellifera*) and bumblebees (*Bombus spp*.). The eggs counted per pod, 'Summarized Eggs', were summarized as total eggs per transect. The estimated damage done by the adult beetle, ‘Proportion damaged beans’, was calculated as a proportion damage beans of total beans per transect.

The response variables, ‘Summarized Eggs’, ‘Apis’, ‘Bombus’ and ‘Proportion damaged beans’ were tested against the continuous fixed effects ‘Position’, ‘Proportion of arable land’, ‘Faba beans- yes or no’ and ‘Sowing day’, with ‘Field’ as a random factor, with the two kilometre buffer. The lmer package (lme4), was used to fit the data to the linear mixed effects models for Eggs, Apis and Bombus. The response variables were fitted with a negative binomial distribution (glmer.nb) and the offset number of pods for the analysis of the eggs and the offset total inventory visits for Apis and Bombus. The proportion data of the response variable ‘Proportion damaged beans’ were fitted with a general linear mixed model and the package glmmTMB, with a beta regression and ‘logit’ link. Continuous independent variables were rescaled to improved model fits. The fixed effects were checked for multi-collinearity with vif (variance inflation factors), indicating no cross correlation (VIF < 1.18 in all cases).

The package DHARMa was used to check the models for under- and over dispersion and validity (Hartig 2022). A QQ- plot was performed to check for significant deviation. The homoscedasticity was checked with the DHARMa non-parametric dispersion test. No model contradictions to the model assumptions were found in the DHARMa tests. A Wald chi-sqaure- ($\chi2$) -test was assessed to check for the significance of the effects in the model, using the Anova (car) package.

The packages (effects) and (ggplot) was used for the visualization of the models.

3. Results

3.1 Pollinator distribution

For all the experimental sites 355 individuals of 7 different species of pollinators were collected, of which honeybees (*Apis mellifera)* were most common (60,8%, Table 2). Due to the low number of *Bombus spp.*, the species were not grouped as short- and longed tongued, but instead analyzed together.

*Table 2. Species list of noted pollinators with scientific name, behaviour and number of observed individuals. EFN=extrafloral nectary, poll=regular pollination, rob=nectar robbing. *Eight individuals presented more than one behaviour. ** The behaviour of three individuals in these species are unknown.*

Species	**EFN**	**Rob**	**Poll**	**Total number**
Apis mellifera*	89	60	67	216
Bombus terrestris**	6	52	48	108
Bombus lapidarius	1	8	6	15
Bombus pascuorum		1	1	2
Bombus soroeensis		4	0	4
Bombus hortorum			2	2
Bombus subterraneus			6	6
Bombus sylvarum			1	1
Bombus hypnorum**				1

3.2 Analysis of bean damage and pollinator visits

Results from the statistical analysis are shown in Table 3. 'Position', had very large p-values (Table 3) and thereby there was no difference between edge and center for neither of the investigated response variables.

Tabell 3. Results from the chi-square(χ2)- test and p-value of number of eggs per pod (Eggs), proportion of beans with emergence holes (Damage), number of honeybees per visit (Apis)and number of bumblebees per visit (Bombus) for each of the fixed variables. Df (Degrees of freedom) are marked in the upper left corner and applies to all response varieble s. Significance ($p<0.05$) is marked in bold.

Df = 1	Eggs		Damage		Apis		Bombus	
	χ2	p	χ2	p	χ2	p	χ2	p
Position	0.002	0.964	0.370	0.542	0.045	0.832	1.431	0.232
Arable Land	2.019	0.155	1.159	0.281	3.954	**0.047**	4.099	**0.043**
Faba Beans	1.762	0.184	0.069	0.791	0.686	0.407	0.519	0.471
Sowing Date	1.860	0.172	0.348	0.555	1.254	0.263	0.347	0.556

There was no significant relation between faba bean cover 'Yes' and 'No' for any of the response variables (Table 3, Figure 1).

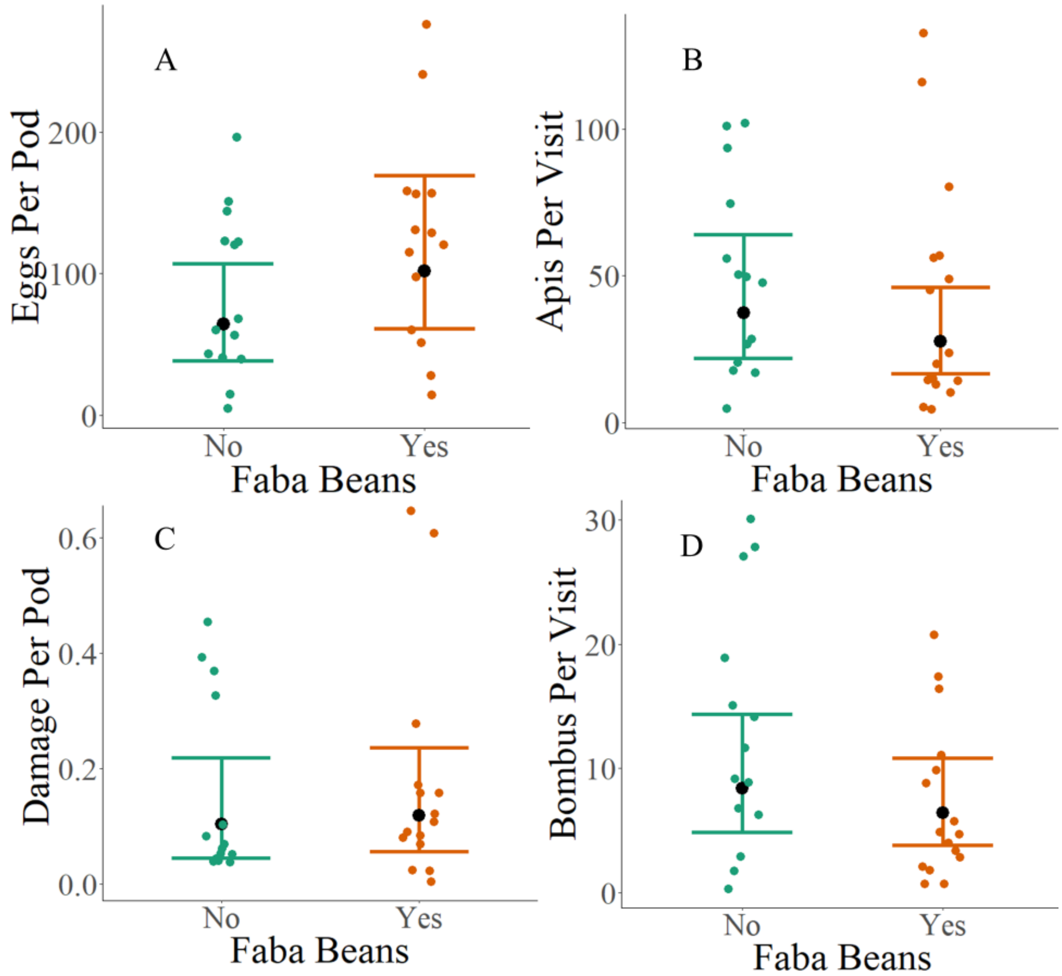


Figure 1. Figures of the model for 'Faba Beans', with with means and 95% confidence intervals and thedata points. X-axis of all figures has the same intervals, but the y-axis has different intervals due to different scale on the data points

There was a significant relation between the response variables *Apis* and *Bombus* and the fixed variable 'Arable Land' (Table 3, Figure 2). The results implies that bumblebees per visit decrease with higher cover of arable land in the area (Figure 3D). But for all responses except bumblebees per visit there was positive tendencies for increased densities with higher cover of arable land, for honeybees this relationship was statistically significant (Figure 3B).

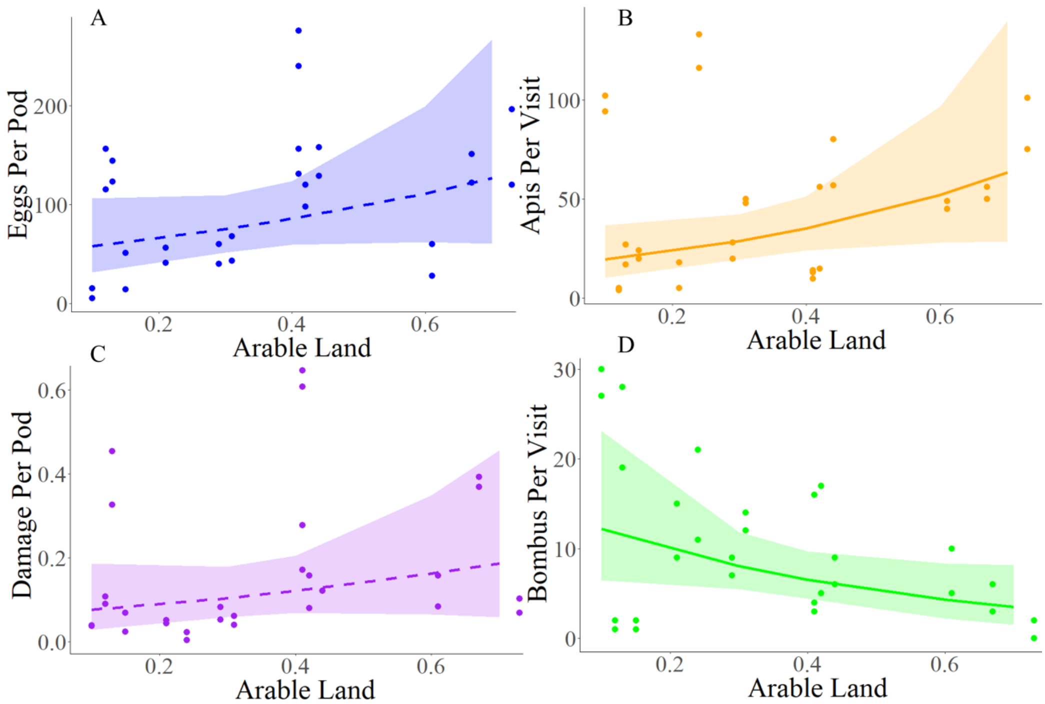


Figure 2. Figures of the model for 'Arable Land', with line for effect sizes, 95% confidence intervals and the data points. X-axis of all figures has the same intervals, but the y-axis has different intervals due to different scale on the data points. Filled lines indicates significance and dashed lines indicates no significance.

There was no significant relation between sowing day and any of the response variables (Table 3).

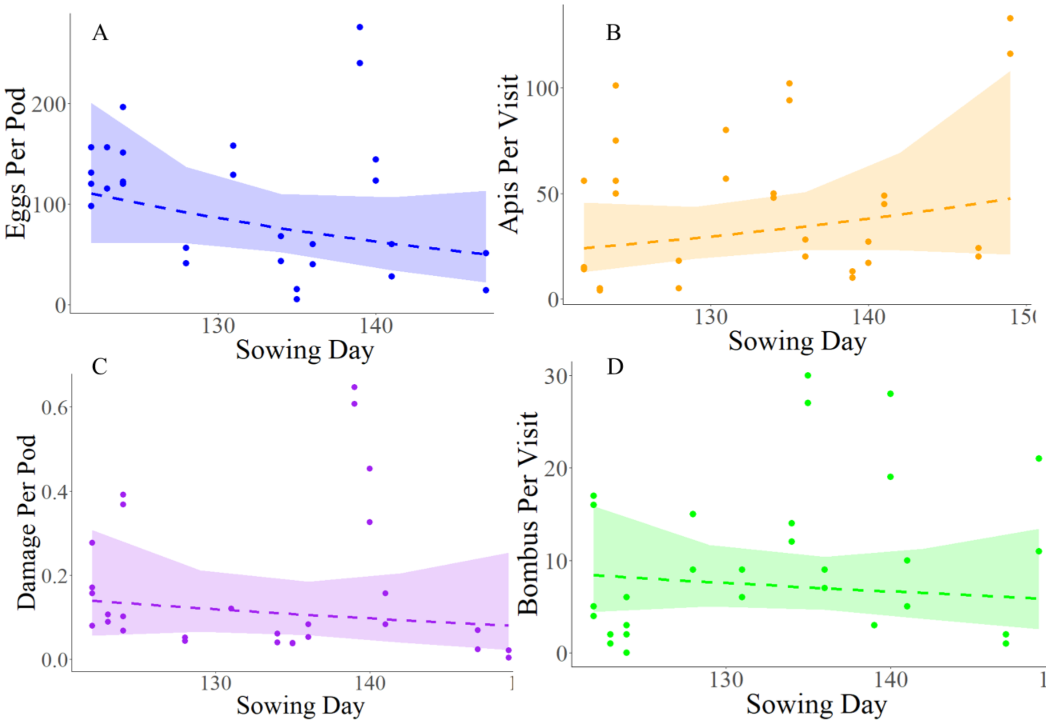


Figure 3. Figures of the model for 'Sowing Day, with line for effect sizes, 95% confidence intervals and the data points. X-axis of all figures has the same intervals, but the y-axis has different intervals due to different scale on the data points.

4. Discussion

The results reveals that there is statistically significant relation between pollinator densities and cover of arable land in the landscape. There are, however, no statistical significant relation between neither faba bean cover nor sowing date and the tested response variables.

4.1 Apis mellifera and Bombus spp.

Honeybees increased with higher cover of arable land, but were unaffected by faba bean cropping in the previous year and sowing date. With honeybees being the most common managed pollinator, the hives are often placed where the beekeeper thinks is the best spot for honeybees, where their nutritional need is covered for the largest period of time (James & Pitts-Singer 2008). This means that beehives are often placed in arable land with much flowering crops or many wild flowers, or simply where beekeepers are productive (Rebolledo Ranz 2020).

Bumblebees did, however, decrease with higher cover of arable land, but were also unaffected by sowing date and faba bean cultivation in the previous year. Bumblebees are wild pollinators and are therefore not managed as honeybees often are. The decrease in bumblebee densities further establish that wild pollinators are sensitive to natural habitat reductions and loss of adequate nesting spots (Potts et al. 2010; Williams et al. 2010; Olynyk et al. 2021).

Although mass-flowering crops increase the densities of pollinators, too high cover of these crops, like faba beans, could dilute the bumblebee population instead, leaving it to be fewer individuals visiting each field (Riedinger et al. 2015; Holzschuh et al. 2016). Further, even though both faba bean cover and arable land were analyzed in this report, there are factors in the landscape that were not considered. One being closeness to cities and to bigger roads, where the bumblebee queen mortality tends to be higher (Dániel-Ferreira et al. 2022).

The non-significant correlations between faba bean cover and sowing date on pollinators densities suggest that there are other, more important factors driving pollinator densities. Different pollinators have different ways of foraging and while som species prefer certain plants and locations, others are more likely to visit many different plant species (Campbell et al. n.d.). Pollinator diversity are affected by the diversity of available flowers (Fründ et al. 2010) and even if an later sowing date will make the faba bean flowers available later, there might still be attractive flowers in the area reducing the effect of the sowing date.

4.2 *Bruchus rufimanus* eggs and damage on pods

Eggs per pod and damage per pod was not significantly affected by any tested variable. Eggs per pod showed numerically somewhat higher numbers with increased proportion of faba beans in the landscape in the previous year. While some *Bruchus rufimanus* overwinter inside faba beans, reducing quality and making them unuseful for human consumption, some of the beetles leave the pods as early as September. They will find another hibernation spot, under leaves and in mulch for example, ready to infest next years' faba bean cultivation. The beetles staying in the pods are removed from the area with harvest and if they are not grown for seed, they will not see faba bean fields again. (Ekbom 2012; Andersson 2021). The weak correlation between faba bean cover and infestation of *B. rufimanus* suggest that other factors might be disturbing the results and one such factor being that the use of infested seeds that were grown in other areas previous year could affect the infestation rate in the fields subsequent growing season (Watanabe 1990; Andersson 2021).

Damage per bean was, however, more or less the same indepent of the faba bean cropping in the previous year. The mortality rate for eggs on pods, larvae, pupae, and adult beetle varies, suggesting that some of the eggs might not have made it to adulthood (Seidenglanz & Huňady 2016).

Though not significantly, delayed sowing day numerically decreased number of eggs per pod and to a lesser extent damage per bean, but there was large variation rendering the results uncertain. The relationship is, however not strong and while the delayed sowing will ultimately lead to delayed flowering and thereby pollen production of the plant, *B. rufimanus* might not be as affected of this as previously assumed. Since consumption of pollen from the plant is a crucial part of the females sexual development, it is possible that the life cycle can be altered to fit the flowering of the host plants (Segers et al. 2021). The idea with a delayed sowing date is to delay flowering, which could affect pollinator densities and pest pressure (Szafirowska 2012; Ward 2018; Toivonen et al. 2019; Eberle et al. 2024). Because flowering time was not included in the analysis, it is difficult to conclude whether a later sowing date delayed flowering or if the faba beans had equalized flowering time, regardless of sowing date.

4.3 Conclusions

In conclusions, the results in this project indicates that while pollinator densities were affected by cover of arable land, faba bean cover and sowing date, did not have a significant impact. Honeybee densities decreased with higher cover of arable land, likely because of beehive placement. The bumblebee densities were reduced with higher cover, highlighting wild pollinator sensitivity to habitat loss and lack of nesting sites. The results emphasize the importance of wild pollinator conservation for plant health, ecosystem stability and agricultural productivity, as managed pollinators can not fully replace the ecological functions of wild pollinators. Further, due to the low number of different species of *Bombus,* it was not possible to divide them into different groups of for example short tongued and long tongued bumblebees, but it would have been interesting to see how the different categories would respond to the different variebles.

As for *B. rufimanus,* the findings indicats that there were no significant relationships between neither faba bean cover nor sowing date and eggs per pod or damage on the pods. While tendencies to trends were observed, such as a slight decrease in eggs per pod with delayed sowing, the results showed too much variation to be viable. The weak correlation between infestation of *B. rufimanus* and faba bean cover indicates that other factors, such as the use of infested seeds, might have more weight in pest dynamics of *B. rufimanus.*

The uncertainty of the results, due to the complexity of landscape analyses, makes it difficult to draw firm conclusions of the work. This could partly be resolved by including more factors in the analysis, such as closeness to cities and bigger roads. However, while interesting to include, some factors might be to extensive to measure, as for example, wild and ley flower densities. To further investigate the legacy effects of faba beans in the landscape and help plan crop rotation, it would be interesting to do a follow up on the experimental sites next year, provided that the there will be cultivation of faba beans.

Overall, this work highlights the complexity of landscape analyses and the relationships between resources at landscape scale and its effects on pests and pollinators. Agricultural land with mostly annual crops decrease the densities of wild pollinators and there is a need to further investigate on implementation of natural habitat management for conservation of wild pollinators. Understanding the drivers of pollinator decline and pest infestation rates in fields is needed to follow how integrated pollinator and pest management (IPPM) could be used in practice.

References

Álvarez-Iglesias, L., Puig, C.G., Revilla, P., Reigosa, M.J. & Pedrol, N. (2018). Faba bean as green manure for field weed control in maize. *Weed Research*, 58 (6), 437–449. https://doi.org/10.1111/wre.12335

Andersson, L. (2021). Utsäde - skadegörare, analys och behandling. Jordbruksverket. https://www2.jordbruksverket.se/download/18.722a20fe17c2a2470535d5ef/1632929267208/be28v3.pdf

Bartomeus, I., Potts, S.G., Steffan-Dewenter, I., Vaissière, B.E., Woyciechowski, M., Krewenka, K.M., Tscheulin, T., Roberts, S.P.M., Szentgyörgyi, H., Westphal, C. & Bommarco, R. (2014). Contribution of insect pollinators to crop yield and quality varies with agricultural intensification. *PeerJ*, 2, e328. https://doi.org/10.7717/peerj.328

Barzman, M., Bàrberi, P., Birch, A.N.E., Boonekamp, P., Dachbrodt-Saaydeh, S., Graf, B., Hommel, B., Jensen, J.E., Kiss, J., Kudsk, P., Lamichhane, J.R., Messéan, A., Moonen, A.-C., Ratnadass, A., Ricci, P., Sarah, J.-L. & Sattin, M. (2015). Eight principles of integrated pest management. *Agronomy for Sustainable Development*, 35 (4), 1199–1215. https://doi.org/10.1007/s13593-015-0327-9

Beyer, N., Gabriel, D., Kirsch, F., Schulz-Kesting, K., Dauber, J. & Westphal, C. (2020). Functional groups of wild bees respond differently to faba bean Vicia faba L. cultivation at landscape scale. *Journal of Applied Ecology*, 57 (12), 2499–2508. https://doi.org/10.1111/1365-2664.13745

Biddinger, D.J. & Rajotte, E.G. (2015). Integrated pest and pollinator management — adding a new dimension to an accepted paradigm. *Current Opinion in Insect Science*, 10, 204–209. https://doi.org/10.1016/j.cois.2015.05.012

Boetzl, F.A., Bommarco, R., Aguilera, G. & Lundin, O. (2023). Spatiotemporal isolation of oilseed rape fields reduces insect pest pressure and crop damage. *Journal of Applied Ecology*, 60 (7), 1388–1398. https://doi.org/10.1111/1365-2664.14424

Campbell, N., Urry, L., Cain, M., Orr, R., Peter Minorsky & Wasserman, S. (n.d.). *Biology: A Global Approach, Global Edition*. Pearson Education Limited.

Castellazzi, M.S., Wood, G.A., Burgess, P.J., Morris, J., Conrad, K.F. & Perry, J.N. (2008). A systematic representation of crop rotations. *Agricultural Systems*, 97 (1–2), 26–33. https://doi.org/10.1016/j.agsy.2007.10.006

Crépon, K., Marget, P., Peyronnet, C., Carrouée, B., Arese, P. & Duc, G. (2010). Nutritional value of faba bean (*Vicia faba* L.) seeds for feed and food. *Field Crops Research*, 115 (3), 329–339. https://doi.org/10.1016/j.fcr.2009.09.016

Cuddington, K. (2011). Legacy Effects: The Persistent Impact of Ecological Interactions. *Biological Theory*, 6 (3), 203–210. https://doi.org/10.1007/s13752-012-0027-5

Dániel-Ferreira, J., Berggren, Å., Bommarco, R., Wissman, J. & Öckinger, E. (2022). Bumblebee queen mortality along roads increase with traffic.

Biological Conservation, 272, 109643. https://doi.org/10.1016/j.biocon.2022.109643
Delaune, T., Ouattara, M.S., Ballot, R., Sausse, C., Felix, I., Maupas, F., Chen, M., Morison, M., Makowski, D. & Barbu, C. (2021). Landscape drivers of pests and pathogens abundance in arable crops. *Ecography*, 44 (10), 1429–1442. https://doi.org/10.1111/ecog.05433
Dhull, S.B., Kidwai, Mohd.K., Noor, R., Chawla, P. & Rose, P.K. (2022). A review of nutritional profile and processing of faba bean (Vicia faba L.). *Legume Science*, 4 (3), e129. https://doi.org/10.1002/leg3.129
Eberle, C., Scott, D.A., Forcella, F., Gesch, R.W., Weyers, S., Johnson, J.M.F. & Schneider, S. (2024). Planting date impact on flowering, pollinator visitation and yield of mass flowering oilseed crops in the Northern Corn Belt. *Agricultural and Forest Entomology*, 26 (4), 534–545. https://doi.org/10.1111/afe.12644
Egan, P.A., Dicks, L.V., Hokkanen, H.M.T. & Stenberg, J.A. (2020). Delivering Integrated Pest and Pollinator Management (IPPM). *Trends in Plant Science*, 25 (6), 577–589. https://doi.org/10.1016/j.tplants.2020.01.006
Ekbom, B. (2012). Bönsmyg. Sveriges Lantbruksuniversitet. https://www.slu.se/globalassets/ew/org/inst/ekol/faktablad/faktablad-vaxtskydd/faktablad_vaxtskydd_129_webb.pdf
Etemadi, F., Hashemi, M., Barker, A.V., Zandvakili, O.R. & Liu, X. (2019). Agronomy, Nutritional Value, and Medicinal Application of Faba Bean (*Vicia faba* L.). *Horticultural Plant Journal*, 5 (4), 170–182. https://doi.org/10.1016/j.hpj.2019.04.004
Fan, F., Zhang, F., Song, Y., Sun, J., Bao, X., Guo, T. & Li, L. (2006). Nitrogen Fixation of Faba Bean (Vicia faba L.) Interacting with a Non-legume in Two Contrasting Intercropping Systems. *Plant and Soil*, 283 (1), 275–286. https://doi.org/10.1007/s11104-006-0019-y
Ferrise, R., Triossi, A., Stratonovitch, P., Bindi, M. & Martre, P. (2010). Sowing date and nitrogen fertilisation effects on dry matter and nitrogen dynamics for durum wheat: An experimental and simulation study. *Field Crops Research*, 117 (2), 245–257. https://doi.org/10.1016/j.fcr.2010.03.010
Fogelfors, H. (2017). *Vår mat - Odling av åker- och trädgårdsgrödor i ett klimat under förändring*. 1:3. Studentlitteratur AB.
Fründ, J., Linsenmair, K.E. & Blüthgen, N. (2010). Pollinator diversity and specialization in relation to flower diversity. *Oikos*, 119 (10), 1581–1590. https://doi.org/10.1111/j.1600-0706.2010.18450.x
Gailis, J., Astašova, N., Jākobsone, E. & Ozoliņa-Pole, L. (2022). Biology of broadbean seed beetle (Bruchus rufimanus; Coleoptera: Chrysomelidae) in Latvia. *Acta Agriculturae Scandinavica, Section B — Soil & Plant Science*, 72 (1), 4–16. https://doi.org/10.1080/09064710.2021.1977841
Hausmann, J., Heimbach, U., Gabriel, D. & Brandes, M. (2024). Effects of regional crop rotations on autumn insect pests in winter oilseed rape. *Pest Management Science*, 80 (5), 2371–2382. https://doi.org/10.1002/ps.7716
Holzschuh, A., Dainese, M., González-Varo, J.P., Mudri-Stojnić, S., Riedinger, V., Rundlöf, M., Scheper, J., Wickens, J.B., Wickens, V.J., Bommarco, R., Kleijn, D., Potts, S.G., Roberts, S.P.M., Smith, H.G., Vilà, M., Vujić, A. & Steffan-Dewenter, I. (2016). Mass-flowering crops dilute pollinator abundance in agricultural landscapes across Europe. *Ecology Letters*, 19 (10), 1228–1236. https://doi.org/10.1111/ele.12657
IPBES (2016). *The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production*. Zenodo. https://doi.org/10.5281/ZENODO.3402856
James, R.R. & Pitts-Singer, T.L. (2008). *Bee Pollination in Agricultural Ecosystems*. Oxford University Press, USA.

Jordbruksverket (n.d.). Växtskyddsinfo. Jordbruksverket. https://fou.jordbruksverket.se/vxinfo/answer_skade.php [2024-11-14]

Khalifa, S.A.M., Elshafiey, E.H., Shetaia, A.A., El-Wahed, A.A.A., Algethami, A.F., Musharraf, S.G., AlAjmi, M.F., Zhao, C., Masry, S.H.D., Abdel-Daim, M.M., Halabi, M.F., Kai, G., Al Naggar, Y., Bishr, M., Diab, M.A.M. & El-Seedi, H.R. (2021). Overview of Bee Pollination and Its Economic Value for Crop Production. *Insects*, 12 (8), 688. https://doi.org/10.3390/insects12080688

Kirk, W.D.J. (2004). Faba bean: Vicia faba. *Bee World*, 85 (3), 60–62. https://doi.org/10.1080/0005772X.2004.11099625

Lanan, M. (2021). Extrafloral Nectaries. In: Starr, C.K. (ed.) *Encyclopedia of Social Insects*. Springer International Publishing. 371–375. https://doi.org/10.1007/978-3-030-28102-1_44

Le Féon, V., Burel, F., Chifflet, R., Henry, M., Ricroch, A., Vaissière, B.E. & Baudry, J. (2013). Solitary bee abundance and species richness in dynamic agricultural landscapes. *Agriculture, Ecosystems & Environment*, 166, 94–101. https://doi.org/10.1016/j.agee.2011.06.020

Lundin, O., Malsher, G., Högfeldt, C. & Bommarco, R. (2020). Pest management and yield in spring oilseed rape without neonicotinoid seed treatments. *Crop Protection*, 137, 105261. https://doi.org/10.1016/j.cropro.2020.105261

Lundin, O., Rundlöf, M., Jonsson, M., Bommarco, R. & Williams, N.M. (2021). Integrated pest and pollinator management – expanding the concept. *Frontiers in Ecology and the Environment*, 19 (5), 283–291. https://doi.org/10.1002/fee.2325

Macarulla, M.T., Medina, C., Diego, M.A.D., Chávarri, M., Zulet, M.Á., Martínez, J.A., Nöel-Suberville, C., Higueret, P. & Portillo, M.P. (2001). Effects of the whole seed and a protein isolate of faba bean (Vicia faba) on the cholesterol metabolism of hypercholesterolaemic rats. *British Journal of Nutrition*, 85 (5), 607–614. https://doi.org/10.1079/BJN2000330

Marzinzig, B., Brünjes, L., Biagioni, S., Behling, H., Link, W. & Westphal, C. (2018). Bee pollinators of faba bean (*Vicia faba* L.) differ in their foraging behaviour and pollination efficiency. *Agriculture, Ecosystems & Environment*, 264, 24–33. https://doi.org/10.1016/j.agee.2018.05.003

Mínguez, M.I. & Rubiales, D. (2021). Chapter 15 - Faba bean. In: Sadras, V.O. & Calderini, D.F. (eds) *Crop Physiology Case Histories for Major Crops*. Academic Press. 452–481. https://doi.org/10.1016/B978-0-12-819194-1.00015-3

Norrlund, L. (2022). Hur bra är du på integrerat växtskydd (IPM)? Jordbruksverket.

Olynyk, M., Westwood, A.R. & Koper, N. (2021). Effects of Natural Habitat Loss and Edge Effects on Wild Bees and Pollination Services in Remnant Prairies. *Environmental Entomology*, 50 (3), 732–743. https://doi.org/10.1093/ee/nvaa186

Pedigo, L. & Zeiss, M. (n.d.). *Use of planting date to avoid injury from soybean insect pests*. https://dr.lib.iastate.edu/entities/publication/10f6a488-b6fd-499d-8aa7-490f14200d46 [2024-10-29]

Potts, S.G., Biesmeijer, J.C., Kremen, C., Neumann, P., Schweiger, O. & Kunin, W.E. (2010). Global pollinator declines: trends, impacts and drivers. *Trends in Ecology & Evolution*, 25 (6), 345–353. https://doi.org/10.1016/j.tree.2010.01.007

Power, J.F. & Follett, R.F. (1987). Monoculture. *Scientific American*, 256 (3), 78–87

Raderschall, C.A., Riggi, L.G.A. & Lundin, O. (2024). Insect pollination enhances faba bean yield more than weed removal or fungicide application. *Agriculture, Ecosystems & Environment*, 374, 109159. https://doi.org/10.1016/j.agee.2024.109159

Rands, S.A. & Whitney, H.M. (2011). Field Margins, Foraging Distances and Their Impacts on Nesting Pollinator Success. *PLOS ONE*, 6 (10), e25971. https://doi.org/10.1371/journal.pone.0025971

Rebolledo Ranz, R.E. (2020). *Beekeeping-New Challenges*.

Revilla, I. (2015). Impact of Thermal Processing on Faba Bean (*Vicia faba*) Composition. In: Preedy, V. (ed.) *Processing and Impact on Active Components in Food*. Academic Press. 337–343. https://doi.org/10.1016/B978-0-12-404699-3.00040-8

Riedinger, V., Mitesser, O., Hovestadt, T., Steffan-Dewenter, I. & Holzschuh, A. (2015). Annual dynamics of wild bee densities: attractiveness and productivity effects of oilseed rape. *Ecology*, 96 (5), 1351–1360. https://doi.org/10.1890/14-1124.1

Risberg, J.M. (2008). Gynna humlorna på gården. Jordbruksverket. https://www2.jordbruksverket.se/download/18.4c8614ac1602a4751f88f657/1512999446415/jo08_3v3.pdf

Röös, E., Carlsson, G., Ferawati, F., Hefni, M., Stephan, A., Tidåker, P. & Witthöft, C. (2020). Less meat, more legumes: prospects and challenges in the transition toward sustainable diets in Sweden. *Renewable Agriculture and Food Systems*, 35 (2), 192–205. https://doi.org/10.1017/S1742170518000443

Schieler, M., Riemer, N., Racca, P., Kleinhenz, B., Saucke, H., Veith, M. & Meese, B. (2024). GIS-Based Tool for Pest Specific Area-Wide Planning of Crop Rotation Distance with Land Use Data. *Insects*, 15 (4), 249. https://doi.org/10.3390/insects15040249

Segers, A., Caparros Megido, R., Lognay, G. & Francis, F. (2021). Overview of *Bruchus rufimanus* Boheman 1833 (Coleoptera: Chrysomelidae): Biology, chemical ecology and semiochemical opportunities in integrated pest management programs. *Crop Protection*, 140, 105411. https://doi.org/10.1016/j.cropro.2020.105411

Seidenglanz, M. & Huňady, I. (2016). Effects of faba bean (Vicia faba) varieties on the development of Bruchus rufimanus. *Czech Journal of Genetics and Plant Breeding*, 52 (1), 22–29. https://doi.org/10.17221/122/2015-CJGPB

Singh, R.J. & Jauhar, P.P. (2005). *Genetic Resources, Chromosome Engineering, and Crop Improvement: Grain Legumes, Volume I*. CRC Press.

van der Sluijs, J.P., Simon-Delso, N., Goulson, D., Maxim, L., Bonmatin, J.-M. & Belzunces, L.P. (2013). Neonicotinoids, bee disorders and the sustainability of pollinator services. *Current Opinion in Environmental Sustainability*, 5 (3), 293–305. https://doi.org/10.1016/j.cosust.2013.05.007

Sveriges Officiella Statistik (2024). *Hektar- och totalskörd efter År, Län, Tabelluppgift, Variabel och Gröda. PxWeb*. https://statistik.sjv.se/PXWeb/pxweb/sv/Jordbruksverkets%20statistikdatabas/Jordbruksverkets%20statistikdatabas__Skordar/JO0601J01.px/table/tableViewLayout1/?loadedQueryId=e0c96688-2b9a-40ea-8d1f-be2767fdf167&timeType=from&timeValue=0 [2024-12-10]

Szafirowska, A. (2012). The Role of Cultivars and Sowing Date in Control of Broad Bean Weevil (Bruchus Rufimanus Boh.) in Organic Cultivation. *Vegetable Crops Research Bulletin*, 77. https://doi.org/10.2478/v10032-012-0013-2

Toivonen, M., Herzon, I., Rajanen, H., Toikkanen, J. & Kuussaari, M. (2019). Late flowering time enhances insect pollination of turnip rape. *Journal of Applied Ecology*, 56 (5), 1164–1175. https://doi.org/10.1111/1365-2664.13349

Walther-Hellwig, K. & Frankl, R. (2000). Foraging habitats and foraging distances of bumblebees, Bombus spp. (Hym., Apidae), in an agricultural landscape. *Journal of Applied Entomology*, 124 (7–8), 299–306. https://doi.org/10.1046/j.1439-0418.2000.00484.x

Ward, R.L. (2018). *The biology and ecology of Bruchus rufimanus (bean seed beetle)*. (Thesis). Newcastle University. http://theses.ncl.ac.uk/jspui/handle/10443/4358 [2024-11-14]

Watanabe, N. (1990). Diversity in Life Cycle Patterns of Bruchids Occurring in Japan (Coleoptera Bruchidae). Fujii, K., Gatehouse, A.M.R., Johnson, C.D., Mitchel, R., & Yoshida, T. (eds), Dordrecht, 1990. 141–147. Springer Netherlands. https://doi.org/10.1007/978-94-009-2005-7_16

Williams, N.M., Crone, E.E., Roulston, T.H., Minckley, R.L., Packer, L. & Potts, S.G. (2010). Ecological and life-history traits predict bee species responses to environmental disturbances. *Biological Conservation*, 143 (10), 2280–2291. https://doi.org/10.1016/j.biocon.2010.03.024

Winfree, R., Aguilar, R., Vázquez, D.P., LeBuhn, G. & Aizen, M.A. (2009). A meta-analysis of bees' responses to anthropogenic disturbance. *Ecology*, 90 (8), 2068–2076. https://doi.org/10.1890/08-1245.1

Xiao, Y., Li, X., Cao, Y. & Dong, M. (2016). The diverse effects of habitat fragmentation on plant–pollinator interactions. *Plant Ecology*, 217 (7), 857–868. https://doi.org/10.1007/s11258-016-0608-7

Zheng, X., Koopmann, B., Ulber, B. & von Tiedemann, A. (2020). A Global Survey on Diseases and Pests in Oilseed Rape—Current Challenges and Innovative Strategies of Control. *Frontiers in Agronomy*, 2. https://doi.org/10.3389/fagro.2020.590908

Popular science summary

Promotion of domestic legume cultivation is becoming increasingly important for health, economy and environmental reasons. Animal fodder has for a long time been the main reason for faba bean cropping in Sweden, but in later years faba beans has become an interest for human consumption. The crop is, as many other, exposed to pest pressure and particularly the broad bean beetle *(Bruchus rufimanus)*. Pest control in agriculture is becoming increasingly difficult due to resistance and ban of pesticides. At the same time, pollinators are decreasing due to a history of over-using insecticides and lack of suitable living environments. Cultivation of mass-flowering crops, such as faba beans, could be away to reduce the decline of pollinators.

In this project, I investigated faba bean cultivation and its impact on infestation of the broad bean beetle (*Bruchus rufimanus*) and pollinator activity in faba beans. I also looked at how cover of arable land and the sowing date affects pollinators and pests in faba beans. This was done by inventory of pollinators, counting of broad bean beetle eggs per pod and counting of proportion of beans damaged by *B. rufimanus*.

I found that higher cover of arable land decreases the densities of wild pollinators and increases the managed honeybees. This led med to conclude that the way farmland is managed today, it is not beneficial for important pollinators. The other factors, cover of faba bean and sowing date, did not have an effect on neither pollinators nor pests. Therefore, I conclude that there is a need for further investigation on how farmland should be managed to mitigate pollinator decline and pest infestation.

Appendix

Table A1. Proportion arable land and proportion faba beans for the 15 fields for buffert radii one and three kilometer

	Distance	Arable land (%)	Faba bean (%)
Hästholmen	1000	43	8
Boxholm	1000	3	7
Vikingstad	1000	44	11
Söderköping	1000	28	4
Heda	1000	41	14
Norrköping	1000	23	11
Kättorp	1000	49	6
Askeby	1000	56	7
Skänninge	1000	66	0
Stigtomta	1000	19	0
Finspång	1000	14	0
Vikbolandet	1000	9	0
Orlunda	1000	32	0
Ekholmen	1000	45	0
Skeppsås	1000	74	0
Hästholmen	3000	38	3
Boxholm	3000	8	1
Vikingstad	3000	41	3
Söderköping	3000	2	2
Heda	3000	49	4
Norrköping	3000	13	1
Kättorp	3000	65	5
Askeby	3000	31	2
Skänninge	3000	59	0
Stigtomta	3000	2	0
Finspång	3000	1	0
Vikbolandet	3000	12	0
Orlunda	3000	24	1
Ekholmen	3000	32	1
Skeppsås	3000	68	1

Tabell A2. Pollinator inventory dates

Site	Inventory 1	Inventory 2	Inventory 3	Inventory 4	Inventory 5
Heda	2024-06-18	2024-06-25	2024-06-27		
Hästholmen	2024-06-18	2024-06-25	2024-06-27		
Skeppsås	2024-06-20	2024-06-25	2024-06-27		
Skänninge	2024-06-20	2024-06-25	2024-06-26	2024-07-19	
Askeby	2024-06-24	2024-06-26	2024-07-02		
Boxholm	2024-06-25	2024-06-27			
Stigtomta	2024-06-27	2024-07-02	2024-07-09		
Orlunda	2024-07-01	2024-07-02	2024-07-09	2024-07-12	2024-07-19
Ekholmen	2024-07-02	2024-07-09	2024-07-11	2024-07-12	2024-07-19
Finspång	2024-07-02	2024-07-09	2024-07-10	2024-07-12	
Kättstorp	2024-07-03	2024-07-09	2024-07-11	2024-07-12	2024-07-19
Vikingstad	2024-07-03	2024-07-09	2024-07-19		
Norrköping	2024-07-08	2024-07-09	2024-07-10	2024-07-12	
Vikbolandet	2024-07-09	2024-07-10	2024-07-11	2024-07-12	
Söderköping	2024-07-25	2024-07-29	2024-07-30	2024-08-01	2024-08-02

Tabell A3. Egg collection dates

Site	**Date**	**Year**
Heda	22-jul	2024
Hästholmen	23-jul	2024
Boxholm	23-jul	2024
Skänninge	24-jul	2024
Skeppsås	24-jul	2024
Askeby	25-jul	2024
Stigtomta	26-jul	2024
Ekholmen	29-jul	2024
Orlunda	30-jul	2024
Vikbolandet	2-aug	2024
Vikingstad	5-aug	2024
Kättstorp	9-aug	2024
Finspång	9-aug	2024
Norrköping	9-aug	2024

Tabell A4. Pod collection dates

Field	Date
Skänninge	2024-09-03
Hästholmen	2024-09-13
Heda	2024-09-13
Boxholm	2024-09-13
Skepssås	2024-09-13
Vikbolandet	2024-09-14
Stigtomta	2024-09-21
Ekholmen	2024-09-20
Orlunda	2024-09-20
Kättstorp	2024-09-20
Norrköping	2024-09-20
Finspång	2024-09-21
Askeby	2024-09-20
Vikingstad	2024-09-21
Söderköpng	2024-10-02

Publishing and archiving

Approved students' theses at SLU are published electronically. As a student, you have the copyright to your own work and need to approve the electronic publishing. If you check the box for **YES**, the full text (pdf file) and metadata will be visible and searchable online. If you check the box for **NO**, only the metadata and the abstract will be visible and searchable online. Nevertheless, when the document is uploaded it will still be archived as a digital file. If you are more than one author, the checked box will be applied to all authors. You will find a link to SLU's publishing agreement here:

- https://libanswers.slu.se/en/faq/228318.

☒ YES, I hereby give permission to publish the present thesis in accordance with the SLU agreement regarding the transfer of the right to publish a work.

☐ NO, I/we do not give permission to publish the present work. The work will still be archived and its metadata and abstract will be visible and searchable.