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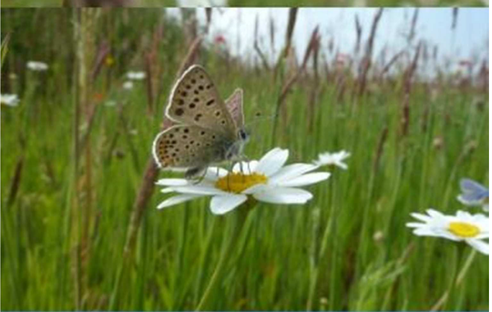

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Research Ecology Group (WUR)

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Effect of experimentally adding mixtures of flowering plants on the local abundance and diversity of wild bees, hoverflies and butterflies in Dutch landscapes

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Preface

This Bachelor thesis has been written for Wageningen University (WUR), Van Hall Larenstein University (VHL) and Dutch Butterfly Conservation (DBC). The described research is part of a project that the WUR started in 2012. This project focuses on how to mitigate the negative effects of floral resource limitation on insect pollinators in Dutch agricultural landscapes.

The research was offered to me by Tibor Bukovinszky (WUR) and Ties Huigens (DBC) after an internship I did on the same project in 2012. Finding a project for my bachelor thesis was not easy at that moment and therefore I would very much like to thank both Tibor and Ties for giving me this chance. The research done for this thesis would not have been completed without the help of my colleagues Esther Klop and Jacob Nugteren. They helped me with my fieldwork that I would not have completed in time without their help. I would like to thank Freek Rensen (VHL) for his help with the writing of the thesis and his mentoring work during this bachelor thesis. He mentored me during this bachelor thesis and always replied quickly by mail or phone call. At Last I would like to thank friends and family who have supported me during the thesis or have had a critical look at my report.

The research has provided insight into the effect of sowing flower mixtures on the diversity and abundance of flower-visiting insects. During the research my knowledge of hoverflies, bees and plants has increased. Finally, this thesis project offered me the opportunity to increase my understanding of the statistical program SPSS and the use of different statistical methods to answer ecological research questions.

R. de Greeff

Wageningen: December 2013

Summary

In Europe there is a general alarming decline of flower-visiting insects like wild bees, hoverflies and butterflies. These flower-visiting insects play an important role in the pollination of flowering plants. This role is of great importance in the agricultural sector and in nature conservation. Decline in nectar offer is a possible cause for this insect decline. However, research on the relation of decline in nectar offer and the decline of flower-visiting insects is still very few. The main goal of this research was to determine the effect of the flower mixtures on the three insect groups.

For this thesis, the effect of the measure taken by the WUR (Sowing flower mixtures), was researched for three different insect groups. The flower mixtures varied in the composition of flowers, and the insect group it was composed for. The bee mixture consisted of mainly difficultly accessible flowers and is composed for wild bees. The parasitoid mixture consisted of mainly *Umbelliferae* and is composed for insects that need easily accessible nectar like hoverflies. The sowed areas varied from 1795.04 m² to 24476.62 m².

The research was spread out over 3 different fieldwork rounds in June, July and late August/begin September 2013. During these three rounds each of the locations was visited. Per location, insect and plant surveys were done in ten transects that were present within two different flowering fields. Butterflies were counted and determined in the field. Hoverflies and wild bees were caught with a net for later determination in the laboratory. All the insects that were seen but not caught were written down. Also the amount of flowers per plant species was written down during the surveys.

Most common insect group was the hoverflies with 727 individuals belonging to 20 species. After that the order was, wild bees (597 individuals belonging to, 6 species of *Bombus* and 6 other genera) and butterflies (386 individuals belonging to 26 species). Also 58 flowering plant species were found in the two flower mixture.

the type of flower mixtures had a significant effect on the abundance of all the insect groups and diversity of wild bees and butterflies. The insect groups clearly preferred the one or the other mixture. The area size of the measure (flower abundance in m²) also had a significant effect on the abundance and diversity of the insect groups. Moreover, the diversity of plant species had an effect on the abundance and even bigger effect on the diversity of the insect groups.

From these results I could conclude that the different flower mixtures, the size of the measure and the flower diversity had an effect on both the abundance and diversity of the three different insect groups. In the future, nature organizations can sow different flower mixtures to increase the abundance and diversity of flower-visiting insects. Furthermore, some subsequent research can be done to investigate the effect of the surroundings for the abundance and diversity of flower-visiting insects.

Samenvatting

In Europa is sprake van een algemene en alarmerende achteruitgang van bloembezoekende insecten zoals wilde bijen, zweefvliegen en vlinders. Deze insecten spelen een belangrijke rol bij de bestuiving van bloeiende planten. Deze bestuiving is ontzettend belangrijk voor de agrarische sector en natuurbeheer. Achteruitgang van het aanbod van nectar is een mogelijke verklaring voor de achteruitgang van de insecten. Onderzoek over de relatie van de achteruitgang in het aanbod van nectar en de achteruitgang van de insectengroepen is er echter nog zeer weinig. Het doel van dit onderzoek was om het effect van de bloemenmengsels op de drie insectengroepen aan te geven.

Voor dit onderzoek werd het effect dat de maatregel (zaaien van bloemenmengsels), die door de WUR genomen was, had op de insectengroepen onderzocht. De bloemenmengsels verschilden in de samenstellingen van bloemen en voor welke insectengroep het mengsel bedoeld was. Het bijenmengsel bestond voornamelijk uit moeilijk toegankelijke bloemen en is samengesteld voor wilde bijen. Het parasietenmengsel bestond voornamelijk uit schermbloemigen en is bedoeld voor insecten die toegankelijke bloemen nodig hebben zoals zweefvliegen. De groottes van de ingezaaide vlakken varieerden van 1795.04 m² tot 24476.62 m².

Het onderzoek werd gedaan in 3 verschillende veldwerkrondes in juni, juli en eind augustus/begin september 2013. Tijdens deze rondes werden alle locaties eenmaal bezocht. Per locatie werden tien transecten geselecteerd in de twee bloemenvelden, hierin werden de insecten en planten geteld. Vlinders werden in het veld geteld en gedetermineerd, zweefvliegen en bijen werden gevangen met een net om later in het lab te determineren. Insecten die niet gevangen maar gezien werden, werden opgeschreven. Het aantal bloemen per plantensoort werd in dezelfde transecten gedaan.

De meest gevangen groep was de zweefvliegen met 727 individuen behorend tot 20 soorten. Daarna was de volgorde, wilde bijen (597 individuen behorend tot 6 soorten *Bombus* en 6 andere genussen) en vlinders (386 individuen behorend tot 26 soorten). Ook werden er 58 plantensoorten gevonden in de twee bloemenmengsels.

Het soort bloemenmengsel had een significant effect op de talrijkheid van alle insectengroepen en de diversiteit van wilde bijen en vlinders. De insectengroepen kozen duidelijk voor het ene of het andere mengsel. De grootte van het inzaaien (bloemenrijkheid in m²) had ook een significant effect op de talrijkheid en diversiteit van de insectengroepen. Bovendien had de diversiteit aan planten een effect op de talrijkheid en zelfs een groter effect op de diversiteit van de insectengroepen.

Met deze resultaten kon in concluderen dat de verschillende bloemenmengsels, de grootte van de maatregel en de soortenrijkdom aan bloemen een effect hadden op de talrijkheid en diversiteit van de insectengroepen. Natuurbeschermingsorganisaties kunnen dus verschillende bloemenmengsels inzaaien om zo de talrijkheid en diversiteit aan insecten te verhogen. Ook kan er nog aanvullend onderzoek gedaan worden om het effect van de omgeving te toetsen op de talrijkheid en diversiteit van de insectengroepen.

Inhoud

List of figures and tables

1. Introduction

Recent studies have shown declines in different groups of flower visiting insects like, wild bees, hoverflies and butterflies (Biesmeijer et al. 2006). These declines are most likely caused by a loss of habitat quantity and quality as well as a range of other potential other causes like, for example, pesticides (Corbet et al. 1992). A recent study shows butterfly declines can be linked to a substantial decline in overall flower abundance and specific nectar plants (Wallis de Vries et al. 2012). Not only butterfly declines can be linked to the decline of flower abundance, wild bees and hoverflies also can be linked to this decline in flowers and nectar abundance (Biesmeijer et al. 2006) In this research I want to investigate the effects of flower supply on three groups of flower-visiting insects that depend on flowering plants in one way or another.

The three insect groups chosen for this research are; wild bees, hoverflies and butterflies. Wild bees are fully dependent on flowering plants, nectar serves as an energy source and pollen allows them to reproduce (Westrich 1996). Hoverflies need flowering plants for the nectar and pollen. Their larvae, however, do not need floral resources to complete their development. There are two types of hoverfly larvae, aphidophagues feed on plant lice and saprophytic species feed on decaying plant material (Reemer et al. 2013). Hoverflies are therefore not only dependent on flowering plants. Butterflies use plants to reproduce, caterpillars all have their (species specific) host pants on which they feed in this stage, adults however, need nectar from flowers as an energy source (Wynhoff et al. 2009). These three insect groups, in particular wild bees, also play a role in the pollinating of plants. Therefore they are very important in the agricultural sector and in ecosystems (Potts et al. 2007, Biesmeijer et al. 2006). The decline of these species groups is not only dangerous for the biodiversity of insects in Europe, but also for the pollinating of plants.

The three insect groups chosen for this research have different needs when it comes to flowering plants. The insect groups have different tools to access the nectar or pollen they need. Wild bees and butterflies are specialized flower-feeders (Peeters et al. 2013, Wynhoff et al. 2009), hoverflies, however, are no specialized flower feeders (Reemer et al. 2013). To investigate the effects of adding floral recourses, flower mixtures (Campbell et al. 2012) had to be chosen to answer to the needs of the three insect groups. Two flower mixtures were selected, mixture 1 (the bee mixture) mostly has flowers (*Trifolium incarnatum, Centaurea jacea, Papaver rhoeas*) that are difficultly accessible and thus suitable for wild bees and butterflies. Mixture 2 (the parasitoid mixture) mostly had umbel plants (*Anethum graveolens, Pastinaca sativa*) that are easily accessible and therefore suitable for hoverflies (see table 1 for full composition of the two mixtures).

In 2011, the WUR started a research on the effect of experimental adding flower resources on agricultural landscapes on wild pollinators (Kleijn 2011). The research also investigates the effectiveness of pollinating by wild bees. In this research, ten different locations in the Netherlands were selected to sow the flower mixtures on. The locations were all sowed with the two different flower mixtures (bee mixture and parasitoid mixture). This research concentrates on these ten different locations that are selected in the Netherlands.

1.1 Main research aim and research question

In this thesis I study the effect of different sown flower mixtures on the diversity and abundance of wild bees, hoverflies and butterflies. The mixtures are sown on ten different locations, two mixtures are sown on the fields and these fields vary from 1795.04 m^2 to 24476.62 m^2 per mixture. The aim of this research is to get insight in the effect of the different flower mixtures and the size of the sowed area on the different insect groups. the report investigates the preference the different insect groups have concerning the two types of flower mixtures. Also, this report investigates the effect of the size of the sowed area on the abundance and diversity of the insect groups. At last the research investigates the effect the amount of plant species has on the abundance and diversity of the different insect groups.

The main question for this research is: What is the effect of the different types of flower mixtures and the different area sizes of the flower mixtures on the abundance and diversity of wild bees, hoverflies and butterflies? In this research I will use four sub questions that are derived from the main question, also I will provide some hypotheses for these sub questions.

1.2 Sub questions and hypotheses

1 Do the different flower mixtures affect the abundance of the flower visiting insects?

The two flower mixtures are not the same as they differ in composition of species. The insect groups will react differently to the two flower mixtures according to their needs (Campbell et al. 2012). The first flower mixture consists of difficultly accessible flowers, therefore this mixture will most likely attract more individuals of wild bees and butterflies. The second mixture consists of easily accessible flowers and will most likely attract more individuals of hoverflies.

2 Do the different flower mixtures affect the diversity of the flower visiting insects?

For this sub question, the same hypothesis can be used as for the first sub question. The flower mixtures differ in composition and therefore, the insect groups will react differently to the flower mixtures.

3 What is the effect of the different area sizes of sowed flower mixtures on the abundance of flower-visiting insects?

The insects will react to the added recourses concerning the recourse concentration hypothesis (Root 1973,). This hypothesis predicts that the abundance of specialist herbivore insect species will increase when a patch of the host plant increases. The insect groups will react to an increase of recourses. However in this research I investigate three different insect groups, these insect groups will react differently to the added floral recourses (Bukovinszky et al. 2005, Hamback & Englund 2005). Wild bees are central place foragers (Westrich 1996), they can explore and learn the landscape, therefore I expect they will aggregate on the most profitable flower mixture (the bee mixture). Butterflies and hoverflies, however, are no central place foragers and will not stay at one site (Wynhoff 2009, Reemer 2013). They may in fact, never return to the field they have been to after they leave.

4 What is the effect of the different area sizes of sowed flower mixtures on the diversity of flower-visiting insects?

The hypothesis for the third sub question also applies to this sub question. the thought is that the area size of the sowed area will affect the diversity of the flower-visiting insects. The thought is that a larger patch of floral recourses will result in a higher diversity of insects. In 2012 a research in the same project was done on the effect of floral resources on the abundance and diversity of butterflies (de Greeff 2012). The diversity of butterflies increased with a larger patch of floral resources. I expect that a bigger patch of floral resources will also result in a higher diversity of wild bees and hoverflies.

5 What is the effect of plant diversity on the different insect groups?

An higher amount of plant species will most likely affect the diversity of the butterflies. Butterflies need foraging plants in the caterpillar stage (Wynhoff et al. 2009). All butterfly species have their own specific foraging plants, therefore I expect that a higher diversity of plants will result in a higher diversity of butterflies. The wild bees and hoverflies are not dependent on specific plant species, therefore I expect that the plant diversity will not have a big effect on the abundance and diversity of these two insect groups.

2. Technique and methods

The goal was to get to know the effect of the sown flower mixtures on the abundance and diversity of wild bees, hoverflies and butterflies. At first information had to be gathered about the abundance and diversity of the flowers in the flower mixtures. The abundance of flowers was needed to calculate the area of flowers in the flower mixtures. After this, information was gathered about the diversity and abundance of the wild bees, hoverflies and butterflies. At last this information was used to do statistical analyses with the program SPSS.

2.1 Locations

The research was going to take place on the different locations that were selected by the WUR in 2011. The flower mixtures were sown on ten different locations throughout the Netherlands in the provinces Noord Brabant, Limburg, Gelderland and Utrecht.

Figure 1: Locations of fieldwork in the Netherlands (© Google Earth)

At each location, the two flower mixtures were sown in adjacent fields, these fields can be viewed in appendix 1. The flower mixture typically contain species that are suitable for one or more of the insect groups. The bee mixture has plant species that have flowers that are not easy to access. The hoverfly mixture however has plants (typically umbels) that are easy to access. The seedstock for sowing was of standarised composition for both mixtures (table 1). In the table, the plant species and proportions per plant species are shown per flower mixture. The table also shows the way of counting the flowers (Flower, umbel, stalk etc.).

Table 1: Flower mixtures: species, proportions and counting method

Mixture 1 (Bee)

Scientific name	Proportion	Count per
Trifolium incarnatum	0.25	flower head
Trifolium pratense	0.01	flower head
Tanacetum vulgare	0.1	umbel
Malva sylvestris	0.1	flower
Borago officinalis	0.1	flower
Papaver rhoeas	0.1	flower
Centaurea jacea	0.1	flower
Hypochaeris radicata	0.1	flower
Lotus corniculatus	0.01	flower head
Crepis biennis	0.05	flower
Onobrychis viciifolia	0.08	raceme

Mixture 2 (Parasitoid)

Scientific name	Proportion	Count per
Anethum graveolens	0.1	umbel
Foeniculum vulgare	0.1	umbel
Pastinaca sativa	0.1	umbel
Fagopyrum esculentum	0.4	raceme
Angelica sylvestris	0.05	umbel
Achillea millefolium	0.1	umbel
Cichorium intybus	0.1	flower
Anthriscus sylvestris	0.05	umbel

Figure 2: Examples of flowering mixture, Mixture 1 (left) and Mixture 2 (right) Photo's: © Roel de Greeff

2.2 Insect fieldwork

To gather information about the butterflies, wild bees and hoverflies, there had to be a standardized way to gather data in the field. Therefore a method has been chosen that is best described as, the 'virtual cage method' (van Swaay et al. 2011). This method uses a virtual cage wherein the observer walks a transect and writes every single individual of the species he/she finds, down. First the observer will write down the abundance and diversity of flowers in this virtual cage, after that the observer will walk this transect forward and back and writes down the species and abundance of butterflies.

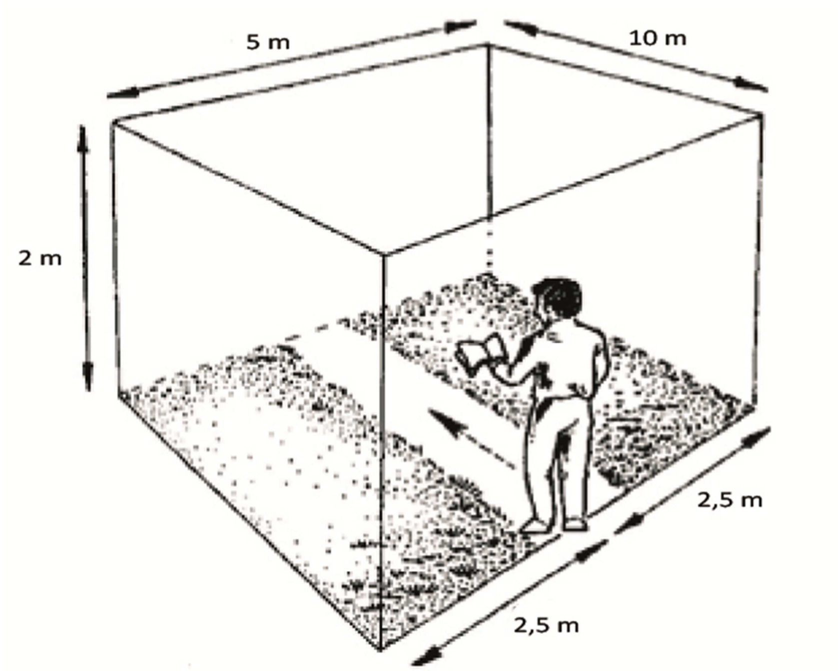

Figure 3: Virtual cage method (Van Swaay et al. 2011)

The same virtual cage also was used to gather data on the wild bees and hoverflies. Walking the same transect, the observer will search for wild bees and hoverflies, when spotting one of these insects he or she will catch the insect with a sweep net. The wild bees and hoverflies were only caught when visible and when resting or foraging on flowers. Butterflies however, were also counted when they only flew inside the virtual cage. After catching, the insect would be put in a plastic bottle with 70% ethanol to conserve the insect. These plastic bottles were stored in a refrigerated place to preserve the specimens until they could be determined.

2.3 Determination of species

After collecting the specimens of wild bees and hoverflies in the flower mixtures, these specimens had to be determined to get knowledge of the biodiversity in the flower mixtures. The wild bees were determined on genus level, however, the genus Bombus was determined on species level. The hoverflies were all determined on species level. This was done by pinning them on Styrofoam, after that, the individuals that seemed to be the same species were put down together, every specimen was labeled with a date, the location, the flower mixture and the transect it was caught on. After this, the specimens all were determined with the help of insect guides (A. Schulten 2013, Peeters et al. 2013) and insect determining keys. The wild bees were determined on genus level because of the little experience from the researcher on this insect group.

2.4 Flower fieldwork

In each sowed area, the flowers in a transect of ten by five meters were counted. The flowers were counted according to the fieldwork protocol of STEP (**S**tatus and **T**rends of **E**uropean **P**ollinators) (Holzschuh 2011). In principle, the flowers were counted one by one, however, flowers that are placed in flower heads, umbels, stalks and racemes were counted per flower head, umbel, stalk or raceme (table 1). The counting of flowers in the transects was done until all the flowers were counted and determined. For the butterflies, bees and hoverflies there was a limited time of 5 min per transect for the bees and hoverflies and 5 minutes per transect for the butterflies.

To answer the sub questions three and four, there had to be information about the total area of flowers. Therefore the amount of flowers had to be multiplied by the area each flower covers. After all flower areas of all the transects have been calculated, another calculation has to be done to extrapolate the flower area to the whole sowed area. This resulted in the following calculation:

$$Total\ flower\ area = \frac{Total\ sowed\ area}{Total\ area\ of\ the\ transects} \times \left(\sum Flower\ area\ per\ transect\right)$$

To gather enough data, the locations were visited three times, every time 10 transects would be selected randomly in the sowed areas, 5 in the bee mixture and 5 in the parasitoid mixture. This will provide the best picture about the whole sowed area. The visits of the locations were done in three different months, the first round of visits was in June, the second in July and the third in late August/ early September.

2.5 Statistical analysis

After collecting the data, a statistical analysis was done with the program SPSS on the computer. First, all the data had to be put into excel files. These excel files contain information about every individual transect. Every transect has information about which round it is, how many plant species, flower, insect species and individuals the transect contains. The area of flowers was then calculated according to the calculation in paragraph 2 'flower fieldwork'

After these calculations, the statistical analysis was done using SPSS (IBM inc.). To answer the sub questions one and two about the effect the different flower mixtures have on the abundance and diversity of the flower visiting insects, a test of correlation and a paired samples t-test was used. The test of correlation tells if the two flower mixtures are correlated with each other, in other words, if one flower mixture has a higher abundance of insects, and the other mixture has the same, then the two flower mixtures are correlated. The mixtures per location are paired, therefore it is important to check the correlation of these two mixtures. Also bar chart graphs were made to visibly show the differences between the two mixtures.

To answer the questions three and four about the effect of area size of the flower mixture on the abundance and diversity of the insect groups, an ANCOVA (analysis of covariance) test was done. This test takes in account multiple variables when testing the data on a correlation between area size of the flowers in the sowed areas and the abundance or diversity of the different insect groups. To execute the ANCOVA-test, the normality of the data had to be checked (Appendix 2 and 3). The abundance of the insect groups is normally distributed, however, the data was Log-transformed to meet the normality assumption for statistical work. After this, correlation graphs were made to visually show the correlation between the area of flowers and the abundance or diversity of insects. All tests were carried out at the significance level of $\alpha <= 0.05$. To answer sub question 5, graphs of correlation were made in SPSS.

3. Results

During the summer of 2013, ten different locations were visited three times, this resulted in 300 transects that were surveyed for the presence of wild bees, hoverflies and butterflies. During these three rounds, 58 plant species, 26 butterfly species and 20 hoverfly species were found. From the group of wild bees 6 different species of the genus Bombus were found, as well as 6 other genuses (The species lists can be found in appendix 1). Also a lot of Honey bees were found during these three rounds, honey bees however are not included in the statistical analysis.

In total, Hoverflies were the most abundant species group in the transects (727 individuals), Wild bees were the second most abundant species group (597 individuals) and butterflies were the third and last most abundant species group (387 individuals). Figure 4 shows some examples of species that were found in the transects during these inventory rounds.

Figure 4: Examples of species found (clockwise*) Argynnis aglaja*, *Syrphus spec.*, *Apis mellifera*, *Andrena spec*.
Photo's: © Roel de Greeff

3.1 Do the different flower mixtures affect the abundance of flower visiting insects?

To determine whether the different flower mixtures have an effect on the different flower visiting insect groups, a test of correlation and a paired samples t-test were used. This t-test, other than the different samples t-test, takes into account that the transects in the bee mixture and parasitoid mixture, for example in America, are paired. Therefore this test reduces the effect of observations with coincidental high numbers of insects.

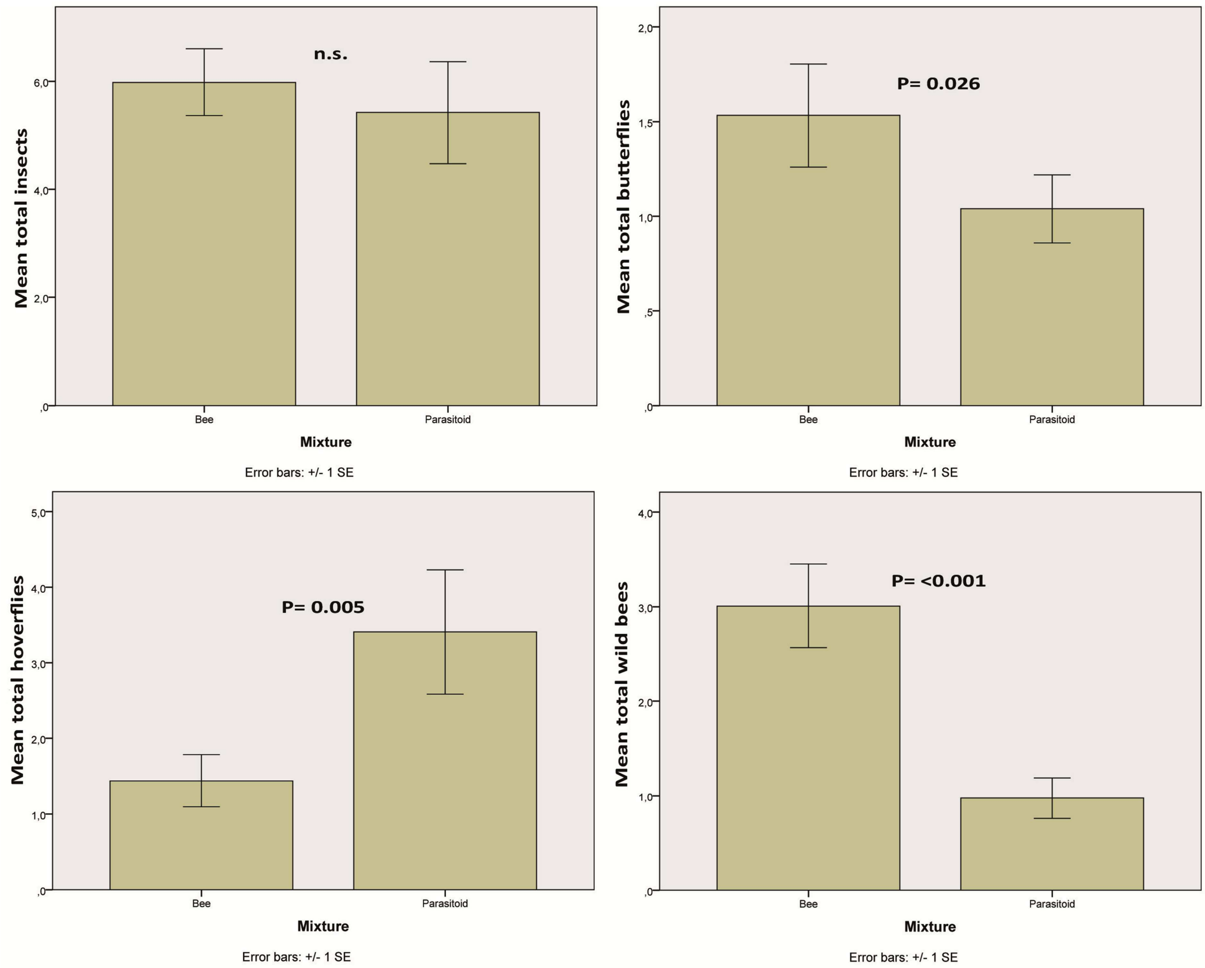

Figure 5: Bar charts for the differences between the two flower mixtures, on the x-axis, the two different flower mixtures are shown and on the y-axis, the mean total of the insect group / insect groups combined is shown

Figure 5 shows the abundances of the three insect groups and of the total amount of insects, it compares the abundance in the bee mixture with the abundance in the parasitoid mixture. The abundance of the total amount of insects is not significantly different (P-values are infigure 5). For the three insect groups separately however, there is a significant difference in which flower mixture the insects prefer. The Hoverflies prefer to forage on the parasitoid mixture, whereas the bees and butterflies prefer the bee mixture.

Table 1 shows the test of correlation for the correlation the two mixtures have on the abundance of the insects. Because the fieldwork was done in different parts of the Netherlands, it is important to check the correlation of the two flower mixtures. If on one location, the bee mixture scores higher in the abundance of insects, the same will go for the parasitoid mixture.

Table 2: Test of correlations for the mean totals of the insects in the two mixtures. Pair one is the mean total of butterflies, pair two is the mean total of hoverflies and pair three is the mean total of wild bees.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Tot_Butt_Mean_Bee & Tot_Butt_Mean_Parasitoid	30	,631	,000
Pair 2	Tot_Hov_Mean_Bee & Tot_Hov_Mean_Parasitoid	30	,673	,000
Pair 3	Tot_Bee_Mean_Bee & Tot_Bee_Mean_Parasitoid	30	,536	,002

Table 2 shows the output of the paired samples t-test on the abundance of the three insect groups. In this table, the flower mixtures are significantly affecting the abundance of all the insect groups. The butterflies show that they have a slight preference ($p = 0.026$) for the bee mixture. The hoverflies show that they have a big preference ($p = 0.005$) for the hoverfly mixture. The last group, the bees, show that they have a very high preference for the bee mixture ($p = <0.001$). These results are shown in Figure 5.

Table 3: Output of the paired samples t-test, pair one is the mean total of butterflies, pair two is the mean total of hoverflies and pair three is the mean total of wild bees.

Paired Samples Test

		Paired Differences			t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean			
Pair 1	Tot_Butt_Mean_Bee - Tot_Butt_Mean_Parasitoid	,4933	1,1552	,2109	2,339	29	,026
Pair 2	Tot_Hov_Mean_Bee - Tot_Hov_Mean_Parasitoid	-1,9667	3,5167	,6421	-3,063	29	,005
Pair 3	Tot_Bee_Mean_Bee - Tot_Bee_Mean_Parasitoid	2,0333	2,0484	,3740	5,437	29	,000

3.2 Do the different flower mixtures affect the diversity of flower visiting insects?

To answer the second sub question, the same paired samples t-test was done on the diversity of flower visiting insects as for the abundance. The results are shown in figure 6, Table 3 and Table 4.

Figure 6 shows which flower mixture scores higher for the diversity of butterflies, hoverflies, wild bees and total insects. Just as the abundance, there is no significant difference for the total amount of insect species on the two different flower mixtures. The figure shows that the butterflies score a higher diversity in the bee mixture than in the parasitoid mixture. The wild bees have a much higher diversity in the bee mixture than in the parasitoid mixture.

The hoverflies however show an overlap in the error bars, the t-test shows (table 5) that the difference is not significant. The two mixtures scored somewhat the same on the diversity of hoverflies. There was no significant difference for the total amount of insects.

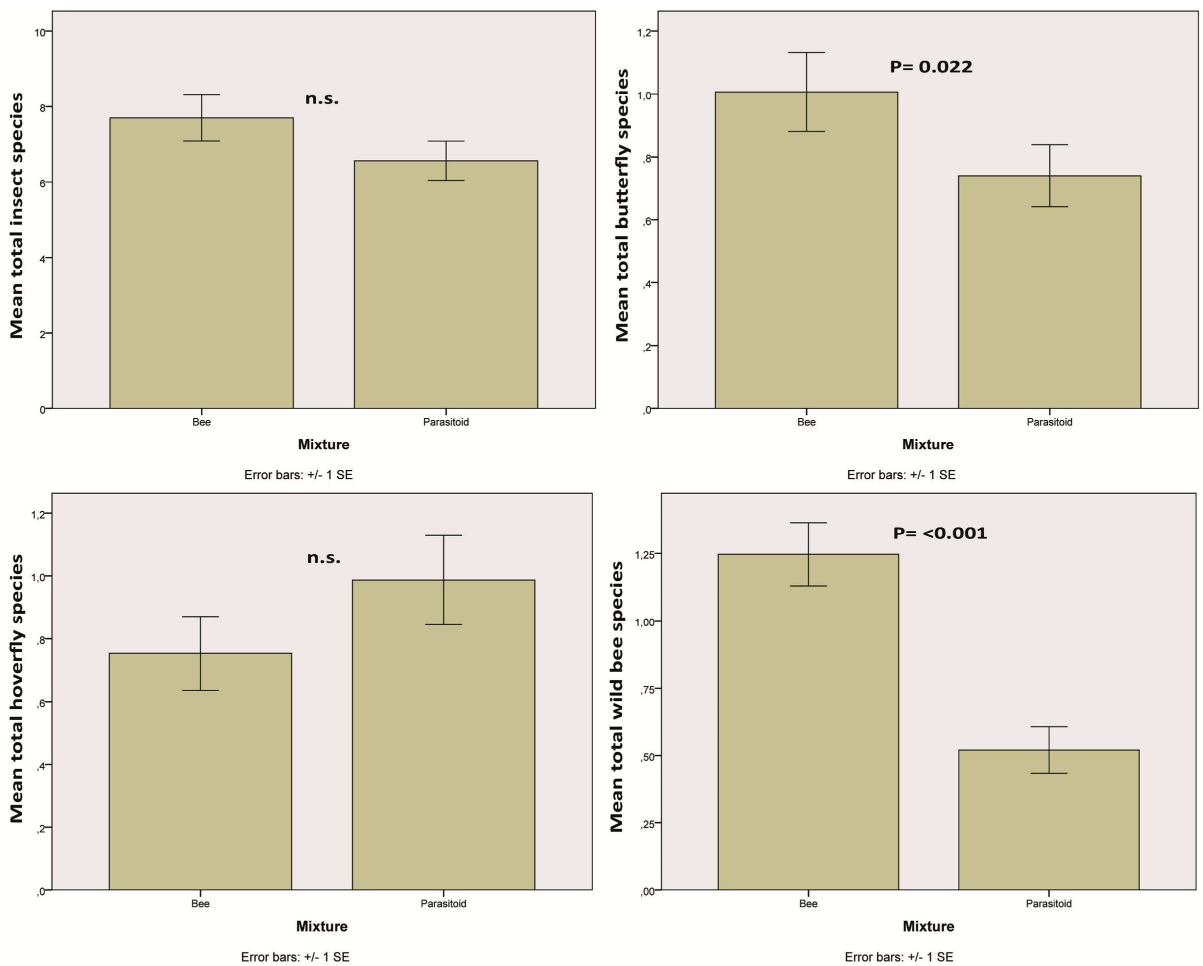

Figure 6: Bar charts for the differences between the two flower mixtures, on the x-axis, the two different flower mixtures are shown and on the y-axis, the mean total of the insect species per insect group / insect groups combined is shown

The test of correlations (Table 4) shows that per location, there was a significant correlation between the two flower mixtures in the number of insect species for all the three insect groups. If one mixture scores high on the amount of wild bee, hoverfly or butterfly species, the other mixture will score high too.

Table 4: Test of correlations for the mean totals of the insect species in the two mixtures. Pair one is the mean total of butterfly species, pair two is the mean total of hoverfly species and pair three is the mean total of wild bee species.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 4	Tot_Butt.sp_Mean_Bee & Tot_Butt. sp_Mean_Parasitoid	30	,542	,002
Pair 5	Tot_Hov.sp_Mean_Bee & Tot_Hov. sp_Mean_Parasitoid	30	,361	,050
Pair 6	Tot_Bee.sp_Mean_Bee & Tot_Bee. sp_Mean_Parasitoid	30	,513	,004

The significances for the paired samples t-test (Table 5) show that the different flower mixtures have a significant effect on the butterflies (significance = 0,022) and bees (significance <0,000). For the hoverflies however, the test shows that the significance (0,126) is not enough (<0,05) to say that the flower mixtures have an effect on the diversity of hoverflies. The bar graphs in figure 5 show virtually per insect group which flower mixture scores higher on the diversity than the other. In the graphs, the significance is indicated with 'n.s.' (not significant) or the P-value.

Table 5: Output of the paired samples t-test, pair one is the mean total of butterflies, pair two is the mean total of hoverflies and pair three is the mean total of wild bees.

Paired Samples Test

		Paired Differences			t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean			
Pair 4	Tot_Butt.sp_Mean_Bee - Tot_Butt. sp_Mean_Parasitoid	,2667	,6019	,1099	2,427	29	,022
Pair 5	Tot_Hov.sp_Mean_Bee - Tot_Hov. sp_Mean_Parasitoid	-,2333	,8104	,1480	-1,577	29	,126
Pair 6	Tot_Bee.sp_Mean_Bee - Tot_Bee. sp_Mean_Parasitoid	,7267	,5693	,1039	6,991	29	,000

3.3 What is the effect of the different area sizes of sowed flower mixtures on the abundance of flower visiting insects?

To answer this question, first the area sizes of the flowers had to be calculated. The calculation used for this is explained in the chapter Technique and methods. For example, the parasitoid mixture of the first round in America had 0,123, I,122, 0,117, 0,032 and 0.111 m² of flowers in the 5 transects in the parasitoid mixture. These 5 transects together were 250 m², the total sowed area of this mixture was 48953.236 m². After that, the following calculation was made to extrapolate the area of flowers:

$\frac{48953.236}{250} \times (\sum 0.1230 : 0.122 : 0.117 : 0.032 : 0.111 = 49.302\ m^2)$ flower area
This was done for all the rounds and both of the flower mixtures on all the locations.
The data was checked for normality (appendix 2) and log-transformed to meet the normality assumption. Table 6 gives information about the ANCOVA-test that was done to answer this sub question. The values for the significance show whether the area of flowers affects the other variables.

The table (Table 6) shows that the area size of flowers has an effect on the abundance of the different insect groups. The significance (P= 0.036 = <0.05) states that the area size of flowers has an effect on the insect groups. The table also shows (Group * Mixture) that there is an effect (P= <0.001) of the mixture on the distribution of the abundance of the insect groups. This is the same as the paired samples t-test shows. Also the catch has an effect (P= 0.001) on the abundance of the insect groups. The catch is related to the time of the year.

Table 6: Significances of the ANCOVA-test for the abundance. Fl_Ab_Field_mean is the mean of the flower abundance (m²) in the flower fields. Catch is the fieldwork rounds, group is the insect groups. mixture is the two mixtures, Group*Mixture is the interaction between the insect group and the flower mixture.

Tests of Between-Subjects Effects

Dependent Variable: LnAbundance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Catch	4.577	2	2.289	7.024	.001
Group	1.314	2	.657	2.017	.136
Mixture	1.495	1	1.495	4.587	.034
Fl_Ab_Field_mean	1.461	1	1.461	4.483	.036
Group * Mixture	8.088	2	4.044	12.411	.000

a. R Squared = .241 (Adjusted R Squared = .206)

To check whether the flower area size has a positive or negative effect graph were made. The test (table 6) shows the values for the effect the area size of flowers has on the insect groups. The following graph (Figure 7), however, visually shows the correlation of the area size of flowers and the different insect groups.

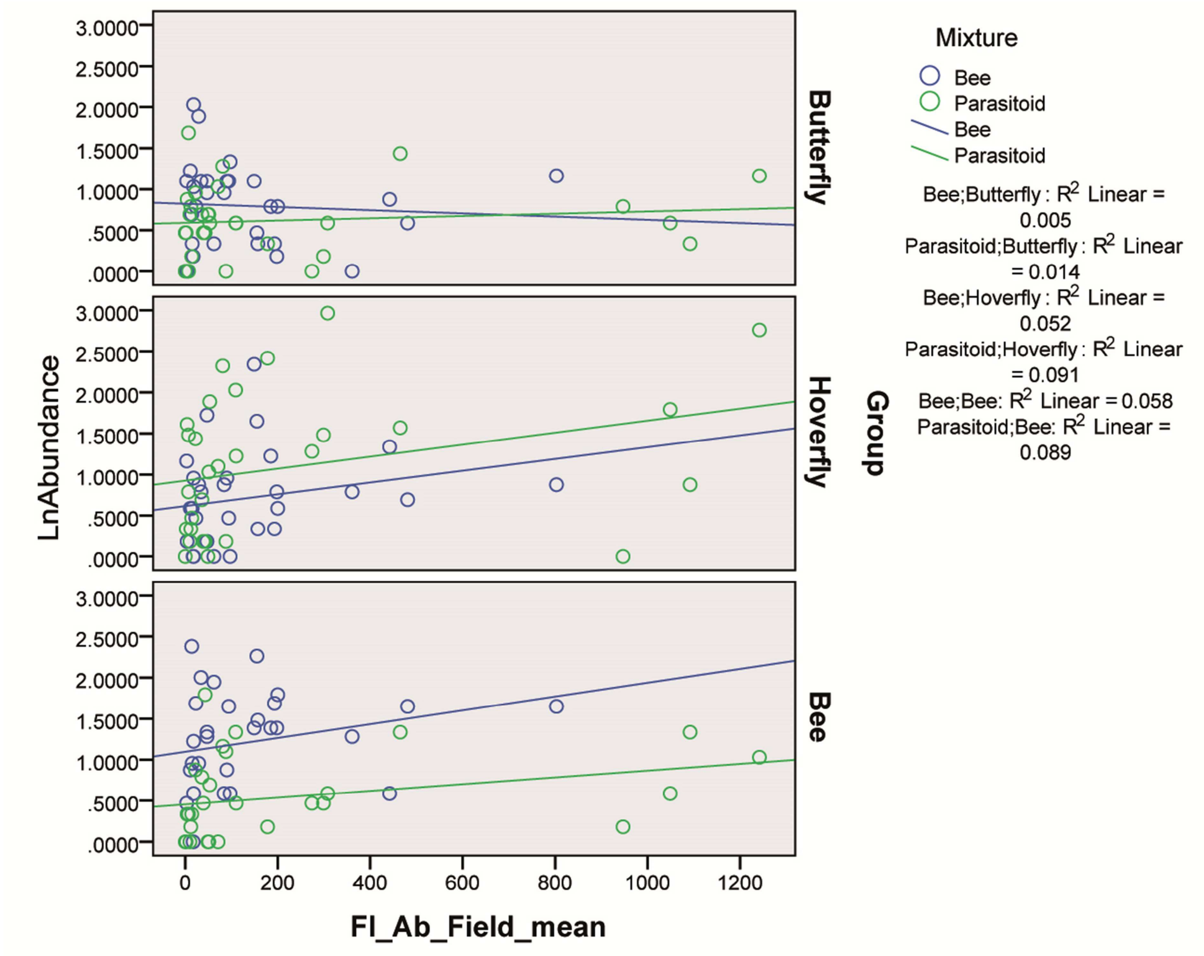

Figure 7: Correlation of size of flower fields and abundance of insect groups The blue circles and lines stand for the bee mixture, the green circles and lines stand for the parasitoid mixture. On the Y-axis number of insects per group is shown and on the X-axis, the area (m²) of flowers is shown.

Figure 7 shows the effects of the area (m²) of the flower fields on the abundance of the different flower visiting insect groups. Some interesting differences are shown in the graphs. The graph seems to show that the wild bees and hoverflies have a positive correlation with the area size of the flower fields. If the area of flowers goes up, the abundance of hoverflies and wild bees goes up too. However, the graph seems to show that the butterflies do not show a positive correlation with the area size of the flower fields. The abundance of butterflies stays somewhat the same in a small or big area of flowers.

3.4 What is the effect of the different area sizes of sowed flower mixtures on the diversity of flower visiting insects?

To test the effect of the flower area size on the diversity of the three different insect groups, the same calculations and ANCOVA-test were done as for the abundance of the insect groups. The data on the diversity of the insects was Log –transformed. This Log-transformation was done so that the test was ran without any zero's. Table 5 is the result of this ANCOVA-test. In appendix 3, the test of normality is shown for the diversity of the insect groups.

Table 7: Significances of the ANCOVA-test for the diversity. Fl_Ab_Field_mean is the mean of the flower abundance (m^2) in the flower fields. Catch is the fieldwork rounds, group is the insect groups. mixture is the two mixtures, Group*Mixture is the interaction between the insect group and the flower mixture.

Tests of Between-Subjects Effects

Dependent Variable: LnDiversity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Fl_Ab_Field_mean	1,157	1	1,157	4,074	,045
Catch	1,230	2	,615	2,165	,118
Mixture	1,337	1	1,337	4,706	,032
Group	,344	2	,172	,606	,547
Group * Mixture	3,327	2	1,664	5,858	,004

a. R Squared = ,202 (Adjusted R Squared = ,112)

The table (Table 7) shows whether the variables have an effect on the diversity of the insects. First of all, the catch does not, other than with the abundance, have a significant (P = 0.118) effect on the diversity of the insects. The area size of the flower fields has an significant (P = 0.045) effect on the diversity of the insects, however this significance is not particularly high. At last, the effect of the mixture on the diversity of the insect groups, again has an significant (P = 0.004) effect. For the correlation of area size of the flower fields with the diversity, the same graphs were made as for the correlation of flower fields and abundance.

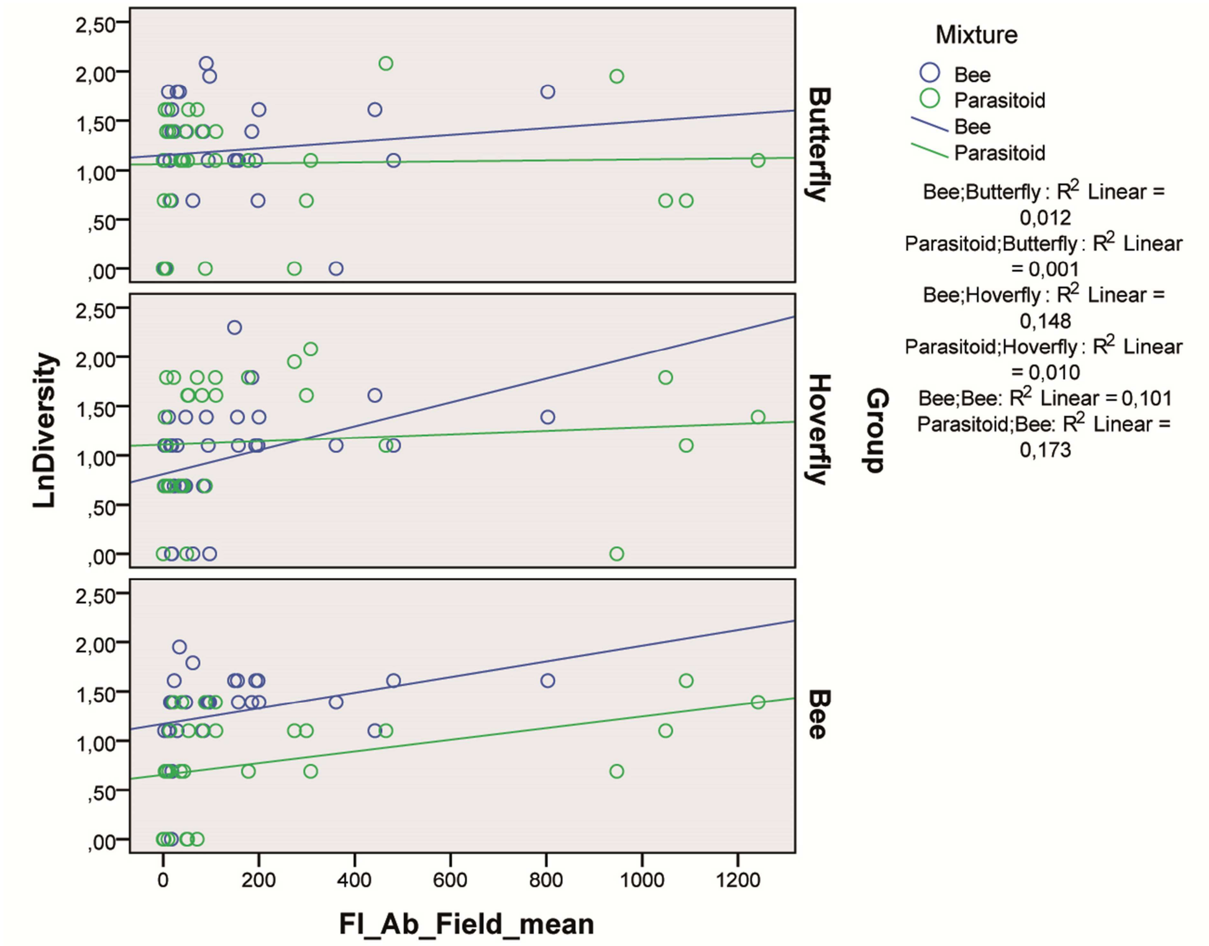

Figure 8: Correlation of size of flower fields and diversity of insect groups The blue circles and lines stand for the bee mixture, the green circles and lines stand for the parasitoid mixture. On the Y-axis number of insects species per group is shown and on the X-axis, the area (m²) of flowers is shown.

Figure 8 shows the correlations of the area size of flower fields (m²) with the diversity of the different insect groups. What the graph seems to show is that the diversity of all the insect groups increases with an increasing area size of the flower fields. The increase of wild bee species is somewhat the same in both of the flower mixtures. The hoverfly diversity however, has a much steeper increase in the bee mixture than in the parasitoid mixture. The butterfly species show a weak increase in both of the flower mixtures.

3.5 What is the effect of plant diversity on the different insect groups?

The question is, does the plant diversity affect the abundance and diversity of the insect groups? To give an answer to this question, the same graphs were made as in the sub chapters 3.3 and 3.4. These graphs show virtually how the diversity of plants affects the abundance and diversity of the insect groups. The graph in figure 9 shows the correlation of plant species and the abundance of the insect groups. The graph in figure 10 shows the correlation of pant species and the diversity of the insect groups.

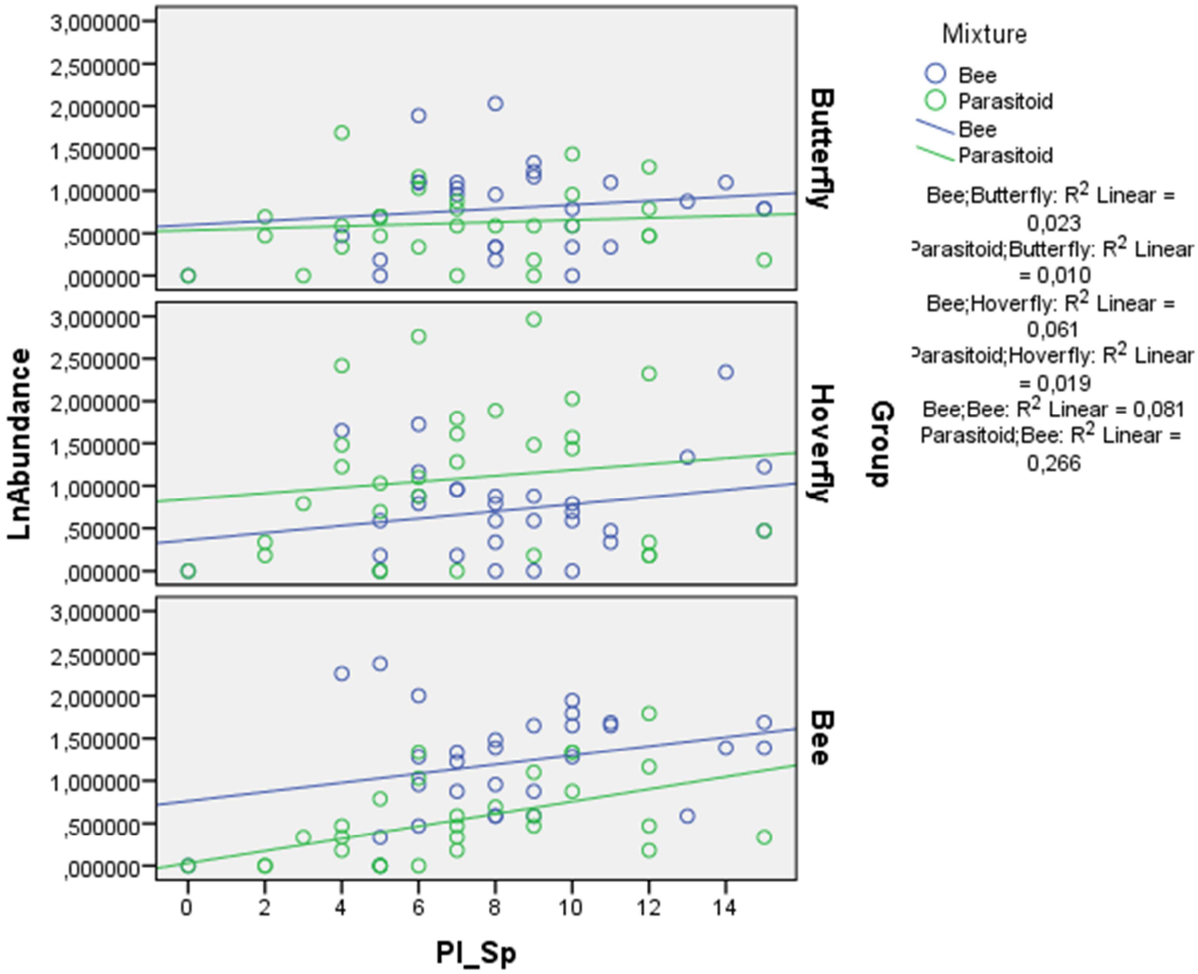

Figure 9: Correlation of plant diversity and abundance of insect groups The blue circles and lines stand for the bee mixture, the green circles and lines stand for the parasitoid mixture. On the Y-axis number of insects per group is shown and on the X-axis, the number of plant species is shown.

Figure 9 seems to show that all the insect groups have a slight increase of abundance with the increase of the area of the flower fields. The wild bees show the steepest increase, the hoverflies show the second steepest increase and the butterflies show the least steepest increase.

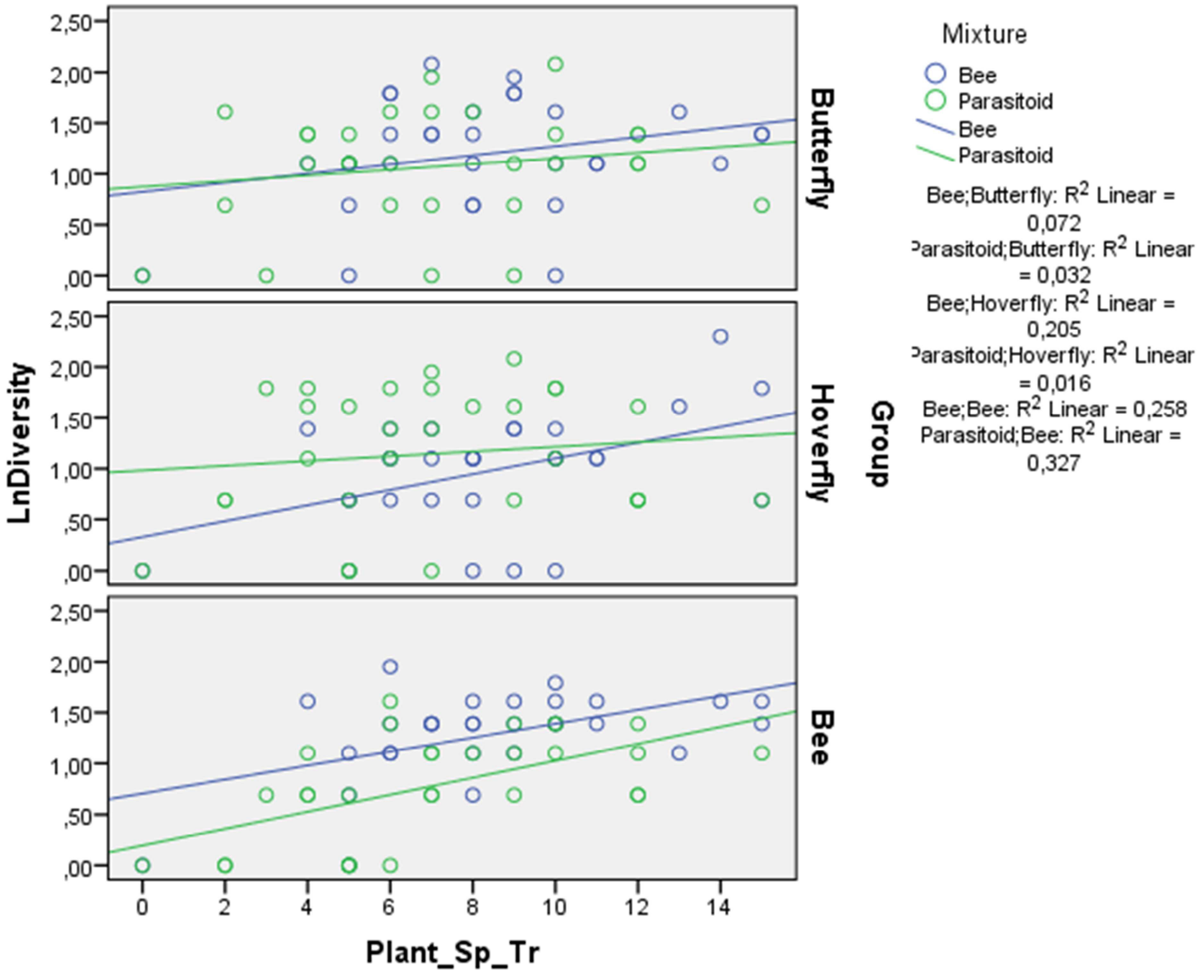

Figure 10: Correlation of plant diversity and diversity of insect groups The blue circles and lines stand for the bee mixture, the green circles and lines stand for the parasitoid mixture. On the Y-axis number of insects species per group is shown and on the X-axis, the number of plant species is shown

Figure 10 shows that an increase of the diversity of flowers results in the increase of the diversity of all the insect groups. The graph shows that the wild bees have an overall steepest increase of diversity with an increase of plant species. The graph shows that the butterflies have somewhat the same steepness in increase with an increase of plant species. The graph shows that the bee mixture has a steeper increase of hoverflies than the parasitoid mixture. In total, the graph shows that the diversity of all the insect groups increases with an increase of plant species.

4. Conclusion

The main goal for this report was to give answers to the main and sub questions, asked in the introduction. The research that was done has resulted in enough data to perform statistical tests on. The results of these test can be found in the chapter 'Results', also the tables and graphs that came out of the SPSS-tests can be viewed in this chapter. This chapter will conclude the questions asked in the introduction, first the sub questions will be answered, and after that the main question.

Sub question 1: Do the different flower mixtures affect the abundance of flower visiting insects?

Yes, the insect groups react differently to the two flower mixtures. The two flower mixtures (Bee mixture and Parasitoid mixture) have species in them that are specially fitted for one or more of the insect groups. The Parasitoid mixture had the biggest abundance of hoverflies of the two mixture. The Bee mixture had the most butterflies and bees. The parasitoid mixture has flowers that are easily accessible for all the insects, therefore the hoverflies were more attracted to the parasitoid mixture. The bee mixture has flower species that are less accessible for all of the insect groups.

Sub question 2: Do the different types of flower mixtures affect the diversity of flower visiting insects?

Yes, the flower mixtures have an effect on the diversity of the bees, butterflies and hoverflies. The bee mixture has the highest number of bee species and the butterfly species. There was no significant difference for the diversity of the hoverflies, both mixtures had more or less the same amount of hoverfly species.

Sub question 3: What is the effect of the different area sizes of sowed flower mixtures on the abundance of flower visiting insects?

The abundance of the three insects groups together increases when the area size of the flowers increases. If we look at the insect groups individually we see different patterns. The butterfly abundance does not increase if the area size of the flower increases. The bee and the hoverfly abundance increases with the increase of the flowering area.

Sub question 4: What is the effect of the different area sizes of sowed flower mixtures on the diversity of flower visiting insects?

The diversity of insects increases with the increase of the area of flowering fields. Again the butterflies show the least increase. The hoverfly and bee diversity grows significantly with an increase of the area of flowering fields.

Sub question 5: What is the effect of plant diversity on the different insect groups?

The effect of plant diversity was also tested in the SPSS program. The plant diversity seems to have an effect on the abundance and diversity of the insect groups, however, there is still need of more research on this.

Main question: What is the effect of different types and different area sizes of sowed flower mixtures on the abundance and diversity of flower visiting insects?

The effect flower types, and area sizes of sowed flower mixtures have, are different for each insect group that was studied. Wild bees and butterflies will be more attracted to the bee mixture than to the other mixture, in contrast to the hoverflies that are more attracted to the parasitoid mixture. The degree in which the diversity and/or abundance increases with an increase of flowering area size also depend on which insect group is focused on. The butterflies show little to no reaction of abundance to an increase in flowering area. However they do show an increase of diversity to an increase in flowering area. The hoverflies show an increase in diversity and abundance if the flowering area increases. The same goes for the bees, they show an increase in diversity and abundance if the flowering area increases. The diversity of plants seems to have an effect on all the insects groups, however, there is still some research that is needed to be done on this.

5. Discussion

In this chapter I will evaluate the research and the contents of this bachelor thesis report. I will give examples of how this research could have been done better and examples of things that can be taken in account next time. Also I will compare this study with other studies that researched somewhat the same as I did. First I will talk about the methods I used for the research, after that I will give examples of things that can be taken in account next time. At last I will give some examples of studies in the same study area.

5.1 Methods

The method I used is a method that takes a while to master and is time consuming. In average, the time I used to catch an insect and put it in a plastic bottle was 30-40 seconds. The small insects were often difficult to find in the sweepnet, the larger insects were easily found, but these insects flew out of the net more often than the small insects. The solution to this problem was found during the fieldwork, sweep netting until the 5 minutes of sampling are over. After that the whole catch will be putted in choke pots with napkins drained in acetone. This would save time, and it also eliminates the effect of the insects that escape. However, the change of a method during the fieldwork would have resulted in fieldwork rounds that could not have been compared with each other.

The other aspects of the method, like the virtual cage worked for this research. The virtual cages of 5 by 10 m² were big enough to gather enough data for statistical results. The determination of the species with the help of guides was not as easy as thought before, online determination keys were proven to be really valuable for me to determine the hoverflies.

5.2 Ideas for further research

The method that was used is proved to be sufficient to gather enough data for a statistical analysis. However the method can be improved by using the other sweepnet method that is explained in paragraph 5.1. This thesis does not take in account the regional species richness because of the little time that was given for the research. If this regional species richness is taken into account, the factor of coincidental high diversities of insects is flattened out. For example, on one location the observer catches 10 specimens and finds 3 specie, on the other location the same observer catches 30 specimens and again finds 3 species. The species richness of the two locations appears to be the same, however, if the observer would have caught 30 specimens on both locations, the second would have scored higher on diversity.

For further research the flowers in the surrounding landscape can be taken in account. This may affect the abundance and diversity of the insects in the sowed areas. Other researches in this project (E. Klop 2013, A. Stip 2013, not yet completed) have looked upon the differences between the sowed areas and the control fields that have been placed in pairs.

The coming two years it is important to compare the different study years, there may be a possibility to view a trend in the three years of sowing of the flower mixtures. It would be a good outcome to see that the abundance and/or the diversity will increase the coming two years. That would mean that sowing areas with flower mixtures helps the increase of abundance and/or diversity. For now we can only say that a the abundance and diversity varies between the two flower mixtures and the area size of the flower mixture.

5.3 Comparison with other studies

This research takes a look at the differences between two flower mixtures and how they affect the abundance and diversity of the insect groups. However, this research focuses on the differences on ten different locations that are spread over a couple of landscapes. The study of Campbell et. al (2012) uses only one location to test their hypothesis. They use small plots that are located randomly on a large grassy field. This study used two sets of flowers, the first one contained flowers with easily accessible pollen and nectar, the other set contained flower with difficultly accessible pollen and nectar. The research that was done for this thesis used the same types of flowers, although the plant species were different, this thesis also used plant species with easily and difficultly accessible pollen and nectar.

The outcome of the thesis by Allistar et al, is somewhat the same as the outcome for this thesis. The study of Allistar et al focused on the hoverflies and wild bees, these two insect groups had very clear preferences for the one or the other flower mixture. The wild bees preferred the plant species that had difficult accessible pollen and nectar and the hoverflies preferred the easily accessible plant species. The same was found in the research done for this thesis.

5.4 Statistical analysis and outcome

The statistical analyses that have been done with the SPSS program have had some interesting results. To start with, the wild bees were more attracted to the bee mixture in abundance and diversity. The tests show the same thing for butterflies, they also prefer the bee mixture. The hoverflies prefer the parasitoid mixture in abundance, but there is nog significant effect on the diversity of hoverflies. The two flower mixtures consisted of species that were selected to be easily or difficultly accessible for the insect groups (paragraph 2.1). Therefore, the insect species that have specific tools to access nectar and pollen chose for the largest offer of nectar. The bee mixture has plants that, very likely, offer more nectar than the parasitoid mixture. The hoverflies do not have the right tool to access these flowers, therefore they are more abundant on the parasitoid mixture that has easily accessible flowers. The tests have shown that there is no significant difference between the diversity of hoverflies in the two mixtures. Not all species of hoverflies are fully dependent on nectar and/or pollen (see introduction). Therefore the diversity is divided between the two mixtures.

The area of the flower fields (m^2) had a significant effect on the diversity and abundance of the insect groups. The correlation graphs that were made to visually show these effects, show that there is an effect on the abundance and diversity of the wild bees. Wild bees are central place foragers (introduction) and learn the landscape, the hypothesis was that wild bees would aggregate on the most profitable patch of flowers. That would be, the biggest patch with the most flowers. The graph show that there is no to little effect on the abundance and diversity of butterflies. The hypothesis was that butterflies are insects that do not learn the landscape, they move on and may never return to the flower fields. They do not aggregate on the most profitable patch. The graph shows and effect on the diversity and abundance in the bee mixture and not in the parasitoid mixture. The reaction of hoverflies in the parasitoid mixture is conform the hypothesis which is the same as for the butterflies. In the bee mixture, however, they react different than was expected. The fact that there are two types of hoverflies, may be the cause for this difference in the two mixtures.

The diversity of plants seemed to have an effect on the diversity of all the insect groups. The butterflies are dependent on different plant species to forage on in the caterpillar stage. Each butterfly species has their own specific foraging plant in this stage. Therefore the hypothesis was that the butterflies would show an increase in diversity with an increase of plant species.

6. Recommendations

The research shows, that to help the biodiversity and abundance of the insect groups, the best solution is to sow different mixtures on big areas. If one sows particularly large areas with the two different mixtures, the diversity and abundance of hoverflies and bees will increase. The diversity of butterflies will also increase, but the abundance of butterflies stays somewhat the same. For the abundance of butterflies, a smaller patch of sowed mixtures is sufficient.

The research also showed, that a higher diversity of plants results in a higher diversity of insects. Therefore it is important that a flower mixture has enough species in it that will germinate and continue to grow. It is important to know which soil and witch landscape the mixture will be sowed in. Some species of flowers will only grow on, for example, sandy soils, and others on clay soils. Before a mixture is sowed it is important to examine the facts about the soil and groundwater depth. If this research is done properly, a choice can be made which plant species will be sowed.

For a subsequent research, the research can look at the regional species richness to correct for the species found and the species that could have been found on the locations. With this correction there is no discussion about how the surroundings affect the findings in the fieldwork.

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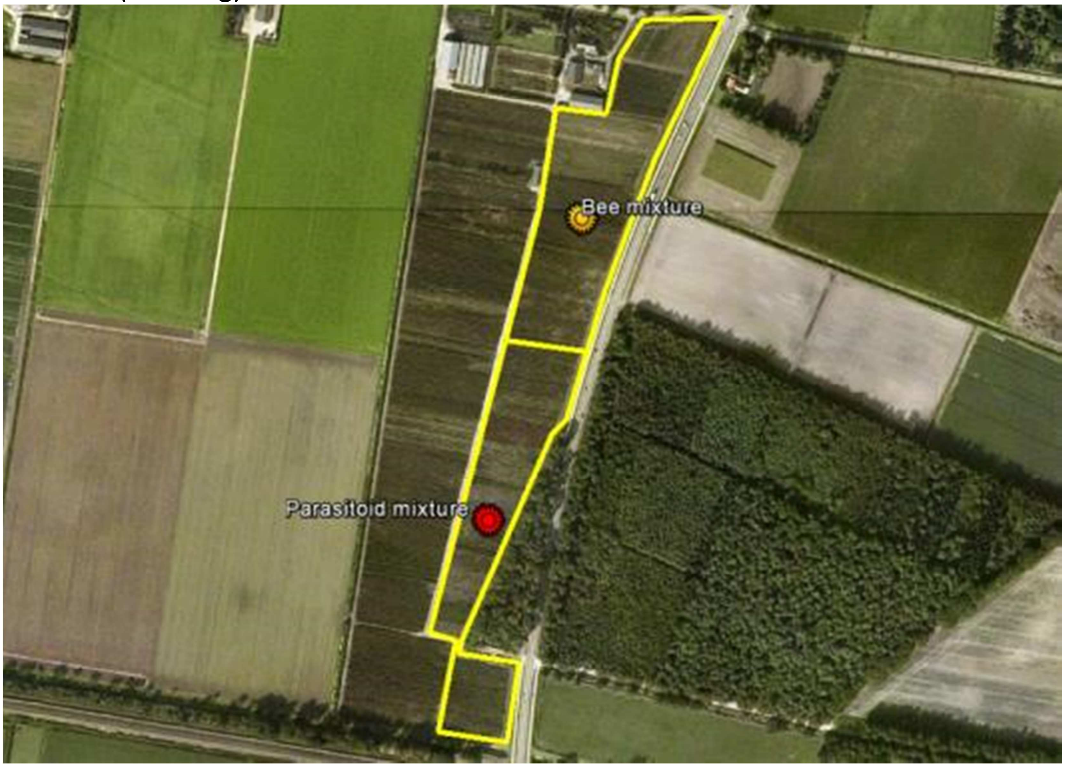
Appendix

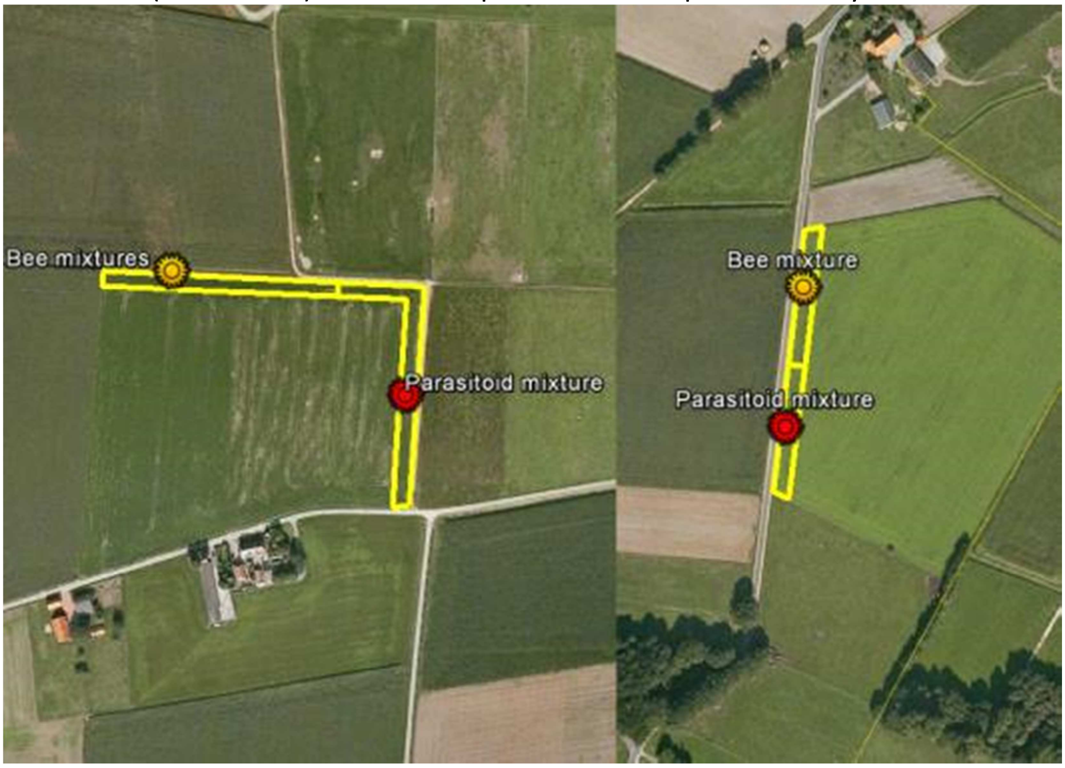
Appendix 1: Fieldwork locations and flower fields

America (Limburg)



Budel (Noord-Brabant)

Groesbeek (Gelderland) this is a composition of two places nearby Groesbeek.



Haarzuilens (Utrecht)

Merkske (Noord Brabant)

Montferland (Gelderland)

Postberg (Limburg)

Rozendaal (Limburg)

Sinderhoeve (Gelderland)

Terworm (Limburg)

Appendix 2: Lists of species

Butterflies

Butterflies		
Scientific	Nederlands	Individuals
Aglais io	Dagpauwoog	1
Aglais urticae	Kleine vos	25
Aphantopus hyperantus	Koevinkje	10
Argynnis aglaja	Grote parelmoervlinder	1
Ariera agestis	Bruin blauwtje	5
Celastrina argiolas	Boomblauwtje	1
Coenonymphia pamphilus	Hooibeestje	1
Colias crocea	Oranje luzernevlinder	33
Colias hyale	Gele luzernevlinder	5
Favonius quercus	Eikenpage	1
Genopteryx rhamni	Citroenvlinder	2
Issoria lathonia	Kleine parelmoervlinder	5
Lycaena phlaeas	Kleine vuurvlinder	12
Lycaena tityrus	Bruine vuurvlinder	1
Maniola jurtina	Bruin zandoogje	32
Ochledes sylvanus	Groot dikkopje	2
Papilio machaon	Koninginnepage	6
Pararge aegenia	Bont zandoogje	7
Pieris brassicae	Groot koolwitje	5
Pieris napi	Klein geaderd witje	7
Pieris rapae	Klein koolwitje	116
Polyommatus icarus	Icarusblauwtje	75
Pyronia tithonus	Oranje zandoogje	2
Thymelicus lineola	Zwartsprietdikkopje	14
Vanessa atalanta	Atalanta	4
Vanessa cardui	Distelvlinder	14

Hoverflies

Hoverflies		
Scientific	Nederlands	Individuals
Episyrphus balteatus	Snorzweefvlieg	14
Eristalinus sepulcharis	Weidevlekoog	1
Eristalis abusiva	Kustbijvlieg	5
Eristalis arbustorum	Kleine bijvlieg	23
Eristalis horticola	Bosbijvlieg	7
Eristalis intricaria	Hommelbijvlieg	2
Eristalis nemorum	Puntbijvlieg	16
Eristalis tenax	Blinde bij	126
Eupeodes corollae	Terrasjeskommazweefvlieg	15
Helophilus pendulum	Pendelzweefvlieg	24
Helophilus trivittatus	Citroenpendelzweefvlieg	23
Melanostoma mellinum	Gewone driehoekszweefvlieg	1
Myathropa florea	Doodskopzweefvlieg	1
Rhingia campestris	Gewone snuitvlieg	1
Scaeva pyrastri	Witte halvemaanzweefvlieg	6
Sphaerophoria scripta	Grote langlijf	21
Syritta pipiens	Menuetzweefvlieg	1
Syrphus ribesii	Bessenbandzweefvlieg	1
Syrphus vitripennis	Kleine bandzweefvlieg	6
Volucella bombulans	Hommelreus	1
Not caught	Not caught	432

Bees

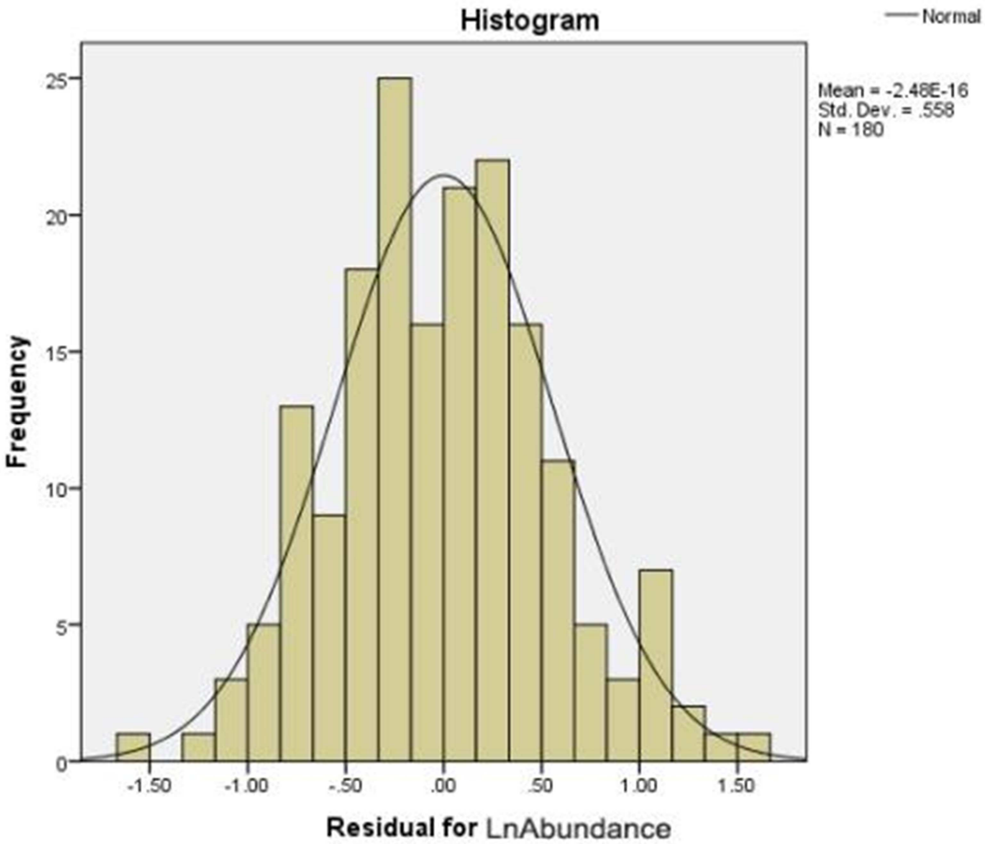
Bees		
Scientific	Nl	Individuals
Andrena spec.	Zandbijen	5
Apis mellifera	Honingbij	556
Bombus hortorum	Tuinhommel	6
Bombus hypnorum	Boomhommel	1
Bombus lapidarius	Steenhommel	127
Bombus pascuorum	Akkerhommel	58
Bombus pratorum	Weidehommel	5
Bombus terrestris gr.	Aardhommelgroep	151
Colletes spec.	Zijdebijen	2
Dasypoda spec.	Pluimvoetbij	2
Lasioglossum spec.	Groefbijen	13
Megachile	Behangersbijen	2
Melitta	Dikpootbijen	2
Panurgus spec.	Roetbijen	1
Not caught	Not caught	222

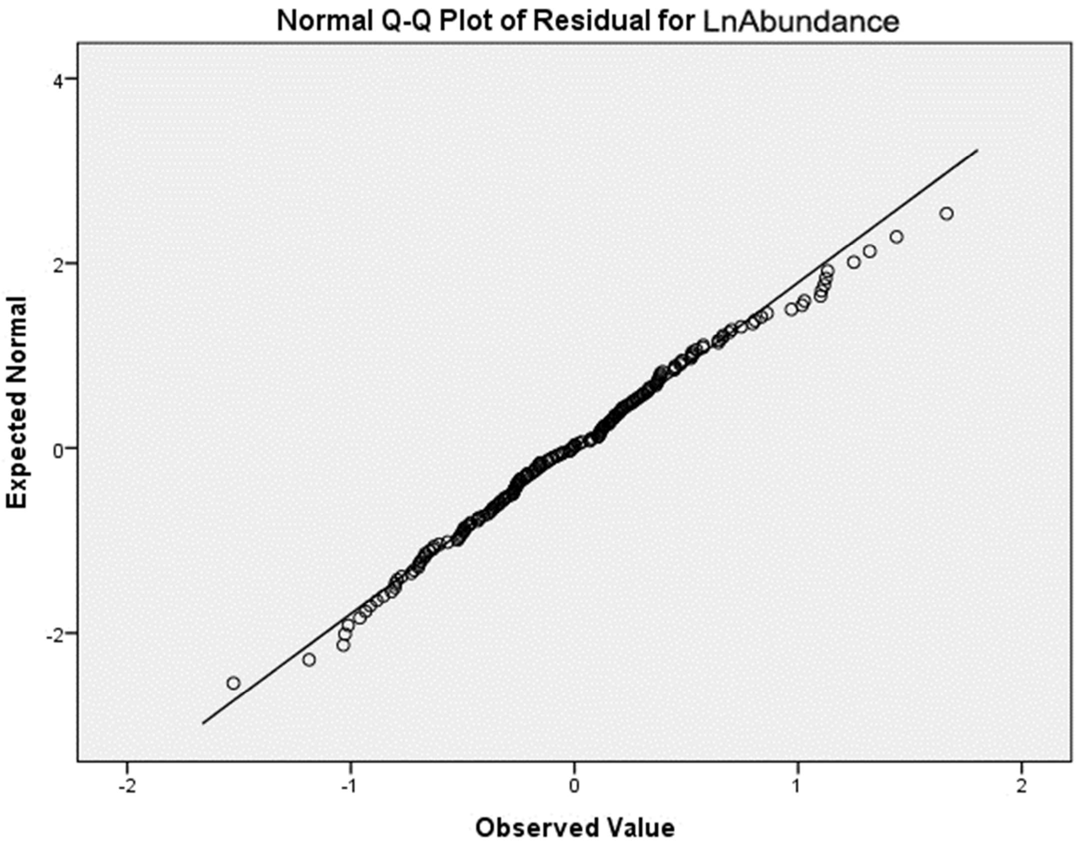
Plants

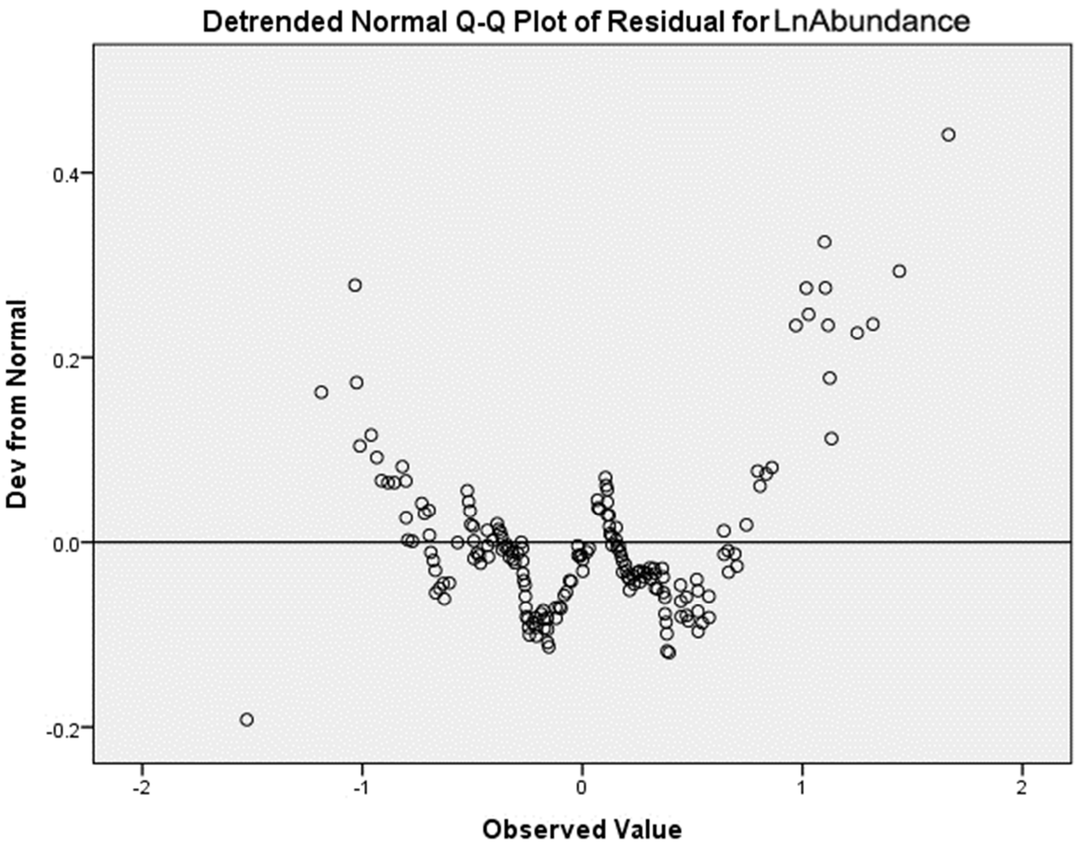
Plants	
Scientific	Nl
Achilea millefolium	Duizendblad
Agrostemma githago	Bolderik
Anethum graveolens	Dille
Anthriscus sylvestris	Fluitenkruid
Borago officinalis	Bernagie
Brassica napus	Koolzaad
Capella bursa-pastoris	Herderstasje
Cenaurea jacea	Knoopkruid
Centaurea cyanus	Korenbloem
Cerastium spec.	Hoornbloem spec.
Chamerion angustifolium	Wilgenroosje
Cichorium intybus	Cichorei
Cirsium arvense	Akkerdistel
Cirsium palustre	Kale jonker
Cirsium vulgare	Speerdistel
Crepis biennis	Groot streepzaad
Daucus carota	Wilde peen
Epilobium hirsitum	Harig wilgenroosje
Erodium spec.	Reigersbek spec.
Fagopyrum esculentum	Boekweit
Foeniculum vulgare	Venkel
Geranium spec.	Ooievaarsbek spec.
Geranium spec.	Geranium spec.
Helianthus spec.	Zonnebloem spec.
Hypericum perforatum	Sint-janskruid
Hypochaeris radicata	Gewoon biggenkruid
Impatiens parviflora	Klein springzaad
Lamium purpureum	Paarse dovenetel
Leucanthemum spec.	Margriet spec.
Lotus corniculatus	Gewone rolklaver
Malva sylvestris	Groot kaasjeskruid
Matricaria spec.	Kamille spec.
Medicago sativa	Luzerne
Myosotis arvensis	Akkervergeet-mij-nietje
Myrrhis odorata	Roomse kervel
Onobrychis viciifolia	Esparcette
Papaver rhoeas	Grote klaproos

Pastinaca sativa	Pastinaak
Persicaria amphibia	Veenwortel
Phacelia tanacetafifolia	Bijenvoer
Planta indet.	Plant spec. (witte bloem)
Ranunculus acris	Scherpe boterbloem
Ranunculus repens	Kruipende boterbloem
Raphanus raphanistrum	Knopherik
Senecia jacobaea	Jakobskruiskruid
Senecio inaequidens	Bezemkruiskruid
Sinapis spec	Mosterd spec.
Sisymbrium officinale	Gewone raket
Sonchus asper	Gekroesde melkdistel
Tanacetum vulgare	Boerenwormskruid
Taraxacum officinale	Paardenbloem
Trifolium dubium	Kleine klaver
Trifolium incarnatum	Incarnaatklaver
Trifolium pratense	Rode klaver
Trifolium repens	Witte klaver
veronica agrestis	Akkerereprijs
Vicia spec.	Wikke spec.
Viola arvensis	Akkerviooltje

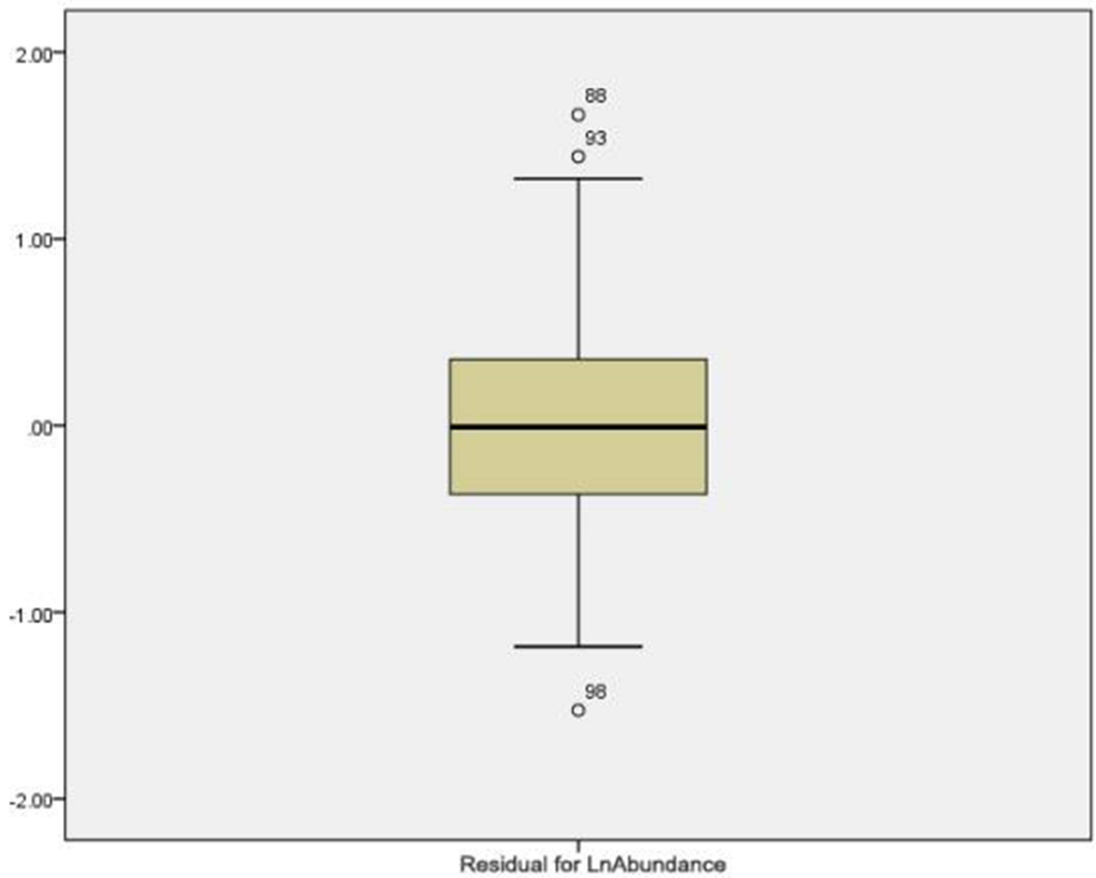
Appendix 3: Test of normality residuals for abundance





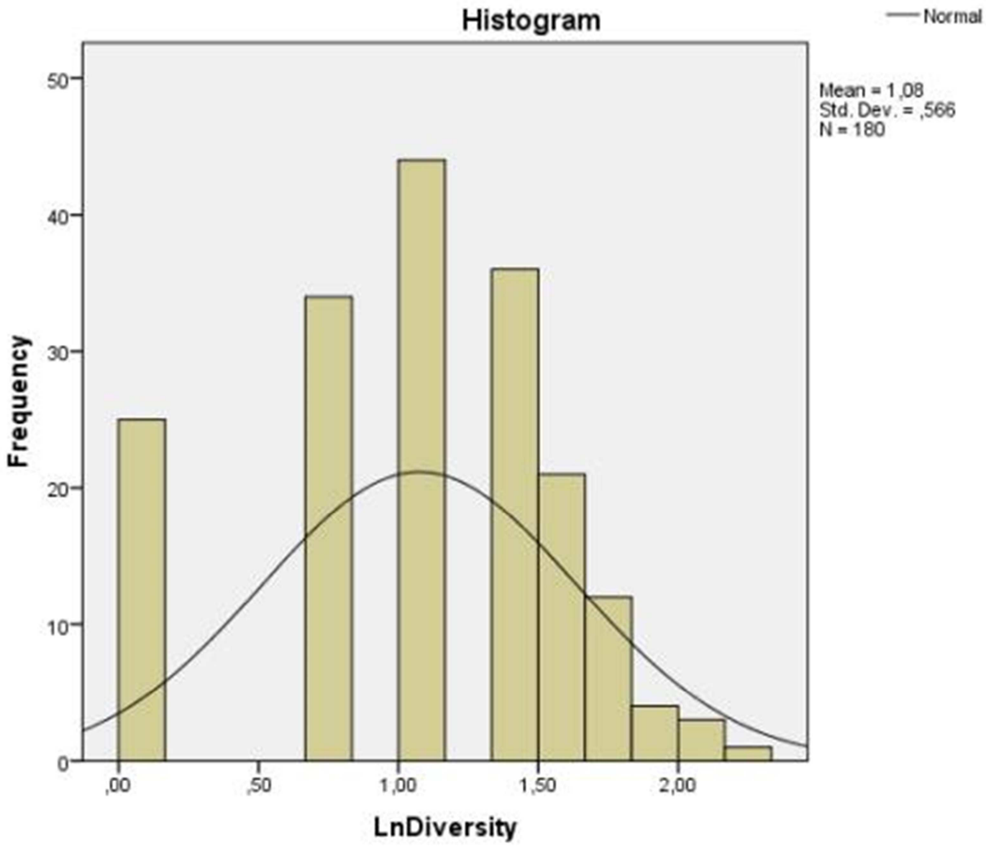


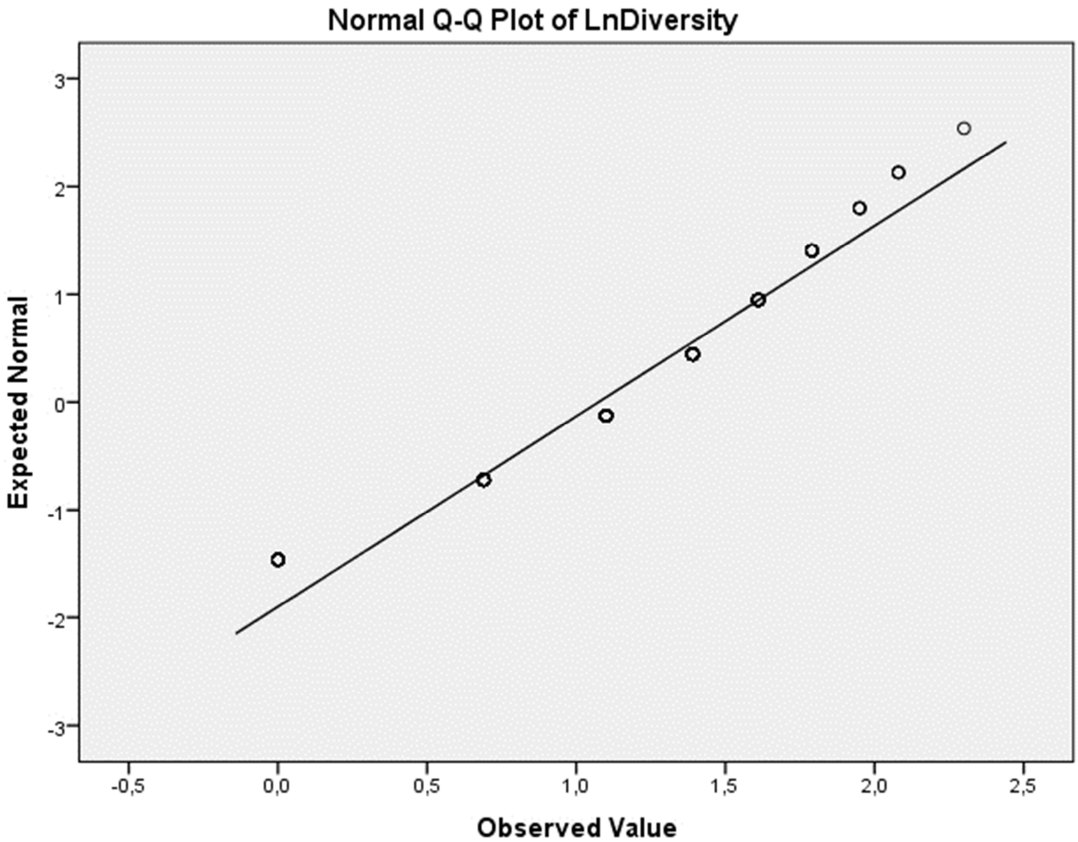
Detrended Normal Q-Q Plot of Residual for LnAbundance
Dev from Normal
0.4
0.2
0.0
-0.2
-2
-1
0
1
2
Observed Value

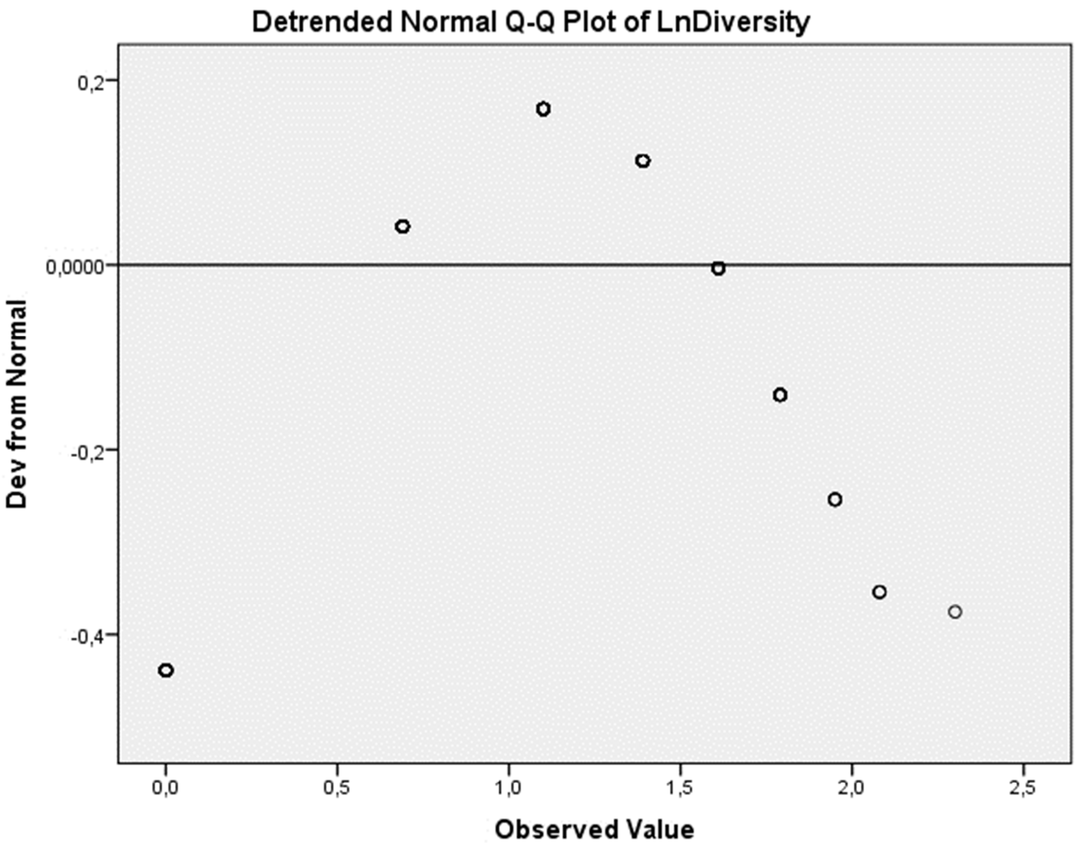


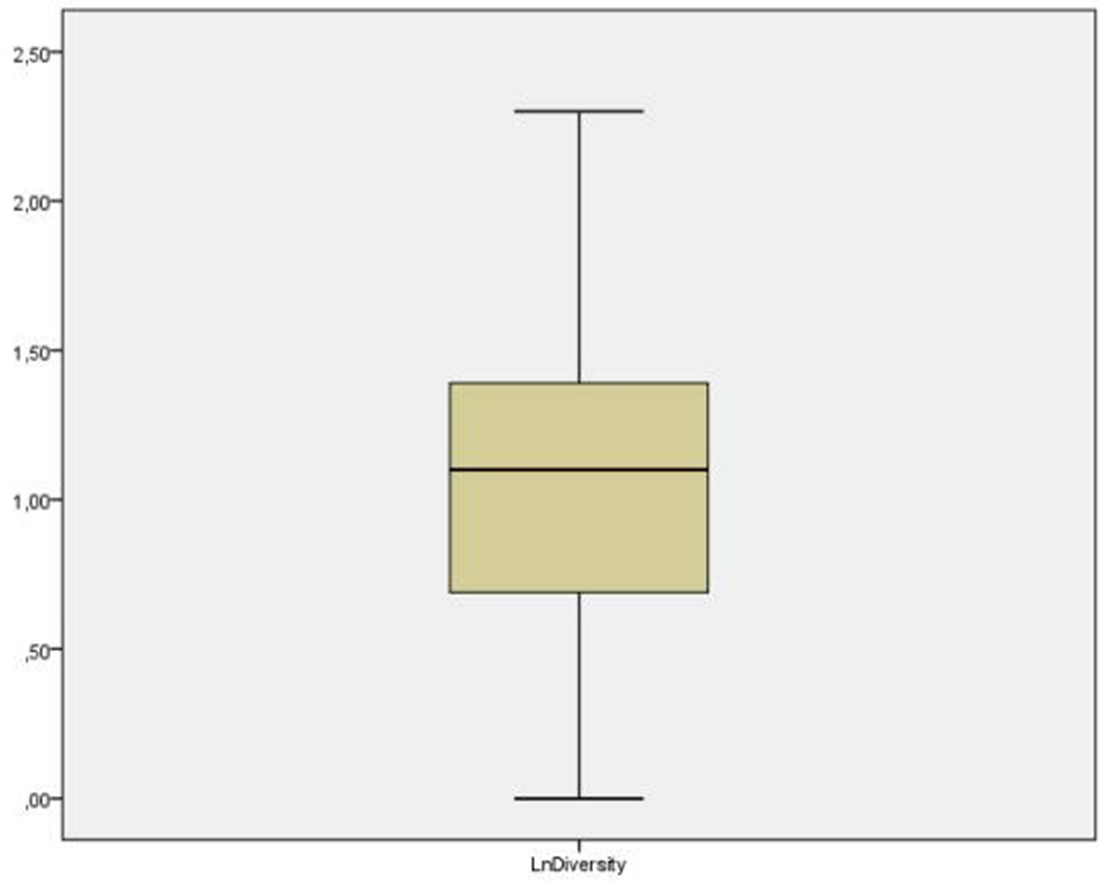
2.00
1.00
.00
-1.00
-2.00
88
93
98
Residual for LnAbundance

Appendix 4: Test of normality residuals for diversity






Detrended Normal Q-Q Plot of LnDiversity
Dev from Normal
0,2
0,0000
-0,2
-0,4
0,0
0,5
1,0
1,5
2,0
2,5
Observed Value


2,50
2,00
1,50
1,00
,50
,00
LnDiversity