KØBENHAVNS UNIVERSITET
DET NATUR- OG BIOVIDENSKABELIGE FAKULTET

Bachelorproject

How Wild is Vild Campus

Birgitte Hyldal Vollmer and Ruth Djurhuus Jakobsen

Supervisors: Jes Søe Pedersen, Henning Bang Madsen and Hans Henrik Bruun
In cooperation with Vild Campus and Urban Green

Handed in: 08/09/2016

Table of content

Abstract

When establishing urban nature, it is usually done with the purpose of raising the biodiversity in the city. The Vild Campus initiative, a part of the Center for Macro ecology, Evolution and Climate at Copenhagen University, created five biotopes with four different types of native habitat, a meadow, a forest, two grasslands and a beach, in Universitetsparken, Copenhagen. The purpose of this study was to provide a quantitative measure on the effect on the amount and diversity of pollinators, in this case wild bees (*Hymenoptera: Apoidae: Anthophila*) and hoverflies (*Diptera*: *Syrphidae*), in Universitetsparken, after establishing the biotopes. From April until July, bees and hoverflies where collected by the means of pan traps and net catching. The Vild Campus the meadow and forest were compared to a well-established meadow and forest at Gentofte Lake, representing suburban nature. To give an indication of the biodiversity in Universitetsparken before the Vild Campus biotopes were established, a control area, dominated by traditionally managed lawn, located in Universitetsparken, was picked out and compared to the current status of biodiversity in Universitetsparken and at Gentofte Lake. The only significant difference found was between the control location and Vild Campus meadow, showing an increase in number of pollinator species. Comparisons were also made between the four types of Vild Campus biotopes, to determine if some biotopes are more favorable when trying to raise the diversity of pollinators in urban areas. No significant difference was found between the four types of biotope. Based on the data from both meadow and forest, it can be estimated that the average effect of establishing a Vild Campus biotope in Universitetsparken, is a 4.6 times increase in the number of individuals and a 2.4 times increase in the number of species. Furthermore we estimate that a Vild Campus biotope will obtain 50.9 % of the richness in individuals and 150 % of the richness in species that a suburban reference location, with a similar habitat, would have. These results also indicate that bees are a better indicator of biodiversity in small-scale urban areas, than hoverflies are.

Resumé

Når der bliver etableret naturområder i byer, er det som oftest med det formål at øge biodiversiteten. Vild Campus initiativet, som er en del af Center for Macroøkologi, Evolution og Klima på Københavns Universitet, anlagde i 2015 fem biotoper med fire forskellige hjemmehørende habitat typer, én eng, én skov, to græsland og én strand, i Universitetsparken. Formålet med dette projekt var at give en kvantitativ måling af virkningen på mængden og mangfoldigheden af bestøvere, i dette tilfælde vilde bier (*Hymenoptera: Apoidae: Anthophila*) og svirrefluer (*Diptera*: *Syrphidae*), I

Universitetsparken, efter at Vild Campus biotoperne blev anlagt. Fra maj frem til juli blev bier og svirefluer indsamlede ved hjælp af fangstbakker og ketsjer fangst. Vild Campus engen og skoven blev sammenlignet med en vel etableret eng og skov ude ved Gentofte Sø, som reference til bynært miljø. Et kontrol område, domineret af traditionelt plejet græsplæne, blev valgt I Universitetsparken, for at sammenligne hvordan biodiversiteten var før Vild Campus biotoperne blev anlagt og den nuværende status af biodiversitet I Universitetsparken og ved Gentofte sø. Den eneste signifikante forskel der blev fundet, var mellem kontrol området og Vild Campus engen, der viste et øget antal arter af bestøvere. Sammenligninger blev også lavet mellem de fire typer Vild Campus biotoper, for at stadefeste om nogle typer af biotoper er mere velegnede I forsøget på at øge diversiteten af bestøvere I bymiljøer. Ingen signifikant forskel blev fundet mellem de fire typer af Vild Campus biotoper. Baseret på data fra bade eng og skov, kan vi estimere at den gennemsnitlige effekt af at anlægge en Vild Campus biotop I Universitetsparken, er en 4,6 gang forøgelse i antallet af individer og en 2,4 gang forøgelse i antallet af arter. Derudover vurderer vi, at en Vild Campus biotop vil få 50,9 % af den rigdom i individer og 150 % af den rigdom i arter, som en bynær lokalitet, med et lignende miljø, ville have. Disse resultater indikere endvidere at bier er en bedre indikator for biodiversitet små bymiljøer end svirrefluer er.

Introduction

Urban nature

As time goes by, the focus on biodiversity and the negative effects of modern day management of agricultural land has on pollinators, is increasing significantly. The world's population of important pollinators', like wild bees and hoverflies, is declining. This has been shown in studies (Biesmeijer et al 2006, Goulson et al 2008) and can have severe consequences for the future pollination of wild plants and agricultural crops (Potts et al 2010). Therefore different programs have been developed to help wild bees (*Anthophila*) populations, and thereby also affecting hoverflies (*Syrphidae*) and other insect populations, by establishing increasing amounts of urban areas with a floral composition that tends to the pollinators' specific needs. Studies show that a specific floral composition can benefit the wild bees (Pawelek et al 2009) When creating new floral beds, it is important that the plants are of native origin (Tuell et al 2008), and that the vegetation height and structure (Carvell 2002) and nesting areas are considered as well. The nesting habits for many species require access to sandy areas, hollow straws or undisturbed ground areas, due to some species preferences for burrowing nests in the ground. Furthermore the direction of the nesting grounds are of important, and need to be facing south, for it to be heated by the sun (Falk & Lewington 2015). The change in the way people think, when establishing urban gardens and green areas (van Heezik et al 2012), could mean, that in time we will have a wider variety of wild bees and hoverflies, hopefully including a wide variety of specialist.

The effect of nature in urban areas

The biodiversity in urban areas can be increased by creating different semi natural biotopes in parks (Cornelis & Hermy 2004). There is a significantly higher species richness of native flora in the cities, giving urban areas the possibility to be a biodiversity hotspot (Kühn et al 2004). Meadows are frequently being created in urban areas to increase biodiversity (Hicks et al 2016) and the effects of urban forests are proven important for nesting, foraging (Alvey 2006, Croci et al 2008) and acting as a corridors for the migration of different organisms (Vergnes et al 2012). There are in general more and more urban gardens being established in Copenhagen and these gardens could potentially become a refuge for a lot of hoverflies (Sutherland et al 2001) and wild bees (Lin et al 2015, Matteson et al 2008). It is still uncertain what effect urban gardens have on different groups of pollinators in general, but some studies indicate that the urban setting enhances the conservation of wild bees (Sirohi et al 2015).

Bees

In Denmark alone there are 286 known species of bees (Madsen et al 2015), including Denmark's two domesticated bees, the honey bee *(Apis mellifera)* and the alfalfa leafcutter bee (*Megachile rotundata*). Most wild bees in Denmark have a solitary or eusocial lifestyle. Some species of *Halictidae* are eusocial, meaning that they live in small, short-lived colonies, with minimal social agreement. Only bumblebees live in social organized societies with a queen, workers and males. The foraging pattern and preference is not consistent either for all bees. Solitary bees have a significantly shorter fly range than the social bees (Krewenka et al 2011), as there is a positive correlation between the body size and fly range of a bee (Greenleaf et al 2007). There are oligolectic bees that specialize in collecting pollen from one or a few genera or species of flowering plants, and polylectic bees that are opportunistic foragers that gather pollen from a broad spectrum of plants. The morphology of the different species' varies from short tongues to long tongues and this trait indicates which type of flowers they are equipped to collect nectar from. There are however bees that are nectar-robbers and therefore not as restricted by tongue length

Hoverflies

There are 270 species of hoverflies observed in Denmark (Bartsch et al 2009b). Their biology is very diverse and the food source and living environment of the larvae differs greatly from that of the imago, which feeds on pollen and nectar from flowering plants. Adult flies lay their eggs near the larvae's specific food sources depending on the species. The larvae can feed on aphids and other small insects, sap or microorganisms contained in the sap, decomposing organic material, fungi or parts of living plants, while others are cleptoparasitic, living in nests of other insects. Among hoverfly species generalist and specialist are also found , but studies indicate that there are more specialized on colors than genus or species of the plants (Haslett 1989). At night when the temperature is low, hoverflies seek refuge. Members of the genus *Melanostoma* can be active at temperatures as low as 8 °C, while most species' need temperatures to be no less than 12 °C. Most species' also become inactive and lie dormant if temperatures rise above 25 °C. Hoverflies can in general withstand relatively strong winds, if all other factors are satisfactory, but seek refuge from the rain (Bartsch et al 2009a, Bartsch et al 2009b).

Gentofte Lake

Gentofte Lake and Brobæk bog, also called the Insulin bog, is a Nature Reserve appointed as a Natura 2000 area (Fødevareministeriet 2016). This means that there are special requirements for how the natural habitat in the area is conserved and developed. There is a rich and varied animal- and plant life, and the bog is managed, so that the natural development of new growth and old fallen trees is retained. In the open areas, there are rare herbs such as orchids and different strategies are being conducted to preserve these areas. In the 19th century the forest and its surrounding area were used for harvesting reed and subsequently for grazing, but since 1932 there has been no maintenance in the forest. The meadow and its surrounding area were used strictly for grazing until 1932. From 1932 until 1970 the area was occasionally used for winter harvesting, but in 1970, the area was filled with excess soil from the construction of Gentofte Town hall and a soccer field was established. In 1980 the organization Gentofte Natur & Ungdom (Gentofte Nature and Youth) persuaded the municipality of Gentofte to restore the meadow that had been destroyed and approximately 20 years later, in 2006, the Southern marsh orchid (*Dactylorhiza praetermissa)* was found this meadow. After the 1st of August each year, the area is harvested and the cut material is removed from the meadow (Thomas Vikstrøm, personal communication 13.07.2016). For further information on the area see the municipality of Gentofte homepage (Gentofte Kommune)

The Vild Campus project

In 2015, the Vild Campus initiative, a part of the Center for Macro ecology, Evolution and Climate at Copenhagen University, established five biotopes in Universitetsparken, at Copenhagen University's Noerre campus. The purpose was to invoke interest and give people easy access to information about Danish nature and to encourage and inspire citizens of Copenhagen to explore nature, outside of the urban environment. The five areas were made to resemble four different habitats, namely forest, meadow, grassland and beach. All five biotopes were established in an area that, for the past 80 years, has been dominated by traditionally managed lawn (personal communication with Jonas Bjørn Ringheim, Gartner at Universitetsparken, 10.08.2016). Such areas are known to have low floral diversity (Ahrné 2008, Thompson et al 2004), but changing and increasing the floral content of traditionally managed lawns, is proven to enhance insect density (Cornelis & Hermy 2004, Smith et al 2015). When the Vild Campus biotopes were established, they contributed with 13,000 individual common native plants, belonging to 98 different species, and the four kinds of biotope, all have a different composition of plant species. The plants were supplied by Urban Green, which is an interdisciplinary project, where gardeners, biologists and architects have combined their best skills to make the city greener, healthier and more beautiful, and that previously have conducted research on similar established biotopes (www.urbangreen.dk; accessed 02.09.2016). The plant composition was made to produce an overlapping flowering period, for insects to maintain a stable food source over a longer period of time. Furthermore, the topsoil cover in each biotope was replaced with soil corresponding to the natural soil cover found in each biotope. The grassland biotopes had nonwovens placed between the new soil cover and the original soil to prevent the plants from obtaining nutrients from the deeper strata. The same procedure was used for the meadow, to prevent water penetrating and disappearing into the deeper strata. This was done in collaboration with Urban Green and GXN, who work with applied architectural research in green materials and technologies (http://gxn.3xn.com)

All reference to Vild Campus and the Vild Campus biotopes will from here on, in the text, be referred to as V.C. and it should be made clear that the purpose of the Vild Campus project was never to enhance biodiversity.

This study

The purpose of this study was to provide a quantitative measure on the effect on the amount and diversity of pollinators in Universitetsparken after establishing the V.C. biotopes. We chose to aim our focus on similarities and differences in bees and hoverflies among the different habitats, dependent on type, and age. To see the degree of effect, we compared the meadow and forest created by V.C. to a well-established meadow and forest at Gentofte Lake, representing suburban nature. Furthermore, to represent the biodiversity of bees and hoverflies before the V.C. biotopes were established, a control location, within an area dominated by traditionally managed lawn, in Universitetsparken was picked out and compared to the V.C. biotopes. To see if it makes a difference, which type of biotope is established, a comparison was made among the five V.C. biotopes.

Materials and Method

The main data was sampled from the five V.C biotopes (55°42’05.9”N 12°33’35.4”E), representing four different types of habitat (Figure 1 – location A-B and D-E). Supplementing material was collected from the control location (Figure 1 – location F) and the two reference locations (meadow 55°44’53.6”N 12°31’48”E and forest 55°44’05.3”N 12°31’54.1”E) at the Insulin bog at Gentofte Lake (Figure 1 – location H-G).

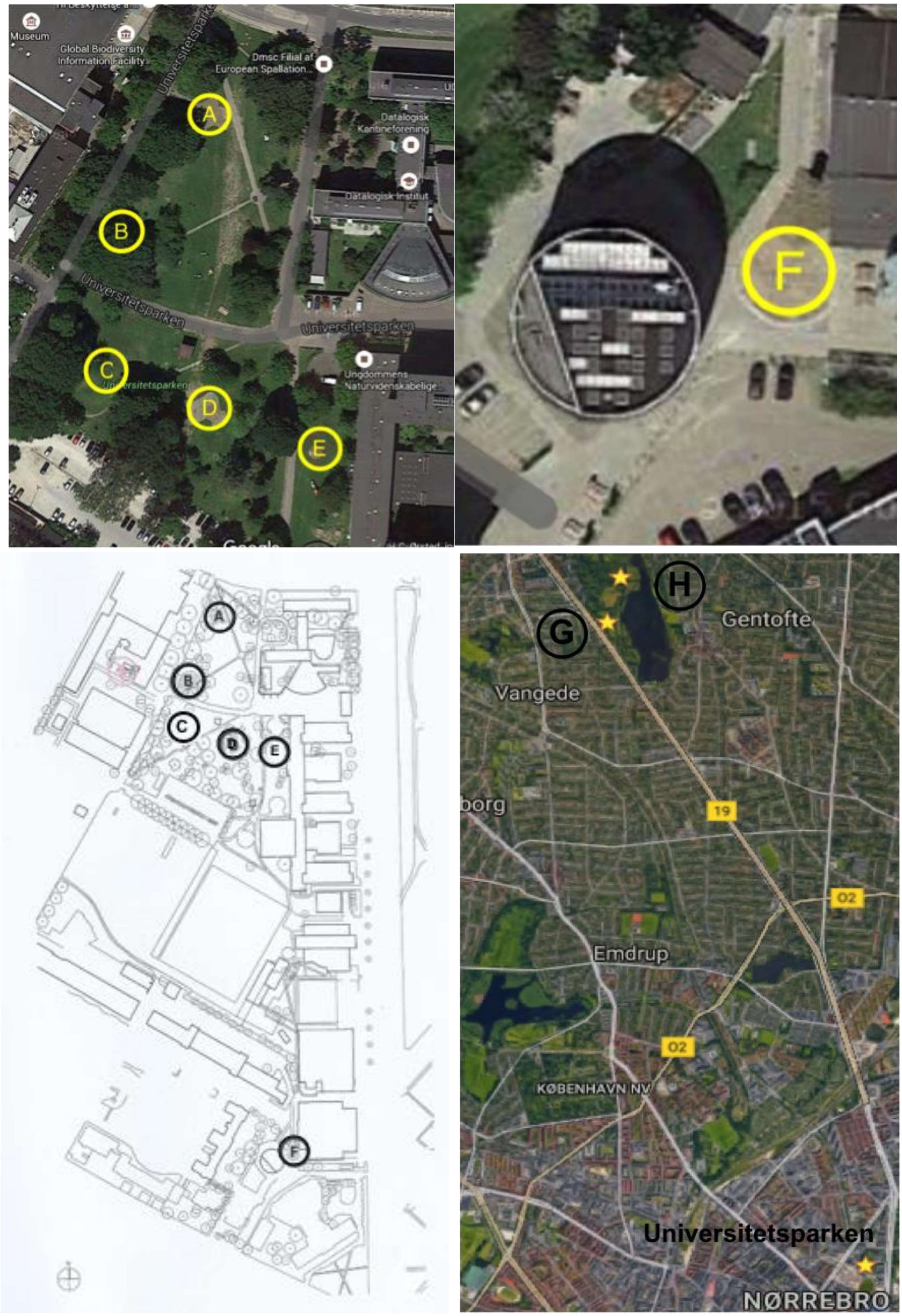


Figure 1 – The photos show an overview of the Vild Campus biotopes. A: 110 m^2 V.C. grassland 1 (V.C. graesland 1), B: 165 m^2 V.C. forest (V.C. skov), C: 100 m^2 control location (kontrol lokalitet), D: 125 m^2 V.C. beach (V.C. strand), E: 110 m^2 V.C.-meadow (V.C. eng), F: 110 m^2 V.C. grassland 2 (V.C. graesland 2), G: 100 m^2 ref. meadow (ref. eng) and H: 100 m^2 ref. forest (ref. skov). All photos are cropped from satellite maps found by Google Maps (Google Maps, accessed 26.08.2016).

Collecting material for data analysis

The sampling method used, was equivalent to the method Urban Green used and described in a previous similar study (Ejrnæs et al 2015), so that they could use the data obtained in this project for their own work in the future.

Sampling period	Setup date	Setup time		Collecting date	Collecting tine including net catching	
		Gentofte Lake	Universitetsparken		Gentofte Lake	Universitetsparken
1	06.04.16	10 am – 12 pm	13 pm – 16 pm	12.04.16	10 am – 12 pm	13 pm – 16 pm
2	20.04.16	10 am – 12 pm	13 pm – 16 pm	28.04.16	10 am – 12 pm	13 pm – 16 pm
3	04.05.16	10 am – 12 pm	13 pm – 16 pm	11.05.16	10 am – 12 pm	13 pm – 16 pm
4	24.05.16	10 am – 12 pm	13 pm – 16 pm	30.05.16	10 am – 12 pm	13 pm – 16 pm
5	08.06.16	10 am – 12 pm	13 pm – 16 pm	15.06.16	10 am – 12 pm	13 pm – 16 pm
6	15.06.16	10 am – 12 pm	13 pm – 16 pm	22.06.16	10 am – 12 pm	13 pm – 16 pm

Table 1 – Table showing dates and time of the sampling period in Universitetsparken and at Gentofte Lake.

Material was sampled twice a month for the duration of April, May and June 2016 (Table 1). Yellow pan traps were filled with 2-3 liters of water, mixed with 2-3 droplets of neutral dish soap to act as a surfactant. Four pan traps were placed at each location and left between six and eight days, depending on the weather. The content was drained and then transferred into a plastic container containing 70% ethanol. Each sampling period was supplemented with 30 minutes of net catching at each location. Subsequently the sampled data was sorted for bees and hoverflies, everything else was discarded. In the first sampling period, observations of crows and magpies feeding on the insects, caught in the pan traps, was observed at the V.C locations. Subsequently, two out of four pan traps was covered with chicken wire, and the remaining two were supplemented with 30 ml of Rodalon[1]. Both methods were effective and continued at the V.C locations throughout the remaining 5 sampling periods. In June, two out of four pan traps were placed on high-stands due to overgrowing vegetation at location A, B, E, F and G (Figure 1).

A loose estimate was done of the blooming flora at the reference locations at Gentofte Lake once in May and once in June, while V.C ambassadors made a more thorough estimate of the biotopes in Universitetsparken Their method of estimating was equivalent to the method used and described by Urban Green (Ejrnæs et al 2015).

[1] Rodalon is a water-based and pH neutral disinfectant that kills both bacteria and fungi.

Data analysis

Every sampled bee was categorized to species using “Field Guide to the Bees of Great Britain and Ireland” by Falk & Lewington (Falk and Lewington 2015). The *Bombus* species *B. cryptarum, B. lucorum, B. magnus* and *B. terrestris,* are difficult to define to exact species. The queen bees have obvious recognizable traits, but the worker bees are difficult to tell apart just by morphological traits. These species are therefore categorized together as one species, *terrestris* complex, to give as exact data as possible. Henning Bang Madsen, University of Copenhagen approved all categorized bee species. All hoverflies were categorized to species using “Nationalnyckeln Til Sveriges Flora och Fauna: Tvåvingar – Blomflugor, bind 53a-b” (Bartsch, Binkiewicz et al. 2009) and approved by Monica Aimée Harlund Oyre, Naturhistorisk Museum Aarhus. There is for bees no Danish red list assessment therefore all species were assessed by the Swedish red list (Westling 2015) for both bees and hoverflies, further was the Schleswig-Holstein red list (van der Smissen 2001) used for bees and the Danish red list (Wind 2004) for hoverflies (appendix 2.1-2.2). All data was entered into an Excel sheet before analyzing (appendix 1).

Graphpad prism, version 7.01, was used to run a 2-way ANOVA tests with time and location as the two variables. If any significant differences were found ($P>0.05$), a Tukeys multiple comparison test was performed. Repeated measures were done on the same location over six periods, but without any replicates, therefore a factorial ANOVA was best suited, due to its ability to compare any number of sample means in one test. It allows us to estimate the effect of the two independent variables: time and location (Fowler et al 2013, McDonald 2009).

The graphs were made in Microsoft excel, version 8.1. The bar charts were made to illustrate the difference in number of species and individuals among the locations. Linear regressions were made to illustrate the distribution of species per. family and tribus over time. Biodiversity measures were calculated using the Shannon-Wiener diversity index, Pielou evenness index and Simpson’s dominance[2], for this the number of species (S) and individuals (N) was used. This was done for bees and hoverflies separately and total, for all locations. Venny 2.1 was used to make the Venn-diagrams (Oliveros 2007-2015), to illustrate any overlapping species among the locations, as well as any location specific species.

[2] Shannon-Wiener diversity index: , Pielou evenness index: , Simpsons dominance:

Information on the weather condition during the whole sampling period was obtained from DMI – the Danish meteorological institute (appendix 5).V.C contributed with all data on the flora in Universitetsparken (appendix 3.2) No analysis was conducted, on the floral composition at Universitetsparken or Gentofte Lake, and the data was not used in any of the statistical analyses on the difference between the locations.

Results

At the end of the sampling period, 1065 bee individuals were sampled and categorized into 47 species, distributed into 15 genera belonging to five different families. The 700 hoverfly individuals were sampled and categorized into 31 species, distributed into 17 genera, belonging to seven different tribes. Out of the 78 species found in total, 26 species were caught exclusively in one specific location, including 15 species that were represented by one individual only. *Hylaeus communis* and *Bombus terrestris* complex were the only species sampled in all eight locations (table 2.1 and 2.2). In total 30 bee species were sampled exclusively in Universitetsparken, including 10 species represented by one individual only, whilst *Nomada ferruginata* was the only species sampled exclusively at Gentofte Lake. *Andrena chrysosceles* and *Apis mellifera* were the only species present at the control-, combined V.C.-, and the combined ref. locations (table 2.1). At Universitetsparken, 13 hoverfly species were sampled exclusively, including *Eristalis arbustorum*, *Helophilus trivittatus* and *Pipizella viduata* with only one individual per. species, and 12 species were sampled exclusively at Gentofte Lake, including *Anasimyia transfuga*, and *Parhelophilus versicolor* with only one individual per. species. *Eupeodes corollae* and *Syrphus vitripennis* were the only species present at the control-, combined V.C-, and the combined ref. locations (table 2.2).

Family	Genus	Species	Control location	V.C. beach	V.C. grassland 1	V.C. grassland 2	V.C. meadow	V.C. forest	Ref. meadow	Ref. forest
Colletidae	*Colletes*	*daviesanus*		5	11	32				
	Hylaeus	*brevicornis*		1		2				
		communis	4	29	40	33	25	1	1	2
		confusus		1						
		hyalinatus	1	4	2	30				
Andrenidae	*Andrena*	*chrysosceles*	1	1	1		1		4	
		fulva	1	1	1		3	2		
		haemorrhea		1	2	2	1	3	3	
		helvola		1	2		1	12		
		minutula			5	1	1	1	2	
		nigroaenea			1	1				
		praecox				1			3	
		subopaca					1	1	1	
Halictidae	*Halictus*	*tumulorum*	1	2	2	5	5	1		
	Lasioglossum	*albipes*			1	1		2		
		calceatum		1	4	9	1	1		1
		leucopus		5	3	12	1	1		
		minutissimum	3	32	8	9	3	1		
		morio	1	39	20	36	42	8		
		nitidulum (NT)	2	3	1	28	4	1		
		punctatissimum				3				
		quadrinotatum (VU)						1		
		sexstrigatum	2	9	3	2	1	1		
		villosulum				1	1			
	Sphecodes	*crassus*		1		1				
		geoffrellus		1						

Megachilidae	*Hoplitis*	*claviventris*					1			
	Chelostoma	*florisomne*					1			
	Osmia	*bicornis*			1		5	20		1
		caerulescens					1			
	Megachile	*centuncularis*			1	6	1			
		willughbiella			1	10	9			
	Coelioxys	*elongata* (CR)					1			
Apidae	*Nomada*	*fabriciana*			1		2		3	
		ferruginata			1					
		fulvicornis					1			
		marshamella							2	
	Anthophora	*quadrimaculata* (CR)				1				
	Bombus	*hortorum*		1		3		7		2
		hypnorum		1	11	17	2	1	3	1
		lapidarius				6	1		5	
		norvegicus					4			
		pascuorum			7	4	12	8	5	3
		pratorum			2			3	2	4
		sylvestris			1		1			
		terrestris complex	5	7	7	31	10	15	17	4
	Apis	*mellifera*	9	1	30	53	57	16	2	

Table 2.1 – Number of bee individuals found in Universitetsparken and at Gentofte Lake. Red-listed species are marked with their individual status, as registered on the Schleswig Holstein red-list (NT= near threatened, VU= vulnerable, CR= critically endangered).

Tribe	Genus	Species	Control location	V.C. beach	V.C. grassland 1	V.C. grassland 2	V.C. meadow	V.C. forest	Ref. meadow	Ref. forest
Melanostomini	*Melanostoma*	*scalare*						3	1	
		mellinum							2	
	Platycheirus	*albimanus*						2		

		scutatus complex				1		3		
Syrphini	*Episyrphus*	*balteatus*		2	2			1		
	Eupeodes	*corollae*	3	5	3	10	5		1	
	Syrphus	*ribesii*		2	1		2	2		
		torvus		2	2					
		vitripennis	2	1	10	1		2	1	
Chrysogastrini	*Neoascia*	*interrupta* (NT)								2
		meticulosa							1	11
		podagrica								9
		tenur							30	118
Eristalini	*Anasimyia*	*lineata*							316	11
		transfuga								1
	Eristalis	*arbustorum*					1			
		intricaria							2	
		pertinax				1				3
		tenax		1	1					
	Helophilus	*hybridus*		1			1			
		pendulus			4	7	4	6	9	4
		trivittatus						1		
	Myathropa	*florea*			1	1				
	Parhelophilus	*frutetorum*								3
		versicolor								1
Eumerini	*Merodon*	*equestris*	1	1	4	4				
Pipizini	*Pipizella*	*viduata*		1						
Xylotini	*Chalcosyrphus*	*nemorum*							1	41
	Syritta	*pipiens*		3	3	9				
	Tropidia	*scita*							10	
	Xylota	*sylvarum*							5	

Table 1.2 – Number of hoverfly individuals found in Universitetsparken and at Gentofte Lake. Red-listed species are marked with their individual status, as registered on Danish red-list (NT= near threatened).

The meadows

The V.C. meadow had 5.8 times more individuals and 2.6 times more species as the control location, as well as having 48.4% of the number of individuals and 138.5 % of the number of species observed in the ref. meadow (figure 2).

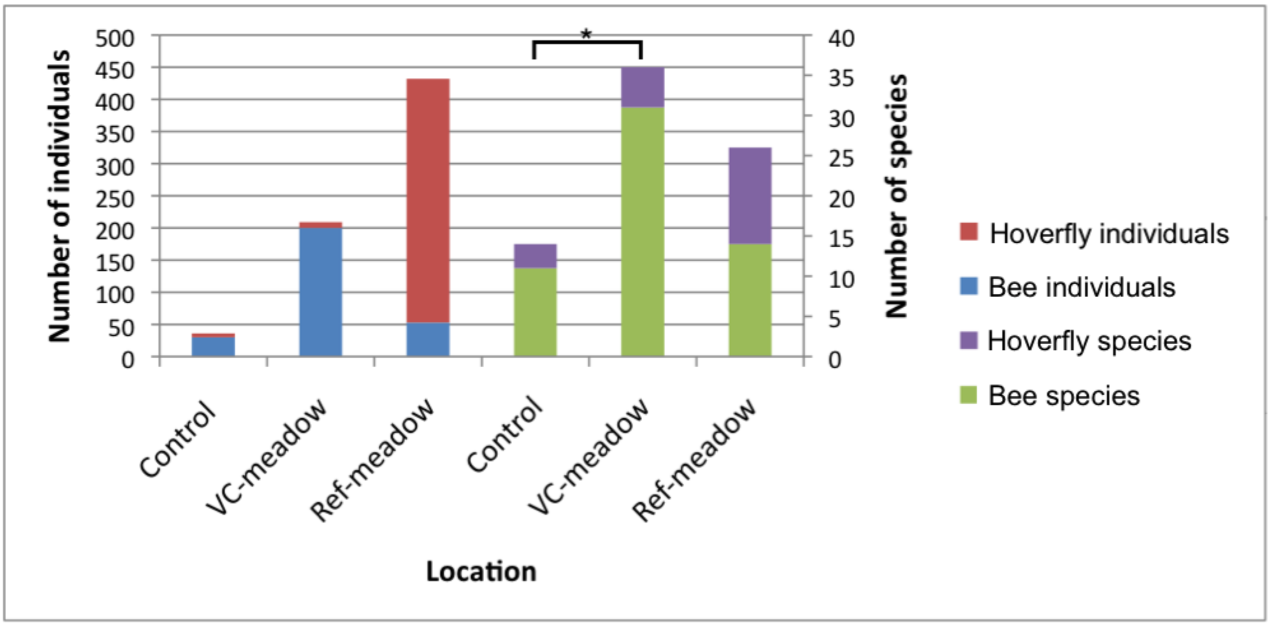


Figure 2 – Graph over the number of individuals and species of bees and hoverflies sampled at the control location, the V.C. meadow and the ref. meadow. The marking "*" shows a significant difference of P<0,05.

Statistical tests show, that there was a significant difference in the number of species in total, caught among locations ($F_{2,10}$ = 4.166, P = 0.048), explaining the 24% variation. A post-hoc test showed the significance to be between the control location and V.C. meadow (P = 0.048). No significant difference was found for individuals in total among the locations ($F_{2,10}$ = 2.756, P = 0.111) and sampling time was not a significant factor either, although it showed a notable tendency when looking at number of species in total (*S*: $F_{5,10}$ = 3.280, P = 0.052; *N*: $F_{5,10}$ = 2.503, P = 0.102).

When analyzing the two groups separately, the number of bee species and individuals differed significantly among locations (*N*: $F_{2,10}$ = 4.209, P = 0.047; *S*: $F_{2,10}$ = 4.742, P = 0.036) and a post-hoc test showed the significance again to be between the control location and the V.C. meadow (*S*: P = 0.045; *N*: P = 0.043). There was no significant difference in hoverfly species or individuals among the locations (*S*: $F_{2,10}$ = 3,601, P = 0.066; *N*: $F_{2,10}$ = 3.221, P = 0.083) and sampling time was not a significant factor either (*S*: $F_{5,10}$ = 1.379, P = 0.3105; *N*: $F_{5,10}$ = 1.039, P = 0.446) (appendix 6).

The Venn-diagrams show that among the locations, there were only five out of the total 51 species that were found in all locations, namely the bees *Hylaeus communis, Andrena chrysosceles, Bombus terrestris* complex and *Apis mellifera* and the hoverfly *Eupeodes corollae* (figure 3.1). Looking at bees separately, *Andrena praecox, Nomada ferruginata* and *Bombus pratorum* were sampled exclusively at the ref. forest and *Hylaeus hyalinatus* at the control location. Out of the 31 bee species sampled in the V.C. meadow, two species are red-listed. *Coelioxys elongata* (CR) was only found in the V.C. meadow, whereas *Lasioglossum nitidulum* (NT) was also found in the control location (figure 3.2). Looking at hoverflies separately, *Syrphus ribesii, Eristalis arbustorum* and *Helophilus hybridus* were exclusive to the V.C. meadow and *Merodon equestris* to the control location. Out of the 12 hoverfly species sampled in the ref. meadow, nine were sampled exclusively at this location (figure 3.3).

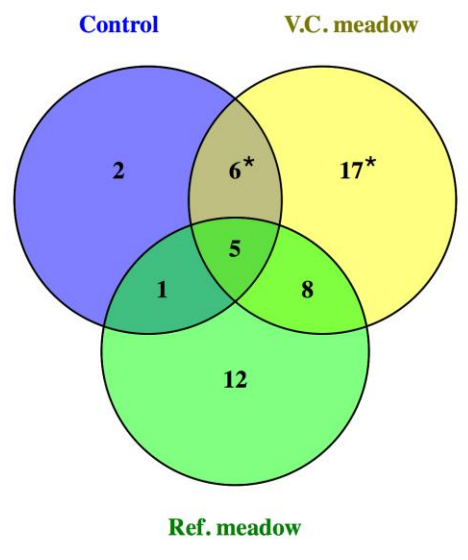


Figure 3.1 – Bees and hoverflies. Venn-diagram showing the overlapping species among the control location, V.C. meadow and ref. meadow. Locations and overlaps including red-listed species are marked with a "*" per. species.

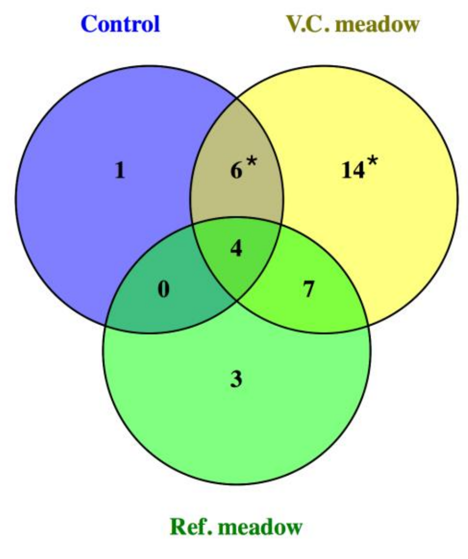


Figure 3.2 - Bees. Venn-diagram showing the overlapping species among the control location, V.C. meadow and ref. meadow. Locations and overlaps including red-listed species are marked with a "*" per. species.

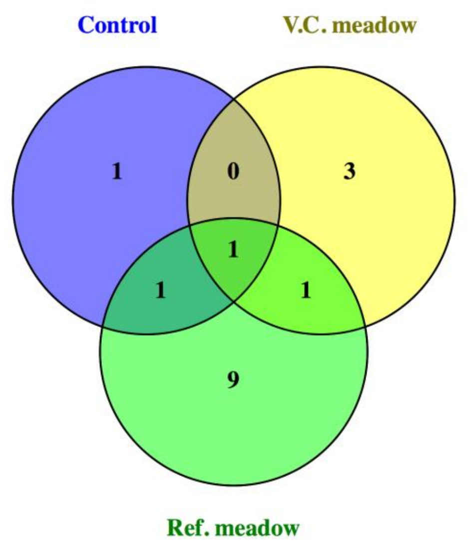


Figure 3.3- Hoverflies. Venn-diagram showing the overlapping species among the control location, V.C. meadow and ref. meadow.

The forests

The V.C. forest had 3.5 times more individuals and 2.1 times more species as the control location, as well as having 55.8% of the number of individuals and 166.7 % of the number of species observed in the ref. forest (figure 4.

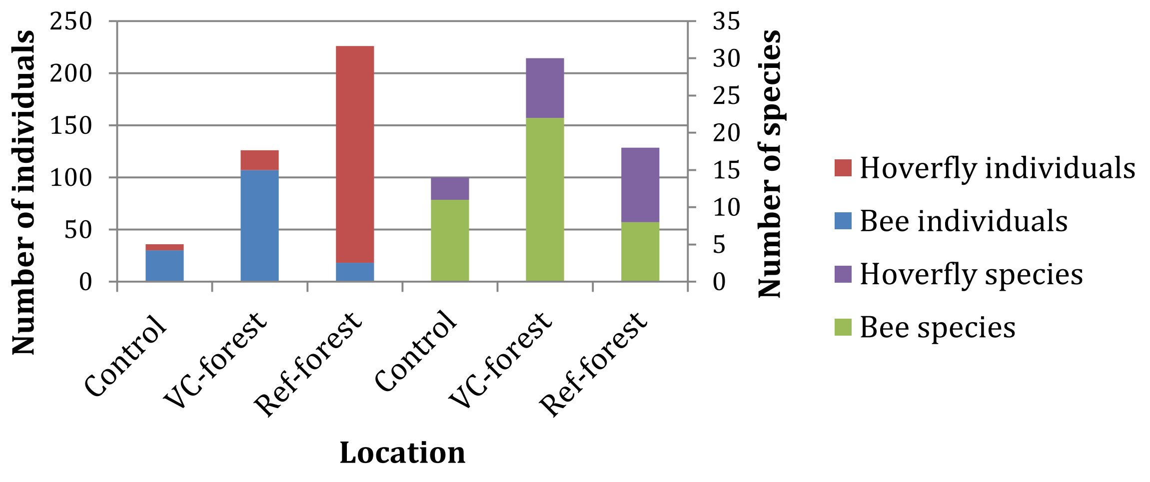


Figure 4 – Graph over the number of individuals and species of bees and hoverflies sampled at the control location, the V.C. forest and the ref. forest.

Based on the data from both meadow and forest, it can be estimated that the average effect of establishing a V.C. biotope in Universitetsparken has a 4.6 time increase in the number of individuals and a 2.4 time increase in the number of species. Furthermore we estimate that a V.C. biotope will obtain 50.9% of the richness in individuals and 150% of the richness in species, as a suburban reference location, with a similar habitat, would.

Statistical tests show that there was no significant difference in the number of species ($F_{2,10}$ = 2.5; P = 0.132) nor individuals ($F_{5,10}$ = 2.104; P = 0.149) among the three locations. The time variable differed significantly for the number of species sampled ($F_{5,10}$ = 3.546; P = 0.042), but the number of individuals was not significantly different over time ($F_{2,10}$ = 2.61; P = 0.122).

When analyzing the two groups separately, the tests showed that there was no significant difference in the number of bee species or individuals over time (*S*: $F_{5,10}$ = 2.325; P = 0.120; *N*: $F_{5,10}$ = 1.152; P = 0.396) or among locations (*S*: $F_{2,10}$ = 3.817; P = 0.057; *N*: $F_{2,10}$ = 2.778; P = 0.110). The same goes for hoverfly species and individuals over time (*S*: $F_{5,10}$ = 1.228; P = 0.365; *N*: $F_{5,10}$ = 1.027; P = 0.452) or among locations (*S*: $F_{2,10}$ = 3.211; P = 0.084; *N*: $F_{2,10}$ = 3.719; P = 0.062) (appendix 6).

The Venn-diagrams show that among the locations, there were two out of the total 44 species that were found in all locations. This was the two bee species *H. communis and B. terrestris* complex (figure 5.1). Looking at bees separately, *H. hyalinatus* and *A. chrysosceles* were sampled exclusively at the control location, while no species was specific to the ref. forest. Out of the 22 species of bees sampled in the V.C. forest, two are red-listed, *Lasioglossum quadrinotatum* (VU) found only in the V.C. forest and *L. nitidulum* (NT), found in the V.C. forest and the control location (figure 5.2). Looking at hoverflies separately, six species were exclusively sampled at the V.C. forest and *E. corollae* and *M. equestris* in the control location. Out of the 11 hoverfly species sampled in the ref. forest, 10 were location specific, including *Neoascia interrupta (NT)*, which is red-listed (figure 5.3).

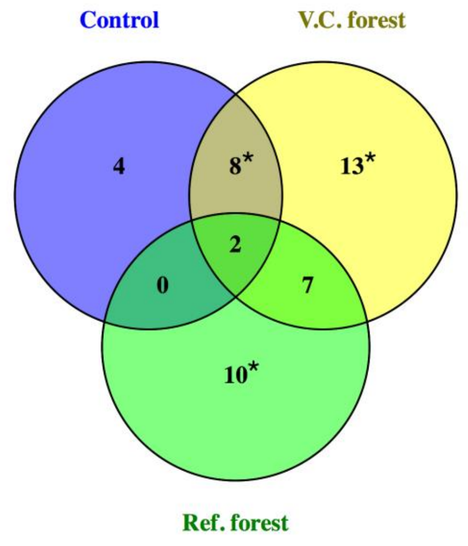


Figure 5.1 – Bees and hoverflies. Venn-diagram showing the overlapping species among the control location, V.C. meadow and ref. meadow. Locations and overlaps including red-listed species are marked with a "*" per. species.

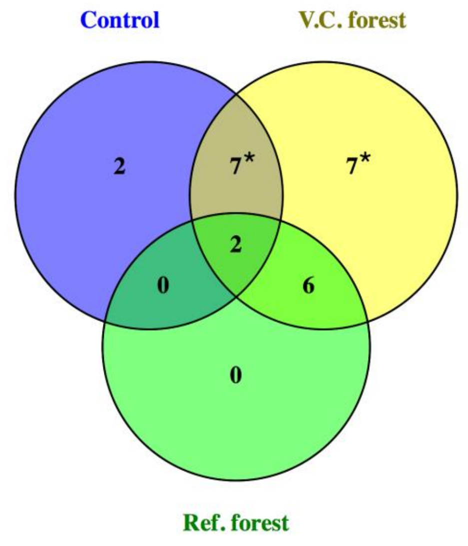


Figure 5.2 - Bees. Venn-diagram showing the overlapping species among the control location, V.C. meadow and ref. meadow. Locations and overlaps including red-listed species are marked with a "*" per. species.

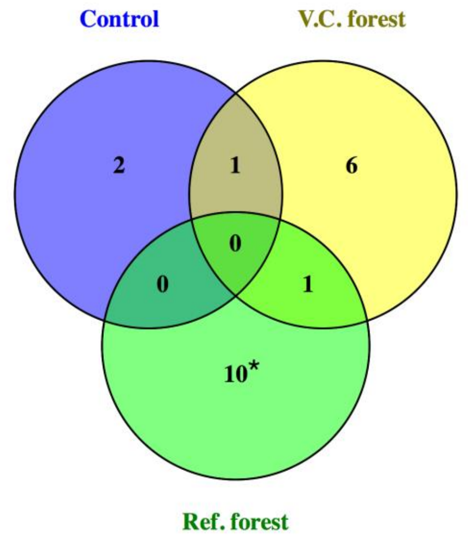


Figure 5.3 - Hoverflies. Venn-diagram showing the overlapping species among the control location, V.C. meadow and ref. meadow. Locations and overlaps including red-listed species are marked with a "*" per. species.

Universitetsparken

The V.C. grassland 2 had the highest total number of individuals in general, but had the same amount of hoverfly individuals as the V.C. grassland 1, which also had the highest number of hoverfly species, as well as the highest number of species in total. V.C. beach had the same amounts of sampled hoverfly species as V.C. grassland 1. The V.C. meadow had the highest number of bee species, but the lowest count of hoverfly individuals. V.C. forest had the lowest number of total species and individuals, as well as the lowest number of bee individuals (figure 6).

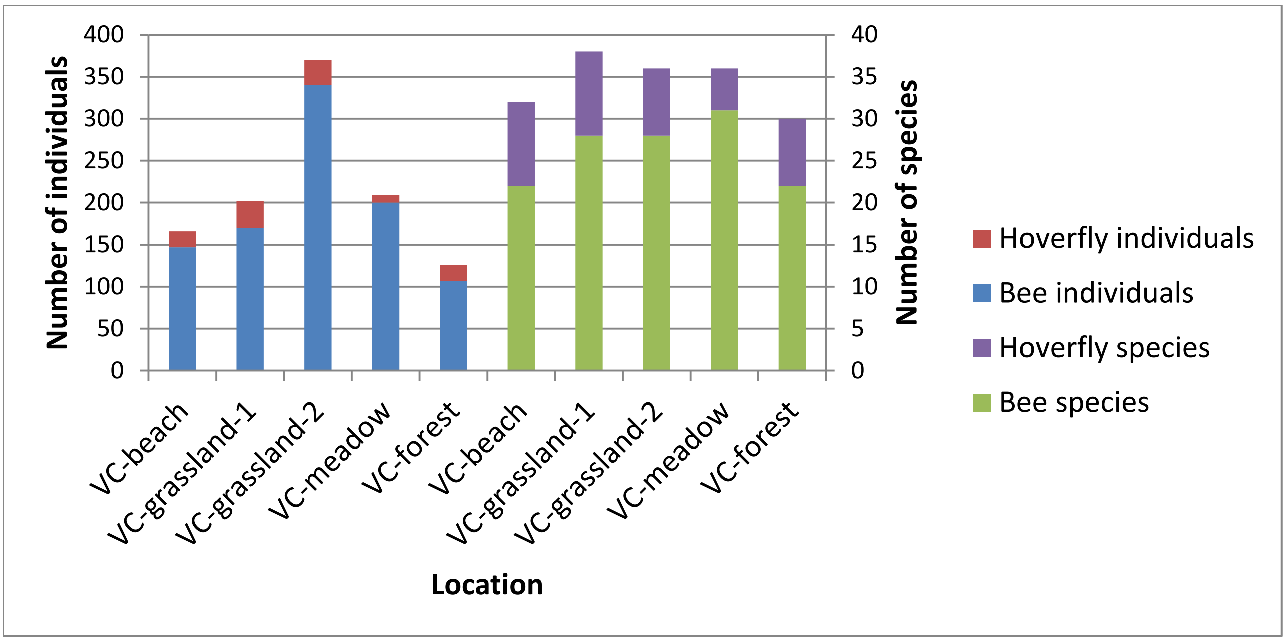


Figure 6 – Graph over the number of bee and hoverfly individuals and species sampled at the V.C. beach, V.C. grassland 1, V.C. grassland 2, V.C. meadow and V.C. forest.

Looking at the total number of species between the five locations at Universitetsparken, there is a significant difference among the sampling periods ($F_{5,20}$ = 13.48; P = <0.0001), but not between the locations ($F_{4,20}$ = 1.775; P = 0.1736). The same goes for total number of individuals, where there is a significant difference over time ($F_{5,20}$ = 7.792;P = 0.0003) but not among locations ($F_{4,20}$ = 2.296;P = 0.095).

When analyzing the two groups separately, there is a significant difference found in the number of species and individuals among the sampling periods for both bees (S: $F_{5,20}$ = 16.1; P = <0.0001; N: $F_{5,20}$ = 7.498; P = 0.0004) and hoverflies (S: $F_{5,20}$ = 4.015; P = 0.0110; N: $F_{5,20}$ = 3.093; P = 0.032) (appendix 6).

The Venn-diagrams[3] show that among the locations, 15 out of the total 64 species were found in all locations. Only one hoverfly species, *Syrphus ribesii*, was included in those 15 species, as well as the bee species, *L. nitidulum* (NT), which is red-listed (figure 7.1). Looking at bees separately, *Hylaeus confuses* and *Sphecodes geoffrellus* were sampled exclusively at the V.C. beach and the red-listed *L. quadrinotatum* (VU) was the only species sampled only in the V.C. forest. At the V.C. grasslands 1+2 there were five bee species exclusively sampled at that location, including the red-listed species *Anthophora quadrimaculata* (CR). The V.C. meadow had six location specific species, including the red-listed *C. elongata* (CR) (figure 7.2). Looking at hoverflies separately, *Pipizella viduata* was only sampled at the V.C. beach, *Melanostoma scalare, Platycheirus albimanus* and *Helophilus trivittatus* at the V.C. forest, *Myathropa florae* and *Eristalis pertinax* at the V.C. grasslands 1+2 and *E. arbustorum* at the V.C. meadow figure 7.3).

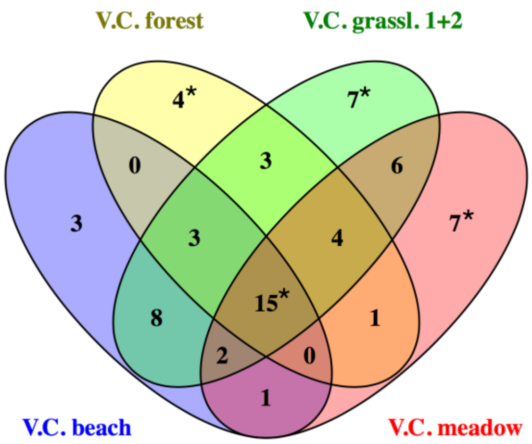


Figure 7.1 – Bees and hoverflies. Venn-diagram showing the overlapping species among the all V.C. locations. Locations and overlaps including red-listed species are marked with a "*" per. species.

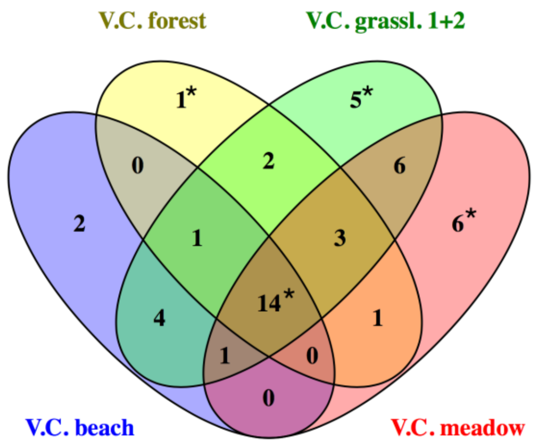


Figure 7.2 – Bees. Venn-diagram showing the overlapping species among all V.C. locations. Locations and overlaps including red-listed species are marked with a "*" per. species.

[3] Due to the program Venny Oliveros JC. 2007-2015. Venny. An interactive tool for comparing lists with Venn's diagrams. limitation in creating Venn diagrams, we were only able to compare up to four locations at one time. Therefore, we merged the two grasslands.

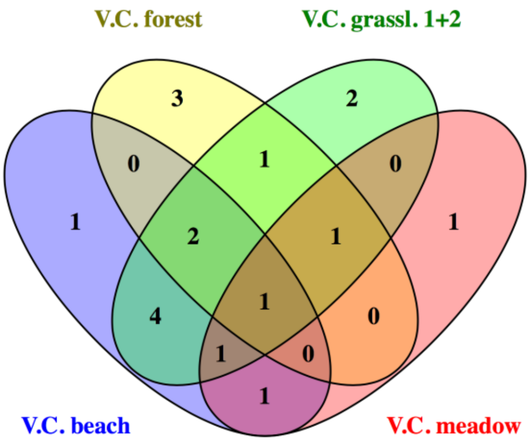


Figure 7.3 - Hoverflies. Venn-diagram showing the overlapping species among all V.C. locations.

Bee families

The distribution of the families is relatively even among the five V.C. locations (figure 8), this goes for both number of species per family and number of individuals per family.

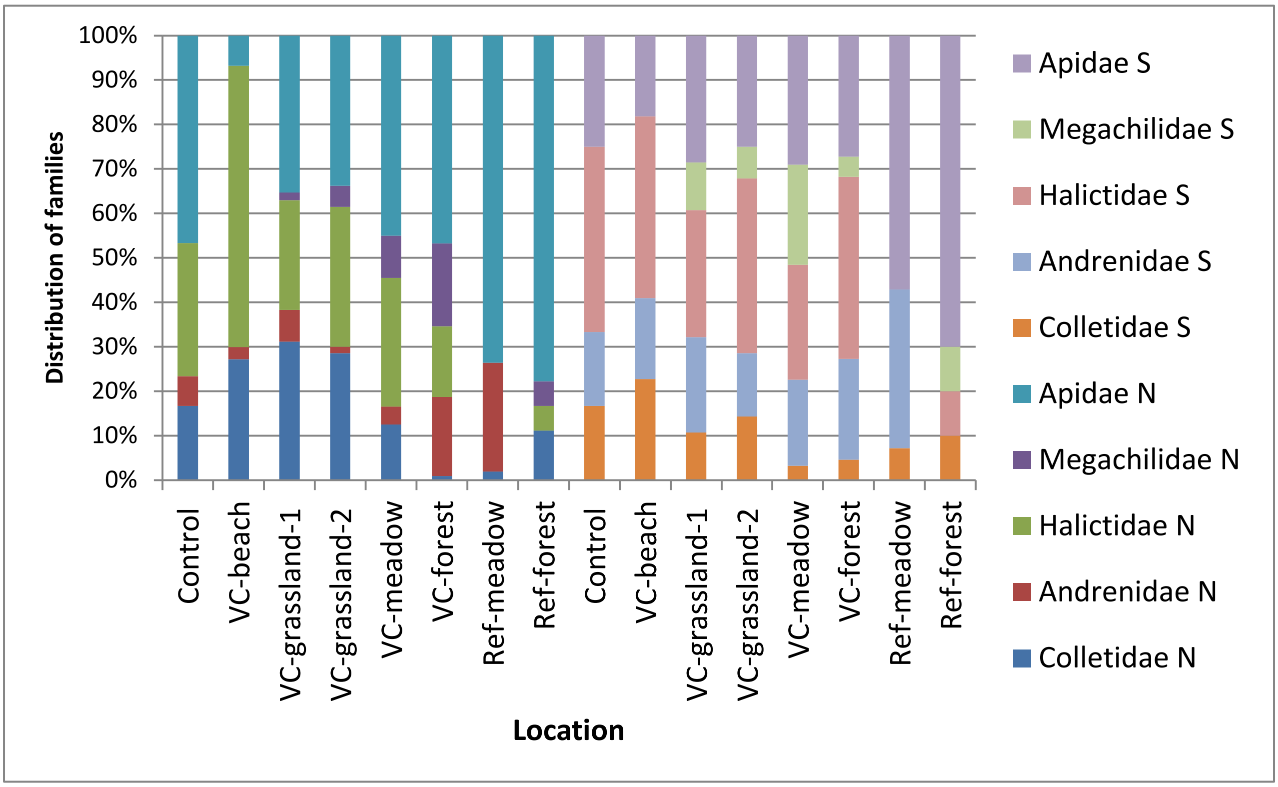


Figure 8 – Graph showing the distribution of bee families, by species and individuals, among locations.

Two families were present at the first sampling and throughout the whole sampling period, *Andrenidae* and *Apidae* (figure 9). The number of *Apidae* species fell by two in the second sampling in April and peaked with 10 species in the first period in June, The number of *Andrenidae* species peaked with eight species in the second sampling in May and fell to two species in the last sampling, being the family with the lowest tendency for growth over time (r^2= 0,011) (figure 10). *Halictidae* appeared with one species in the second sampling and was represented by eight more species in the next sampling, as well as 10 species in the last sampling, increasing continuously throughout the field period and being the family with the second highest tendency for growth over time (r^2= 0,757). *Megachilidae* appeared in the first sampling in May with two species and peaked in the first sampling in June with only four species. *Colletidae* was not represented until the second sampling in May, increasing continuously from three to five species and showing the highest tendency for growth over time (r^2 square = 0.8791)(appendix 4.2).

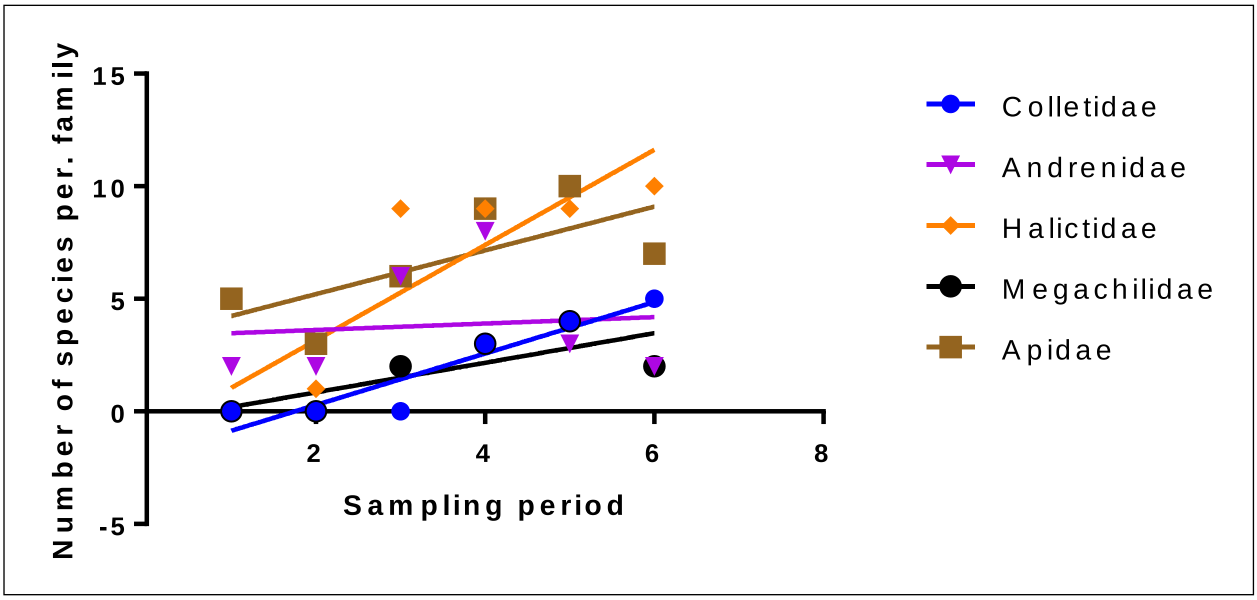


Figure 9 – Graph over linear regressions showing the tendency for number of species, from the families *Colletidae, Andrenidae, Halictidae, Megachilidae* and *Apidae*, to increase over the whole sampling period.

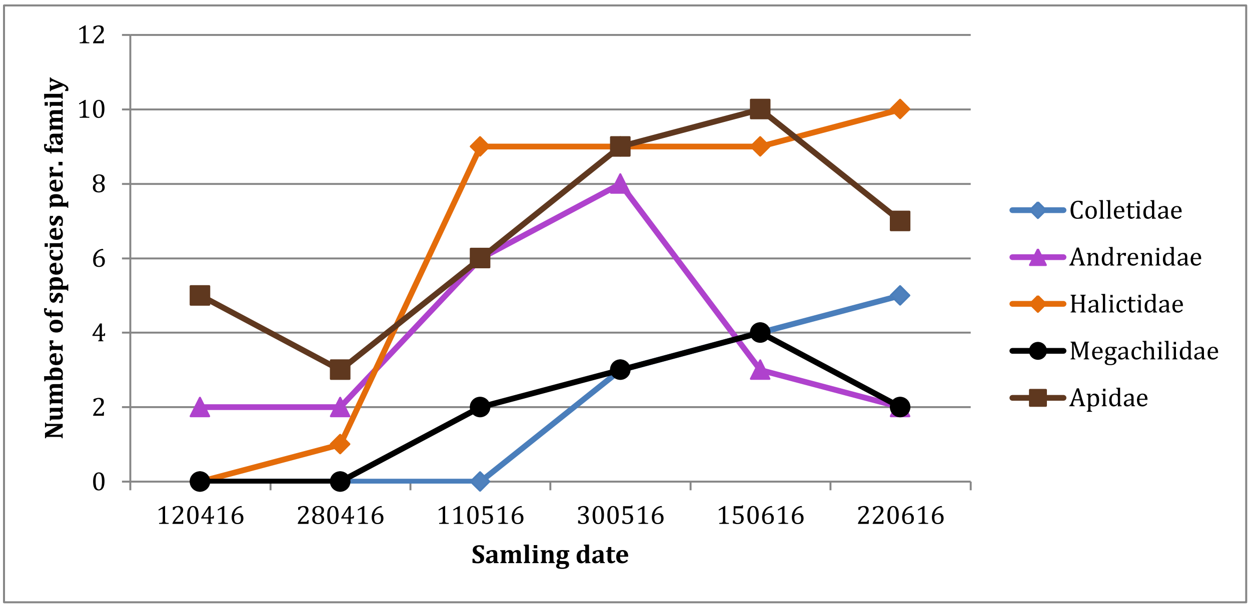


Figure 10 – The graph illustrates the increase/decrease of species per. family of bees, over time.

Hoverfly families

The distribution of tribes is not relatively even among the five V.C. locations and some tribus are only found in a few locations (figure11).

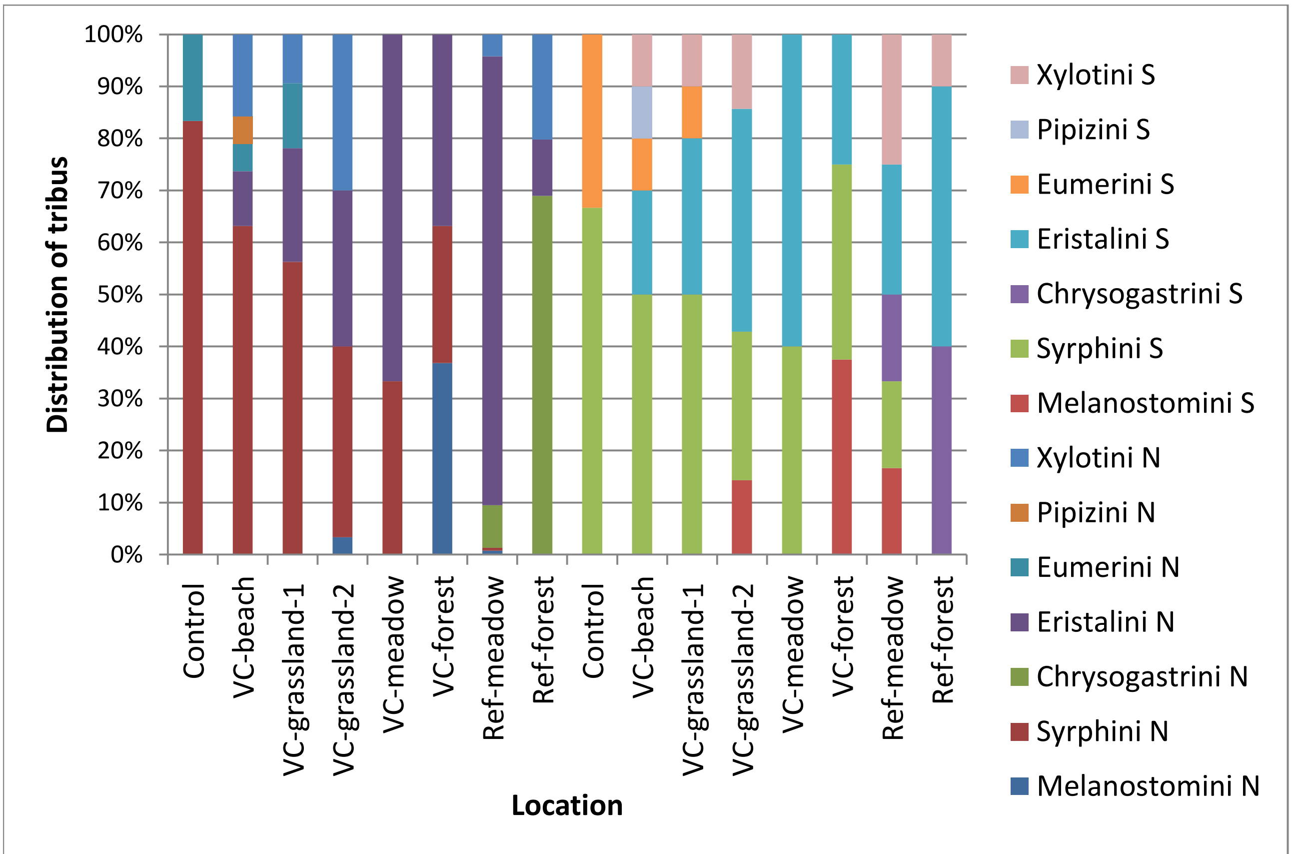


Figure 11 – Graph showing the distribution of hoverfly tribes, by species and individuals, among locations

Analyses show that the main difference is the composition of tribes found at Universitetsparken and Gentofte Lake. Only five out of seven tribes are found at Gentofte Lake and six out of seven tribes are found in Universitetsparken. *Chrysogastrini* are only registered at Gentofte Lake, and *Pipizini* and *Eumerini* are only registered in Universitetsparken.

Two tribes were present at the first sampling in April, *Eristalini* and *Syrphini* with *Eristalini* being the only tribe present throughout the whole sampling period (figure 12). The number of *Eristalini* species rose until May with two peaks of 10 species in both May and June, but with a drop in between of two species, this making it the tribe with the second highest tendency for growth (r^2 = 0.826). *Xylotini* had the highest tendency for continuously to increase over the whole sampling period as the only tribe (r^2 square = 0.964)(figure 13). *Pipizini* was only present with one species in June and thereby also the tribe with the lowest tendency for growth (r^2 square=0.154). *Eumerini* appeared first in May and with only one species through the rest of the sampling period. Both *Chrysogastrini* and *Melanostomini* where present from April, though *Chrysogastrini* was first present in the second sampling period. Both peaked in May but *Melanostomini* with four species and *Chrysogastrini* with only three species (appendix 4.1).

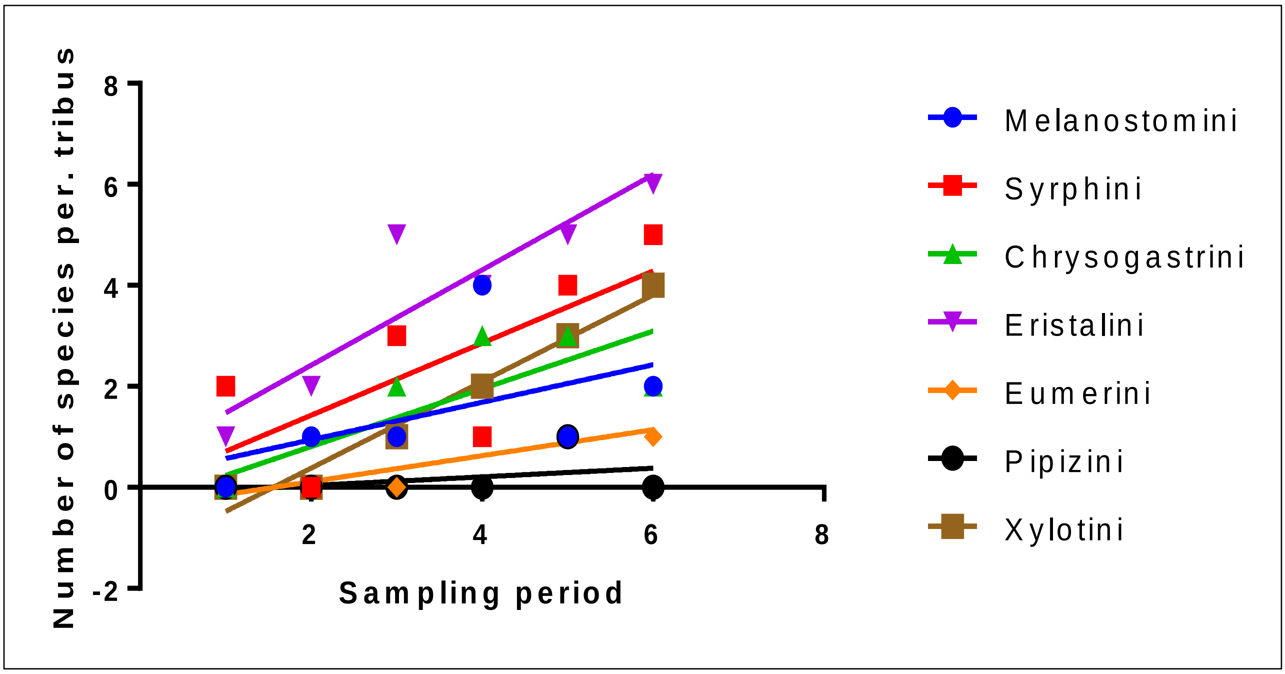


Figure 12 – non-linear regression showing the tendency for increase in the number of species from the Tribe *Melanostomini, Syrphini, Chrysogastrini, Eristalini, Eumerini, Pipizini* and *Xylotini*, through the entire field period.

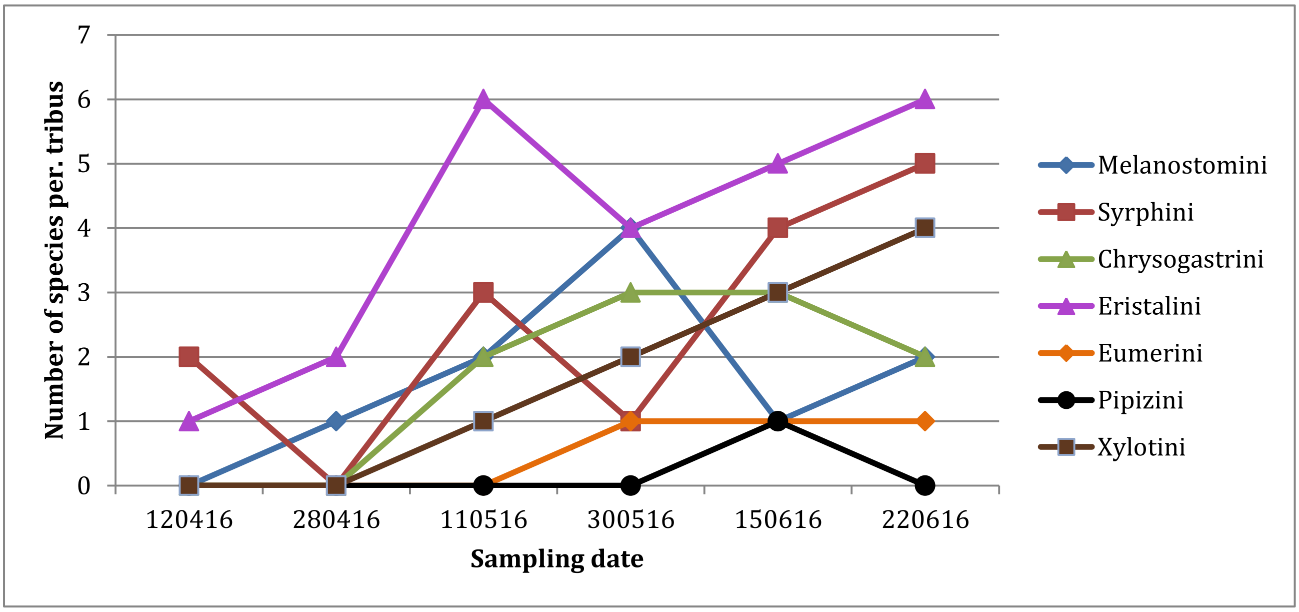


Figure 13 - illustration of the increase/decrease of hoverfly species per. tribe over time.

Biodiversity measures

Analysis showed that the diversity at Universitetsparken was higher than at Gentofte Lake. The only location with a less diversity and evenness was the V.C. forest. When looking at the dominance, Gentofte had a higher dominance than Universitetsparken (table 3.1). When looking at bees and hoverflies separately there is still on average, higher diversity and evenness at Universitetsparken than at Gentofte Lake. The location V.C. forest is lower in diversity in bees than the control (table 3.2) and when looking at hoverflies they have the same score of diversity (table 3.3).

Bees and hoverflies	Control location	V.C. beach	V.C. grassland 1	V.C. grassland 2	V.C. meadow	V.C. forest	Ref. meadow	Ref. forest
N - individuals	36	166	201	374	209	126	432	221
S - species	14	32	38	36	36	30	26	18
Shannon diversity index	3.21	4.36	4.64	4.45	3.88	2.16	3.14	3.53
Pielou evenness index	1.22	1.26	1.27	1.24	1.08	0.64	0.96	1.22
Simpsons dominance	0.54	0.31	0.28	0.30	0.43	0.20	0.83	0.52

Table 3.1 – Bees and hoverflies - Overview of individuals, species, diversity, evenness and dominance for each location.

Bees	Control location	V.C. beach	V.C. grassland 1	V.C. grassland 2	V.C. meadow	V.C. forest	Ref. meadow	Ref. forest
N - individuals	30	147	170	340	200	107	53	18
S - species	11	22	28	28	31	22	14	8
Shannon diversity index	2.20	2.23	2.60	2.74	2.46	1.73	2.42	2.17
Pielou evenness index	0.92	0.72	0.78	0.82	0.72	0.56	0.92	1.04
Simpsons dominance	0.15	0.17	0.12	0.08	0.15	0.03	0.12	0.13

Table 3.2 – Bees - Overview of individuals, species, diversity, evenness and dominance for each location.

Hoverflies	Control location	V.C. beach	V.C. grassland 1	V.C. grassland 2	V.C. meadow	V.C. forest	Ref. meadow	Ref. forest
N - individuals	6	19	31	34	13	19	379	204
S - species	3	10	10	8	5	8	12	11
Shannon diversity index	1.01	2.13	2.03	1.70	1.43	1.01	0.73	1.37
Pielou evenness index	0.92	0.92	0.88	0.82	0.89	0.49	0.29	0.59
Simpsons dominance	0.39	0.14	0.17	0.22	0.28	0.17	0.70	0.39

Table 3.3 – Hoverflies - Overview of individuals, species, diversity, evenness and dominance for each location.

The flora

The V.C volunteers made a floral estimate of the V.C. biotopes on May 11th and July 5th (appendix 3.2). We ourselves made estimates of the floral composition at the reference locations at Gentofte Lake (appendix 3.1)).

The weather

The first sampling period started with the lowest temperature, least sunlight and relatively little rainfall. The second period had 21 more hours of sunlight, but came with a 1.6 °C fall in temperature and the largest amount of wind and rain for the whole sampling period. The third period had an 8.5 °C rise in temperature, no rain and the amount of sunlight peaked, with 55.5 more hours. The temperature rose further in the fourth period, with little rain and the lowest amount of wind. There was a 1.9 °C fall in temperature in the fifth period and rose again at the sixth and last sampling period, which also had a relatively high amount of rainfall (table 4).

Sampling period	Date duration	Mean temp. (°C)	Rainfall (mm)	Sunlight (hours)	Mean wind (m/s)
1	06-12.04.16	7.0	8.0	37.5	4.0
2	20-28.04.16	5.4	32.7	58.5	4.5
3	04-11.05.16	13.9	0.0	114.0	3.3
4	24-30.05.16	16.1	2.8	75.0	3,2
5	08-15.06.16	14.2	8.4	59.0	3.7
6	15-22.06.16	16,2	24.9	46.0	3.5

Table 4– Mean temperature, amount of rainfall, amount of sunlight and mean wind speed at each time period, for the duration of the sampling period. All values are estimates from the monthly weather prognosis in DMI's weather archives. (**http://www.dmi.dk/vejr/arkiver/vejrarkiv/**; accessed 10.08.2016)

Discussion

The Meadow

There was no significant difference found in species or individuals found over the sampling time, though there was a notable tendency when looking at number of species in total. This result was not expected, because of the temporal fluctuation in the presence of pollinators and flowering flora. The reason for this could be explained by the weather, with only sampling period three having 114 hours of sunlight and no rainfall compared to the remaining five periods (table 4).

A significant difference was found in the number of species between the control location and the V.C. meadow as (figure 2). This indicates that establishing biotopes with a diverse floral composition, in otherwise lawn-dominated areas, has an effect on the diversity of pollinators, and even though there was no significant difference found in the number of individuals, a 5,8 times increase, from the control area to the V.C. meadow, indicates that establishing these biotopes has an effect on the number of pollinator individuals as well. The difference between the V.C. meadow and the ref. meadow was not large enough to be significant, which could indicate that the changes in Universitetsparken have been effective enough to be positively compared to a well-established suburban area. The V.C. meadow had 138,5 % of the number of species observed in the ref. meadow, but only 48,4 % of the number of individuals. If looking at the diversity measures the V.C meadow had a higher diversity with a lower dominance, whereas the ref-meadow had a high dominance, so the result of the 48,4% could be explained by the large amount of *Anasimyia lineata* individuals caught in the pan traps in the ref. meadow (table 2.2). The lacking significant difference between the control location and the ref. meadow, could also, however, give doubt to whether the ref. meadow has as high a diversity as first expected. The flora in the ref. meadow had a low number of different flowering species, though *Trifolium repens, Trifolium pretense, Anthriscus sylvestris* and *Ranunculus repens* were present as the dominant flora (appendix 3.1), compared to the flora at the V.C. meadow, with approximately 19 different species in bloom (appendix 3.2).

Forest

There was a significant difference in the number of species and individuals over the sampling time, which was expected due to the temporal fluctuation in the presence of pollinators (Oertli et al 2005), but also due to the temporal variation in flowering flora (Potts et al 2003) (appendix 6).

There was no significant difference found, in number of species or individuals, among the control location, the V.C. forest and the ref. forest. Though the V.C. forest had 3,5 times as many individuals and 2,1 times as many species as the control location (figure 4), this indicating that it does have some effect on the number and diversity of pollinator, when establishing a biotope resembling a forest in an urban habitat, but not enough to be significant. The V.C forest there were sampled 166,7 % of the number of species sampled in the ref. forest, implying that the diversity in the V.C. forest can be positively compared to that of a well-established suburban forest. The V.C forest was the location with the lowest score of diversity measures, also lower that the ref-forest. So if only judging from a diversity measuring point of view it is not as obvious a choice for raising the diversity, even though it did contain more species than both the control location and the ref-forest. The V.C. forest had 55,8% of the number of individuals observed in the ref. forest, which could be explained by the large amount of *Neoascia tenur* individual caught in the pan traps in the ref. forest (table 2.2). The ref. forest was a swampy area with moss dominated vegetation and sparse floral vegetation, compared to the forest at Universitetsparken with approximately 19 different species of herbs planted, but in May and June only seven and eight species respectively were in bloom. A few flowering species, were found in the ref. forest. In May, three was registered; *Geum rivale, Salix repens, Sorbus aucuparia*, and in June, four species were registered; *Geum rivale, Iris pseudacorus, Cornus sericea* and *Crepis paludosa* and in sparse numbers. A tree log is placed by the forest at Universitetsparken but it is still not contaminated with enough decay to have an influence on the composition of hoverflies.

Vild Campus

There was a significant difference in the number of species and individuals, found in the V.C biotopes, over the whole sampling period, which again was expected due to the temporal fluctuation in the presence of pollinators and flowering flora (appendix 6).

Creating the four different types of biotopes at V.C made a difference in the biodiversity at Universitetsparken, though it did not show any statistical difference. It raised the number of species 2.4 times and the number of individuals 4,6 times. To say what type of biotope to create for enhancing the diversity the most, this study is not sufficient. Maybe in fact, it was the effect of establishing four different types, with four different soil types, and the variation of flora that has given Universitetsparken the possibility to obtain 50.9% of the richness according to individuals, and 150% of the richness in species that a suburban reference location, with a similar habitat, would. When comparing the results in this study with the results found in the previous study by Urban green, this study also indicates a high potential for the urban environment to contain a rich pollinator fauna (Ejrnæs et al 2015). The variation of soil cover and flora gives possibilities for nesting and foraging for both groups of pollinators examined.

The distribution of species among the V.C. locations was fairly even (figure 6), but comparing the number of individuals, the V.C. grassland 2 had 374 individuals, which is 161 more than the 213 individuals the second richest location, the V.C. meadow, had. One explanation could be the placement of the location. The V.C. grassland 2 is more isolated than the remaining locations, it has high buildings surrounding it, and this could results in a slightly higher temperature and less wind. There are fewer students located in that area and therefore less pedestrian disturbances.

The biodiversity measures showed that the V.C. biotopes have in general a higher diversity and lower dominance than the reference locations. This enhances the suggestion that it does make a difference in diversity when establishing new biotopes in an urban environment, but not which biotope to create, if one were only to establish one of the four. If only looking at the diversity measures the V.C. forest could be excluded, but in the long run, this habitat could provide the right conditions for the hoverflies that are related to decaying wood, and thereby attract new genus to the pool of pollinators.

The probability of the same species being present at each of the five locations is likely to be high due to the size of Universitetsparken, and this could be an explanation to the lack of significant difference. All species found could originate from the same aggregations or colony of animals.

Bees

Insects are affected by the weather conditions (Tuell & Isaacs 2010, Vicens & Bosch 2000) and at low temperatures only few pollinators are active. Also when it is raining, only few genus are active. This includes e.g. *Bombus*. This could be an explanation for the 20% of *Bombus* out of the total number of bees sampled during this study. We had one sampling period in May with the highest number of sunlight hours compared to the remaining two months. A sampling period in April and one in June had a fair amount of rain and also the temperature was not that high (table 4). This could have affected the number of sampled individuals.

There was a remarkable difference in the number of hoverflies compared to bees found in all locations with the dominant group being bees, which was not expected; the expectation was that the two groups had been even in the distribution between the locations. The number of bee species found was also not expected, 46 at Universitetsparken in total, which is a higher number than we expected. It is also interesting that four red listed species appeared, and that *Chelostoma florisomne*, *Colletes daviesanus* and *Andrena praecox*, who are all oligolectic bee species, were found (appendix 7.1). So the new established biotope have been able to attract not only the generalist, but also a few specialists.

Out of the 46 species of bees found, 23 nest in the ground but with different preferences of soil. The four different locations consist of different soil types which could be beneficial for the soil and ground living bees and there by hosting a wider variety of species, which (Cane 1991) also demonstrates

Coelioxys elongata was sampled in the V.C. meadow and its main host *Megachile willughbiella*, which was the species occurring the most frequently of the *Megachile* genus in V.C with 20 individuals out of a total of 28 individuals. *C. elongate* habitat varies, but includes coastal dunes and gardens. It is known to forage on *Lotus corniculatus* but also other flowers. *C. florisomne*, another species found at the meadow, requires specific nesting sites and pollen source. It needs *Ranunculus* and pre-existing holes in for example decaying wood, hollow stems or building timber and is usually found in meadows (Falk & Lewington 2015). *Anthophora quadrimaculata* (CR), another species found at the meadow, is a solitary ground nesting species, it is polylectic, though *Lamiaceae* is mainly used for pollen foraging. For all species goes that the meadow provides the food source necessary. *Ranunculus acris, Lotus pedunculatus, Prunella vulgaris* and *Mentha aquatica* are all found in the meadow, but also the nesting sites is present. *Lasioglossum* is mostly a ground nesting genus from the family *Halictidae*. They are mostly polylectic and can be both social and eusocial. They are attacked by cleptoparasitic bees and mostly from the genus *Sphecodes* whom we also found at V.C. *Lasioglossum quadrinotatum* a polylectic species, associated with acid grassland and heath land was found in V.C forest, which is placed relatively close to V.C-grassland-. *Lasioglossum nitidulum*[4] is a polylectic species that prefers cliff faces, old walls or slopes without dense vegetation for nesting and often large nesting aggregations. We found 39 individuals in total, 28 of these where in VC- græsland-2

There is a slightly higher diversity of bees than hoverflies, at Universitetsparken. An indication, that the type of biotopes that V.C has created enhances a more positive environment for bees than for hoverflies.

Hoverflies

A difference is observed in the species of hoverflies. The difference could be explained by the biology of these. The species found at Gentofte Lake, where mainly related to decaying wood or sap for their larvae to feed, whereas the ones at Universitetsparken was mainly related to having aphid feeding larvae. The imago with aphid feeding larvae sampled at Gentofte was all found at the meadow location. At Gentofte Lake two species was highly dominant in the number of individuals found, *Anasimyia lineata* and *Neoascia tenur. A. lineata* is a species known for occurring in numbers of hundreds within a few square meters (Bartsch et al 2009a). Furthermore, the different biology of bees and hoverflies could explain the lesser abundance of hoverfly species. Hoverflies larvae need other resources than adult hoverflies and no parental care is known. Also they are very good fliers and can travel very long distances following the same route over several years (Sommaggio 1999). Little is known on their fly range but it seems that if wanting to use hoverflies as indicators on

[4] . After consulting with Henning Bang Madsen, it was decided, due to the lack of descriptions on *L.nitidulum*, the information on this species is from the description of *Lasioglussom smeathmanellum*, because these two species are almost identical in behavior.

biodiversity you need to look at them in a larger scale (Hennig & Ghazoul 2012) than what V.C. can provide.

The flora

The reason for the V.C. locations to have a higher number of species then the ref. location could be explained by, as with (Pawelek et al 2009), the change of flower composition in the park to a more bee friendly environment. If the surrounding green areas had been closer examined, these could also be an explanation of the relatively high number of species found in Universitetsparken. In the last couple of years an expanse of rooftop gardens has increased combined with individual homes in the city creating their own small gardens, containing a wider combination of flowers, herbs and vegetables. This development might increase the number of pollinators in the city (Lin et al 2015) and thereby create the possibility for pollinators to easier colonize the new biotopes at Universitetsparken. A research on the catchment area was not prioritized in this study due to a limited time period.

Biases and limitations

Universitetsparken is an area with many disturbances. It is a public park which students from the University of Copenhagen, children on excursions, dog walkers and so on walking through daily. The Vild Campus project is designed to be for the public to use and interact with and because there are benches placed at each V.C. biotope, it encourages people to spend time there. Information signs with QL codes also invite the public to smell the flowers and taste the herbs and fruits growing there. In the beginning children were playing in the pan traps at the V.C. grassland 1, because of its location near the Zoological Museum, but after placing signs, asking the public to stay out, this was no longer an issue. Subsequently a new problem arose. Crows and magpies started to empty the traps, but with a supplement of 30 mL Rodalon and covering the pan traps with chicken wire, this was prevented. These problems could also be an explanation to the difference between the V.C. grassland 2 and the remaining four locations.

Due to a strict time schedule, data was only sampled in April, May and June 2016. This excluded some species of both bees and hoverflies, and thereby does not give a complete impression on what could be at the new established biotopes(Oertli et al 2005).

The sampling method could have affected the results, the use of only yellow pan traps might have exclude some species and could explain that *Lasioglossum* being the genus most frequent represented by 29% out of the complete number of bees found in this study. The use 30 min of net catching compared to one week with the pan traps can give a wrong picture of the relationship between species and individuals, but because we have use the same method at all location it gives a correct picture when comparisons are made among the locations (Cane et al 2000, Gollan et al 2011, Leong & Thorp 1999, Roulston et al 2007).

The lack of experience in net catching could also have skewed the results. Due to no experience the beginning of this study to have developed an effective technique during the study. A high amount of insects, not interesting for this study, was also collected. When sorting these some, some species of bees and hoverflies, could have been lost. Species from the *Lejogaster* tribus are small and black and could resemble *Musca domestica* when an untrained eye looks at it. Many species of bees are also small such as species from the *Halictidae* family or the *Andrena* family and could easily disappear when not knowing what to look for.

There was no study done on the biodiversity in Universitetsparken before creating these new biotopes, and with the control location being relatively close to the new biotopes, the data sampled in this could be suspected to be part of the same pool of pollinators as sampled in the V.C. biotopes. When selecting reference areas, an knowledge about these areas are important in the matter of flora and already existing biodiversity, for them to be as comparative a reference area as possible

Recommendations for further studies

If establishing such new biotopes as V.C has done, to see the proper effect it would be recommendable to do an analysis on the biodiversity of the area beforehand. This could give a better indication on the development in biodiversity. When using pan traps, it would be preferable to use a variation of colors. Also when sampling, to see the whole picture and a possible development of the biodiversity, a sampling during the complete flight season and also over more than one year. A comparison between all V.C locations, and a corresponding reference location, could give a better indication, on which type of biotype to establish to enhance biodiversity the most, if only choosing one of the four types.

Conclusion

The establishment of the four different types of biotopes in Universitetsparken, in the centre of Copenhagen, has changed the biodiversity in the park. It has increased the number of species and individuals in both bees and hoverflies. The increase in number of bee species was higher than of hoverflies, which could imply that Universitetsparken has a better environment for wild bees than for hoverflies. In this study we could not conclude which type of biotope is the most beneficial, but there is an indication that either grassland or meadow would benefit more than forest or beach. The effect of establishing four different types of biotope, with four different soil types and floral compositions gives the insects at greater variation of habitat, than establishing only one type of biotope would. This is possibly the reason for the 4.6 time increase in the number of individuals and 2.4 time increase in the number of species from the time of establishment. As well as the reason for the 50.9% of richness in individuals and 150% of richness in species, that a suburban reference location, with a similar habitat, would. However, there need to be conducted further studies, to be able to conclude the full effect of the Vild Campus biotopes in Universitetsparken.

Acknowledgement

Thanks to our supervisors, Jes Søe Pedersen, Henning Bang Madsen and Hans Henrik Brunn for giving great advice on data analyses and a perspective on our sampled data. A special thanks to Henning Bang Madsen, University of Copenhagen, for his effort on approving all categorized bees and to Monica Aimée Harlund Oyre, Naturhistorisk Museum Aarhus, for approving all categorized hoverflies. Thanks to Urban Green and Vild Campus for giving us the opportunity to make this study on the V.C. biotopes; and for supplementing with data on both the establishment and the floral composition of the biotopes. Thanks to Brian Kerr for proof reading.

References

Svensk rødliste.
Ahrné K. 2008. *Local management and landscape effects on diversity of bees, wasps and birds in urban green areas*.
Alvey AA. 2006. Promoting and preserving biodiversity in the urban forest. *Urban Forestry & Urban Greening* 5: 195-201
Bartsch H, Binkiewicz E, Klintbjer A, Rådén A, Nasibov E. 2009a. Nationalnyckeln till Sveriges flora och fauna. Tvåvingar: Blomflugor: Eristalinae & Microdontinae. *ArtDatabanken, SLU, Uppsala*
Bartsch H, Binkiewicz E, Rådén A, Nasibov E. 2009b. Nationalnyckeln till Sveriges flora och fauna. Tvåvingar: Blomflugor: Syrphinae. Diptera: Syrphidae: Syrphinae. *ArtDatabanken, Sveriges lantbruksuniversitet*
Biesmeijer JC, Roberts S, Reemer M, Ohlemüller R, Edwards M, et al. 2006. Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science* 313: 351-54
Borkenhagen P. 2014. *Die Säugetiere Schleswig-Holsteins-Rote Liste*. Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein.
Cane JH. 1991. Soils of ground-nesting bees (Hymenoptera: Apoidea): texture, moisture, cell depth and climate. *Journal of the Kansas Entomological Society*: 406-13
Cane JH, Minckley RL, Kervin LJ. 2000. Sampling bees (Hymenoptera: Apiformes) for pollinator community studies: pitfalls of pan-trapping. *Journal of the Kansas Entomological Society*: 225-31
Carvell C. 2002. Habitat use and conservation of bumblebees (Bombus spp.) under different grassland management regimes. *Biological conservation* 103: 33-49
Cornelis J, Hermy M. 2004. Biodiversity relationships in urban and suburban parks in Flanders. *Landscape and Urban Planning* 69: 385-401
Croci S, Butet A, Georges A, Aguejdad R, Clergeau P. 2008. Small urban woodlands as biodiversity conservation hot-spot: a multi-taxon approach. *Landscape Ecology* 23: 1171-86
Ejrnæs R, Brunbjerg AK, Wind P, Brøndum L, Hansen MD. 2015. Urban Green. En undersøgelse af vilde blomster som afsæt for en rigere natur I byerne In *Urban Green. En Undersøgelse Af Vilde Blomster Som Afsæt for En Rigere Natur I Byerne*: Aarhus Universitet, DCE-Nationalt Center for Miljø og Energi
Falk SJ, Lewington R. 2015. *Field guide to the bees of Great Britain and Ireland*. British Wildlife Publishing Lt.
Fødevareministeriet Mo. 2016. http://svana.dk/natur/natura-2000/natura-2000-omraaderne/fakta-om-omraaderne/.
Fowler J, Cohen L, Jarvis P. 2013. *Practical statistics for field biology*. John Wiley & Sons.
Gentofte. Kommune. http://www.gentofte.dk/borger/by-og-milj%C3%B8/gr%C3%B8nne-omr%C3%A5der/naturomr%C3%A5der/gentofte-s%C3%B8.
Gollan JR, Ashcroft MB, Batley M. 2011. Comparison of yellow and white pan traps in surveys of bee fauna in New South Wales, Australia (Hymenoptera: Apoidea: Anthophila). *Australian Journal of Entomology* 50: 174-78
Goulson D, Lye GC, Darvill B. 2008. Decline and conservation of bumble bees. *Annu. Rev. Entomol.* 53: 191-208
Greenleaf SS, Williams NM, Winfree R, Kremen C. 2007. Bee foraging ranges and their relationship to body size. *Oecologia* 153: 589-96
Haslett J. 1989. Interpreting patterns of resource utilization: randomness and selectivity in pollen feeding by adult hoverflies. *Oecologia* 78: 433-42
Hennig EI, Ghazoul J. 2012. Pollinating animals in the urban environment. *Urban Ecosystems* 15: 149-66
Hicks DM, Ouvrard P, Baldock KC, Baude M, Goddard MA, et al. 2016. Food for pollinators: quantifying the nectar and pollen resources of urban flower meadows. *PLoS One* 11: e0158117

Krewenka KM, Holzschuh A, Tscharntke T, Dormann CF. 2011. Landscape elements as potential barriers and corridors for bees, wasps and parasitoids. *Biological Conservation* 144: 1816-25
Kühn I, Brandl R, Klotz S. 2004. The flora of German cities is naturally species rich. *Evolutionary ecology research* 6: 749-64
Leong J, Thorp RW. 1999. Colour-coded sampling: the pan trap colour preferences of oligolectic and nonoligolectic bees associated with a vernal pool plant. *Ecological Entomology* 24: 329-35
Lin BB, Philpott SM, Jha S. 2015. The future of urban agriculture and biodiversity-ecosystem services: challenges and next steps. *Basic and applied ecology* 16: 189-201
Madsen HB, Schmidt HT, Rasmussen C. 2015. Distriktskatalog over Danmarks bier (Hymenoptera, Apoidea). *Entomologiske Meddelelser*
Matteson KC, Ascher JS, Langellotto GA. 2008. Bee richness and abundance in New York City urban gardens. *Annals of the Entomological Society of America* 101: 140-50
McDonald JH. 2009. *Handbook of biological statistics*. Sparky House Publishing Baltimore, MD.
Oertli S, Mueller A, Dorn S. 2005. Ecological and seasonal patterns in the diversity of a species-rich bee assemblage (Hymenoptera: Apoidea: Apiformes). *European Journal of Entomology* 102: 53-63
Oliveros JC. 2007-2015. Venny. An interactive tool for comparing lists with Venn's diagrams.
Pawelek J, Frankie GW, Thorp RW, Przybylski M. 2009. Modification of a community garden to attract native bee pollinators in urban San Luis Obispo, California. *Cities and the Environment (CATE)* 2: 7
Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE. 2010. Global pollinator declines: trends, impacts and drivers. *Trends in ecology & evolution* 25: 345-53
Potts SG, Vulliamy B, Dafni A, Ne'eman G, Willmer P. 2003. Linking bees and flowers: how do floral communities structure pollinator communities? *Ecology* 84: 2628-42
Roulston TaH, Smith SA, Brewster AL. 2007. A comparison of pan trap and intensive net sampling techniques for documenting a bee (Hymenoptera: Apiformes) fauna. *Journal of the Kansas Entomological Society* 80: 179-81
Sirohi MH, Jackson J, Edwards M, Ollerton J. 2015. Diversity and abundance of solitary and primitively eusocial bees in an urban centre: a case study from Northampton (England). *Journal of Insect Conservation* 19: 487-500
Smith LS, Broyles ME, Larzleer HK, Fellowes MD. 2015. Adding ecological value to the urban lawnscape. Insect abundance and diversity in grass-free lawns. *Biodiversity and Conservation* 24: 47-62
Sommaggio D. 1999. Syrphidae: can they be used as environmental bioindicators? *Agriculture, ecosystems & environment* 74: 343-56
Sutherland JP, Sullivan MS, Poppy GM. 2001. Distribution and abundance of aphidophagous hoverflies (Diptera: Syrphidae) in wildflower patches and field margin habitats. *Agricultural and forest Entomology* 3: 57-64
Thompson K, Hodgson JG, Smith RM, Warren PH, Gaston KJ. 2004. Urban domestic gardens (III): composition and diversity of lawn floras. *Journal of Vegetation Science* 15: 373-78
Tuell JK, Fiedler AK, Landis D, Isaacs R. 2008. Visitation by wild and managed bees (Hymenoptera: Apoidea) to eastern US native plants for use in conservation programs. *Environmental Entomology* 37: 707-18
Tuell JK, Isaacs R. 2010. Weather during bloom affects pollination and yield of highbush blueberry. *Journal of economic entomology* 103: 557-62
van der Smissen J. 2001. *Die Wildbienen und Wespen Schleswig-Holsteins-Rote Liste*. pp. 138. Landesamt für Natur und Umwelt des Landes Schleswig-Holstein.
van Heezik YM, Dickinson KJ, Freeman C. 2012. Closing the gap: communicating to change gardening practices in support of native biodiversity in urban private gardens. *Ecology and Society* 17: 34
Vergnes A, Le Viol I, Clergeau P. 2012. Green corridors in urban landscapes affect the arthropod communities of domestic gardens. *Biological Conservation* 145: 171-78

Vicens N, Bosch J. 2000. Weather-dependent pollinator activity in an apple orchard, with special reference to Osmia cornuta and Apis mellifera (Hymenoptera: Megachilidae and Apidae). *Environmental Entomology* 29: 413-20
Westling A. 2015. *Rödlistade arter i Sverige 2015*. Artdatabanken.
Wind PPS. 2004. The Danish Red List. The National Environmental Research Institute, Aarhus University

Appendix 1

An electronic version of the excel data sheet with all information on species, gender, location, time and method of sampling.

Appendix 2.1

Species list of bees, with red-list assessment from the Schleswig- Holstein red-list (van der Smissen 2001), after modification to the UICN categories (Borkenhagen 2014). The red-list assessment for Sweden is relative to (Westling 2015).

Family	Genus	Species	Danish names	Sweden	Sl-Ho
Colletidae	*Colletes*	*daviesanus*	Vægsilkebi	LC	LC (*)
	Hylaeus	*brevicornis*	Lille maskebi	LC	LC (*)
		communis	Havemaskebi	LC	LC (*)
		confusus	Engmaskebi	LC	LC (*)
		hyalinatus	Kantmaskebi	LC	LC (*)
Andrenidae	*Andrena*	*chrysosceles*	Gulbenet jordbi	LC	LC (*)
		fulva	Rødpelset jordbi	LC	LC (*)
		haemorrhea	Havejordbi	LC	LC (*)
		helvola	Æblejordbi	LC	LC (*)
		minutula	Parksmåjordbi	LC	LC (*)
		nigroaenea	Sortbrun jordbi	LC	LC (*)
		praecox	Forårsjordbi	LC	LC (*)
		subopaca	Skovsmåjordbi	LC	LC (*)
Halictidae	*Halictus*	*tumulorum*	Bronzevejbi	LC	LC (*)
	Lasioglossum	*albipes*	Græslandsmalbi	LC	LC (*)
		calceatum	Moskussmalbi	LC	LC (*)
		leucopus	Bronzesmalbi	LC	LC (*)
		minutissimum	Lille smalbi	LC	LC (*)
		morio	Metalsmalbi	LC	LC (*)
		nitidulum	Smaragdsmalbi	LC	NT (V)
		punctatissimum	Punkteret smalbi	LC	LC (*)
		quadrinotatum	Tætpunkteret smalbi	LC	VU (3)
		sexstrigatum	Frynset smalbi	LC	LC (*)
		villosulum	Hedesmalbi	LC	LC (*)
	Sphecodes	*crassus*	Bred klintblodbi	LC	LC (*)
		geoffrellus	Lille blodbi	LC	LC (*)
Megachilidae	*Hoplitis*	*claviventris*	Gulsporet gnavebi	LC	LC (*)
	Chelostoma	*florisomne*	Ranunkelsaksebi	LC	LC (*)
	Osmia	*bicornis*	Rød murerbi	LC	LC (*)
		caerulescens	Blå murerbi	LC	LC (*)
	Megachile	*centuncularis*	Rosenbladskærebi	LC	LC (*)
		willughbiella	Træboende bladskærerbi	LC	LC (*)
	Coelioxys	*elongata*	Slank keglebi	LC	CR (1)
Apidae	*nomada*	*fabriciana*	Fabricius hvepsebi	LC	LC (*)

		ferruginata	Forårshvepsebi	LC	LC (*)
		fulvicornis	Gul hvepsebi	LC	LC (*)
		marshamella	Majhvepsebi	LC	LC (*)
	Anthophora	*quadrimaculata*	Havevægbi	LC	CR (1)
	Bombus	*hortorum*	Havehumle	LC	LC (*)
		hypnorum	Hushumle	LC	LC (*)
		lapidarius	Stenhumle	LC	LC (*)
		lucorum	Lys jordhumle	LC	DD (D)
		norvegicus	Hussnyltehumle	LC	LC (*)
		pascuorum	Agerhumle	LC	LC (*)
		pratorum	Lille skovhumle	LC	LC (*)
		sylvestris	Skovsnyltehumle	LC	LC (*)
		terrestris	Mørk jordhumle	LC	DD (D)
		terrestrisk cf.	jordhumle	x	x
	Apis	*meliffera*	Honningbi	NA	NA/NE

Appendix 2.2

Species list of hoverflies, with red-list assessments for Sweden (Westling 2015) and Denmark (Wind 2004).

Tribe	Genus	Species	Danish names	Sweden	DK
Melanostomini	*Melanostoma*	*scalare*	Lang græssvirreflue	LC	LC
		mellinum	Alm. Græssvirreflue	LC	LC
	Platycheirus	*albimanus*	Sortblå bredfodsflue	LC	LC
		scutatus cf	Skovbredfodsflue	LC	LC
Syrphini	*Episyrphus*	*balteatus*	Dobbetbåndet svirreflue	LC	LC
	Eupeodes	*corollae*	Alm marksvirreflue	LC	LC
	Syrphus	*ribesii*	Alm. Havesvirreflue	LC	LC
		torvus	Stor havesvirreflue	LC	LC
		vitripennis	Lille havesvirreflue	LC	LC
Chrysogastrini	*Neoascia*	*interrupta*	Plettet køllesvirreflue	LC	NT
		meticulosa	Sort køllesvirreflue	LC	LC
		podagrica	Alm køllesvirreflue	LC	LC
		tenur	Sump-køllesvirreflue	LC	LC
	Anasimyia	*lineata*	Snude-damsvirreflue	LC	LC
		transfuga	Parallel-damsvirreflue	LC	LC
	Eristalis	*arbustorum*	Alm. Dyndflue	LC	LC
		intricaria	Håret dyndflue	LC	LC
		pertinax	Gulfodet dyndflue	LC	LC
		tenax	Droneflue	LC	LC
	Helophilus	*hybridus*	Hybrid-sumpsvirreflue	LC	LC
		pendulus	Alm. Sumpsvirreflue	LC	LC
		trivittatus	Trebåndet sumpsvirreflue	LC	LC
	Myathropa	*florea*	Dødningehoved-svirreflue	LC	LC

	Parhelophilus	*frutetorum*	Krat-sumpsvirreflue	LC	LC
		versicolor	Gærde-sumpsvirreflue	LC	LC
Eumerini	*Merodon*	*equestris*	Stor narcisflue	LC	LC
Pipizini	*Pipizella*	*viduata*	Alm. Rodsvirreflue	LC	LC
Xylotini	*Chalcosyrphus*	*nemorum*	Lund-træsmuldsvirreflue	LC	LC
	Syritta	*pipiens*	Kompost-svirreflue	LC	LC
	Tropidia	*scita*	Køl-svirreflue	LC	LC
	xylota	*sylvarum*	Gulhåret træsvirreflue	LC	LC

Appendix 3.1

Estimation of flora at Gentofte Lake done by the authors of this project.

Ref. meadow 23.05.2016			Ref. forest 23.05.2016		
Species	Danish name	Estimated cover %	Species	Danish name	Estimated cover %
Vicia sativa	Foder-vikke	1%	*Geum rivale*	Eng-nellikerod	1%
Ranunculus repens	Lav ranunkel	2%	*Carex flacca*	Blågrøn-star	1%
Anthriscus sylvestris	Vild kørvel	10%	*Salix repens*	Krybende pil	1%
Holcus lanatus	Fløjlsgræs	50%	*Sorbus aucuparia*	Almindelig røn	1%
Poa trivialis	Almindelig rapgræs	10%			
Carex disticha	Toradet-star	2%			
Myosotis arvensis	Mark-forglemmigej	1%			
Taraxacum. sect. Taraxacum	Vej-mælkebøtte	2%			

Ref. meadow 22.06.2016			Ref. forest 22.06.2016		
Species	Danish name	Estimatet cover %	Species	Danish names	Estimatet cover %
Vicia sativa	Foder-vikke		*Geum rivale*	Eng-nellikerod	
Ranunculus repens	Lav ranunkel		*pseudacorus*	Gul iris	
Anthriscus sylvestris	Vild kørvel		*Cornus sericea*	Pile-kornel	
Holcus lanatus	Fløjlsgræs		*Crepis paludosa*	Kær-høgeskæg	
Poa trivialis	Almindelig rapgræs		*Dactylis glomerata*	Almindelig hundegræs	
Trifolium repens	Hvid-kløver				
Trifolium pratense	Rød-kløver				
Rumex crispus	Kruset skræppe				

Solanum dulcamara	Bittersød-natskygge				
Arrhenatherum elatius	Draphavre				

Appendix 3.2

Estimation of flora in Universitetsparken done by ambassadors from Vild Campus.

Species checks and flower estimates	V.C. grassland 1		11.05.2016	05.07.2016
Species – Danish names	Present	Not present	Flower estimate	
Agrostis capillaris - Alm. hvene	X		0	>100
Anthyllis vulneraria - Rundbælg	X		10-100	1-10.
Campanula rotundifolia - Liden klokke	X		0	10-100.
Carlina vulgaris - Bakketidsel	X		0	10-100.
Centaurea jacea - Alm. knopurt	X		0	10-100.
Dianthus deltoides - Bakkenellike	X		0	>100
Festuca ovina - Fåre-svingel	X		Not possible	10-100
Filipendula vulgaris - Knoldet mjødurt	X		0	1-10.
Galium verum – Gul snerre	X		0	0
Geranium sanguineum - Blodrød storkenæb	X		0	0
Hypochoeris radicata - Alm. kongepen	X		0	10-100
Knautia arvensis - Blåhat	X		1-10	0
Leucanthemum vulgare - Hvid okseøje	X		0	
Luzula campestris - Mark-frytle	X		0	10-100
Origanum vulgare - Merian	X		0	10-100
Pilosella officinarum – Håret høgeurt	X		0	0
Plantago media - Dunet vejbred	X		1-10	1-10.
Potentilla argentea - Sølv-potentil	X		0	1-10.
Rhinanthus minor - Liden skjaller (planted seed)		X		10-100
Saxifraga granulata - Kornet stenbræk	X		10-00	10-100
Thymus pulegioides - Bredbladet timian	X		0	0

Thymus serpyllum – Smalbladet timian		X		0
Tussilago farfara - Følfod (immigrated in 2016)	X		0	10-100
Viscaria vulgaris - Tjærnellike	X		0	0
Viola canina- Hunde-viol (planted in 2016)		X		0
Anchusa officinalis - Læge oksetunge (immigrated in 2016)	X		1-10	0
Echium vulgare - Slangehoved (immigrated in 2016)	X			0
Silene vulgaris - Blæresmelde				1-10.
Trifolium arvense - Harekløver				1-10.
Plantago lanceolata - Lancet vejbred				10-100

Species checks and flower estimates	V.C. grassland 2		11.05.2016	05.07.2016
Species – Danish names	Present	Not present	Flower estimate	
Agrostis capillaris - Alm. hvene	X		0	>100
Anthyllis vulneraria - Rundbælg	X		10-100	1-10.
Campanula rotundifolia - Liden klokke		X		10-100.
Carlina vulgaris - Bakketidsel	X		0	10-100.
Centaurea jacea - Alm. knopurt	X		0	10-100.
Dianthus deltoides - Bakkenellike	X		0	>100
Festuca ovina - Fåre-svingel	X		0	>100
Filipendula vulgaris - Knoldet mjødurt	X		0	1-10.
Galium verum – Gul snerre	X		0	0
Geranium sanguineum - Blodrød storkenæb	X		0	0
Hypochoeris radicata - Alm. kongepen	X		0	10-100
Knautia arvensis - Blåhat	X		1-10	0
Leucanthemum vulgare - Hvid okseøje	X		0	1-10.
Luzula campestris - Mark-frytle	X		10-100	10-100
Origanum vulgare - Merian	X		0	0
Pilosella officinarum – Håret høgeurt	X		0	?

Plantago media - Dunet vejbred	X		1-10	10-100
Potentilla argentea - Sølv-potentil	X		0	0
Rhinanthus minor - Liden skjaller (planted seed)		X		1-10.
Saxifraga granulata - Kornet stenbræk	X		10-100	>100
Thymus pulegioides - Bredbladet timian	X		0	0
Thymus serpyllum – Smalbladet timian		X		0
Tussilago farfara - Følfod (immigrated in 2016)	X		0	10-100
Viscaria vulgaris - Tjærnellike	X		0	0
Viola canina - Hunde-viol (planted in 2016)		X		0
Viscaria vulgaris - Tjærnellike				0
Viola canina- Hunde-viol (planted in 2016)				0
Trifolium arvense - Harekløver				1-10.

Species checks and flower estimates	V.C. forest		11.05.2016	05.07.2016
Species – Danish names	Present	Not present	Flower estimate	
Anemone hepatica - Blå anemone (planted in 2016)		X		
Anemone nemorosa – Hvid anemone	X		0	0
Athyrium filix-femina - Almindelig fjerbregne (planted in 2016)		X		
Campanula latifolia - Bredbladet klokke	X		0	10-100
Campanula trachelium - Nælde-klokke	X		0	10-100
Corydalis cava - Hulrodet lærkespore (planted in 2016)	X		0	0
Cornus sanguinea - Rød kornel	X		0	0
Crataegus laevigata - Alm. hvidtjørn	X		0	0
Dryopteris filix-mas - Almindelig Mangeløv (planted in 2016)	X		Not possible	1-10.
Fragaria vesca – Skovjordbær	X		10-100	0
Gagea lutea – Alm. guldstjerne (planted in 2016)		X		
Geranium sylvaticum - Skov-storkenæb	X		1-10	0
Hedera helix - Vedbend		X		0
Hypericum hirsutum - Lådden perikon	X		0	0

Lamiastrum galeobdolon – Alm. guldnælde (immigrated 2016)	X		1-10	>100
Lathyrus sylvestris - Skov-fladbælg	X		0	0
Lathyrus vernus - Vår-fladbælg (planted seed)	X		1-10	1-10.
Milium effusum - Miliegræs	X		>100	0
Myosotis sylvatica - Skov-forglemmigej	X		>100	0
Polypodium vulgare – Alm. engelsød (planted 2016)		X		1-10.
Primula veris - Hulkravet kodriver	X		0	
Scrophularia nodosa - Knoldet brunrod	X		0	0
Stellaria holostea - Stor fladstjerne	X		10-100	10-100
Viburnum opulus - Kvalkved	X		0	0
Vicia sepium - Gærde-vikke	X		0	0
Viola riviniana - Krat-viol (planted seed)		X		1-10.
Digitalis purpurea – Alm. fingerbøl (immigrated 2016)	X			0

Species checks and flower estimates	V.C. beach		11.05.2016	05.07.2016
Species – Danish names	Present	Not present	Flower estimate	
Achillea millifolium - Alm. røllike	X		0	>100
Beta vulgaris ssp. maritima - Strandbede	X		0	10-100
Cochlearia danica - Dansk kokleare	X		10-100	0
Crambe maritima - Strandkål (planted seed)		X		0
Cynoglossum officinale - Læge-hundetunge	X		10-100	0
Dauncus carota - Vild gulerod	X		0	>100
Jasione montana - Blåmunke		X		1-10.
Koeleria glauca - Klit-kambunke	X		0	0
Lathyrus japonicus - Strand-fladbælg (planted seed)	X		0	1-10.
Linaria vulgaris – Alm. Torskemund (planted seed)	X		0	1-10.
Rumex acetosella - Rødknæ	X		>100	10-100

Sedum acre - Bidende stenurt	X		0	1-10.
Silene nutans - Nikkende limurt	X		0	0
Tripleurospermum maritimum - Strand-kamille	X		1-10	10-100
Verbascum nigrum - Mørk kongelys	X		0	1-10.

Species checks and flower estimates	V.C. beach		11.05.2016	05.07.2016
Species – Danish names	Present	Not present	Flower estimate	
Achillea ptarmica – Nyse-røllike	X		0	10-100
Alopecurus pratensis - Eng-rævehale (immigrated 2016)	X		1-10	0
Anthoxanthum odoratum - Vellugtende gulaks	X		>100	10-100
Briza media - Hjertegræs	X		0	10-100
Cardamine pratensis - Engkarse	X		1-10	0
Carex flacca - Blå-grøn star (planted seed)		X		0
Cerastium fontanum - Alm. hønsetarm (immigrated 2016)	X		1-10	1-10.
Cirsium palustre – Kær-tidsel	X		0	10-100
Climacium dendroides - Stor engkost (planted in june 2016)				0
Cynosurus cristatus - Alm. kamgræs	X		0	10-100
Filipendula ulmaria - Alm. Mjødurt (planted seed)		X		1-10.
Galium mollugo - Hvid snerre (immigrated 2016)	X		0	0
Geum rivale – Eng-nellikerod	X		1-10	0
Lathyrus pratensis - Gul fladbælg	X		0	10-100
Leontodon autumnalis - Høstborst	X		0	10-100
Lotus pedunculatus - Sump-kællingetand	X		0	0
Lychnis flos-cuculi - Trævlekrone	X		1-10	1-10.
Mentha aquatica - Vand-mynte		X		0
Poa trivialis - Alm. rapgræs (immigrated 2016)	X		1-10	0
Potentilla erecta - Tormentil (planted seed)		X		0
Prunella vulgaris - Alm. brunelle	X		0	10-100

Ranunculus acris - Bidende ranunkel	X		10-100	0
Rumex acetosa - Alm. syre	X		1-10	0
Silene dioica -Dag-pragtstjerne	X		10-100	10-100
Stellaria graminea - Græsbladet fladstjerne	X		0	0
Succisa pratensis - Djævelsbid	X		0	0
Valeriana officinalis - Læge-baldrian	X		0	1-10.
Climacium dendroides - Stor engkost (planted in 2016)	X			

Appendix 4.1

Linear regression on tribus of hoverflies created in GraphPad Prism 7.01

Tribe	Melanostomini	Syrphini	Chrysogastrini	Eristalini	Eumerini	Pipizini	Xylotini
Straight line							
Best-fit values							
Y Intercept	0.2	-3.06E-16	-0.3333	0.5333	-0.4	-0.1333	-1.333
Slope	0.3714	0.7143	0.5714	0.9429	0.2571	0.08571	0.8571
Std. Error							
Y Intercept	1.239	1.363	0.8855	0.8425	0.2726	0.3908	0.3212
Slope	0.3182	0.3499	0.2274	0.2163	0.06999	0.1003	0.08248
95% CI (profile likelihood)							
Y Intercept	-3.24 to 3.64	-3.784 to 3.784	-2.792 to 2.125	-1.806 to 2.873	-1.157 to 0.3567	-1.218 to 0.9516	-2.225 to -0.4415
Slope	-0.5119 to 1.255	-0.2573 to 1.686	-0.05987 to 1.203	0.3422 to 1.544	0.06283 to 0.4515	-0.1929 to 0.3643	0.6281 to 1.086
Goodness of Fit							
Degrees of Freedom	4	4	4	4	4	4	4
R square	0.2541	0.5102	0.6122	0.826	0.7714	0.1543	0.9643
Absolute Sum of Squares	7.086	8.571	3.619	3.276	0.3429	0.7048	0.4762
Sy.x	1.331	1.464	0.9512	0.905	0.2928	0.4198	0.345
Number of points							
# of X values	6	6	6	6	6	6	6
# Y values analyzed	6	6	6	6	6	6	6

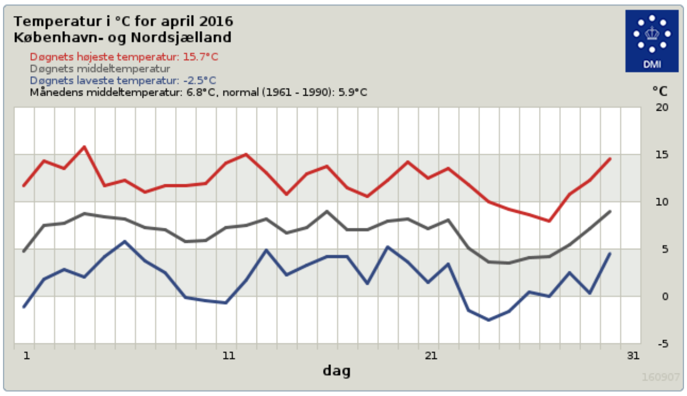
Appendix 4.2

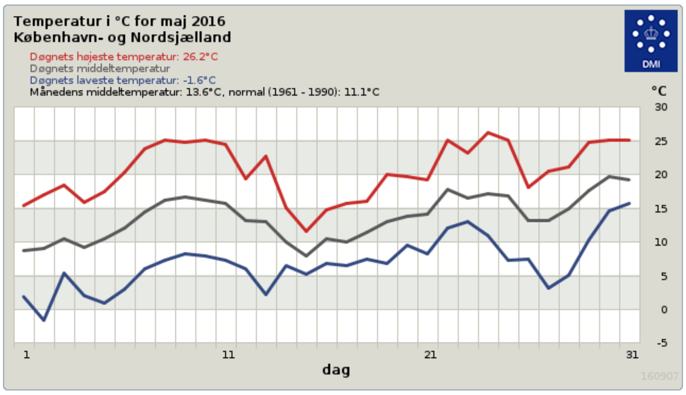
Linear regression on families of bees created in GraphPad Prism 7.01

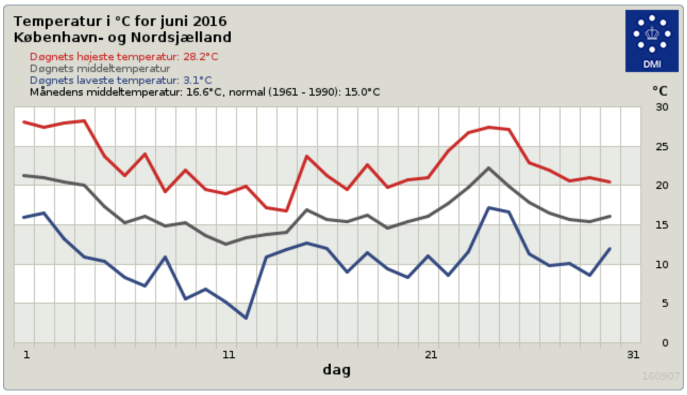
Family	Colletidae	Andrenidae	Halictidae	Megachilidae	Apidae
Straight line					
Best-fit values					
YIntercept	-2	3.333	-1.067	-0.4667	3.267
Slope	1.143	0.1429	2.114	0.6571	0.9714
Std. Error					
YIntercept	0.8252	2.653	2.332	1.069	1.909
Slope	0.2119	0.6811	0.5989	0.2745	0.4902
95% CI (profile likelihood)					
YIntercept	-4.291 to 0.2911	-4.032 to 10.7	-7.542 to 5.409	-3.435 to 2.502	-2.033 to 8.567
Slope	0.5546 to 1.731	-1.748 to 2.034	0.4516 to 3.777	-0.1051 to 1.419	-0.3895 to 2.332
Goodness of Fit					
Degrees of Freedom	4	4	4	4	4
R square	0.8791	0.01088	0.7571	0.5889	0.4954
Absolute Sum of Squares	3.143	32.48	25.1	5.276	16.82
Sy.x	0.8864	2.849	2.505	1.148	2.051
Number of points					
# of X values	6	6	6	6	6
# Y values analyzed	6	6	6	6	6

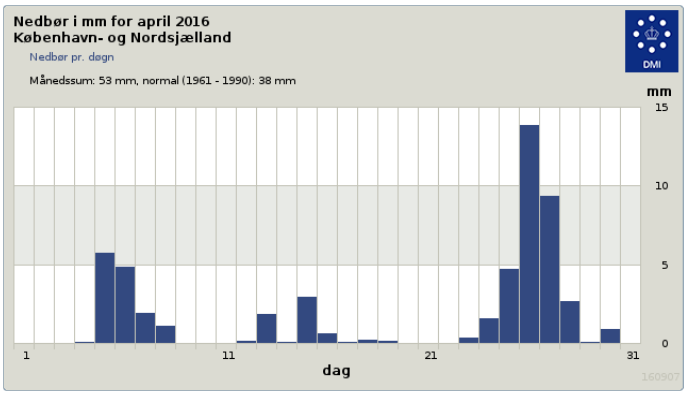
Appendix 5

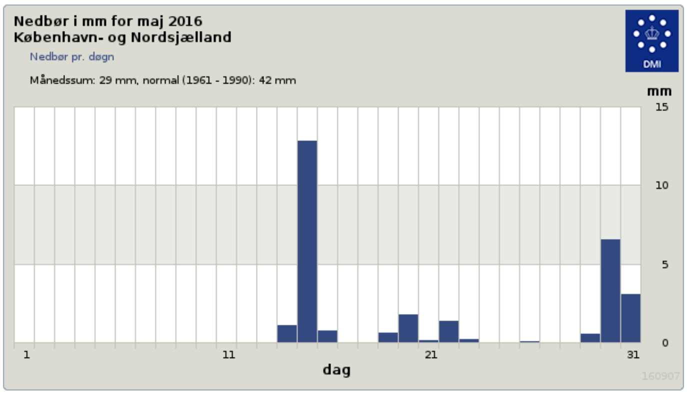
Weather data obtained from The Danish Meteorological Institute (http://www.dmi.dk/vejr/arkiver/vejrarkiv/ accessed 10.08.2016)

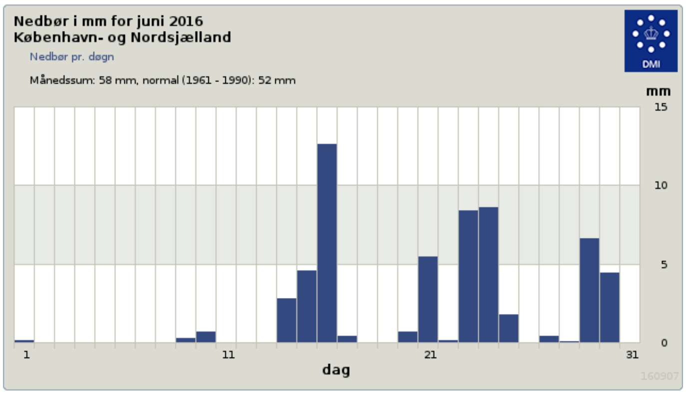


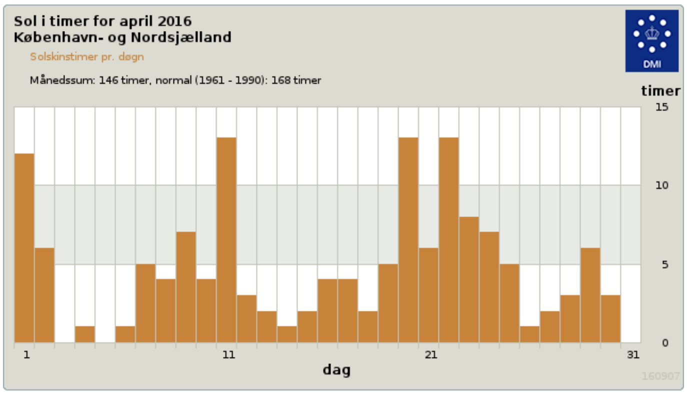


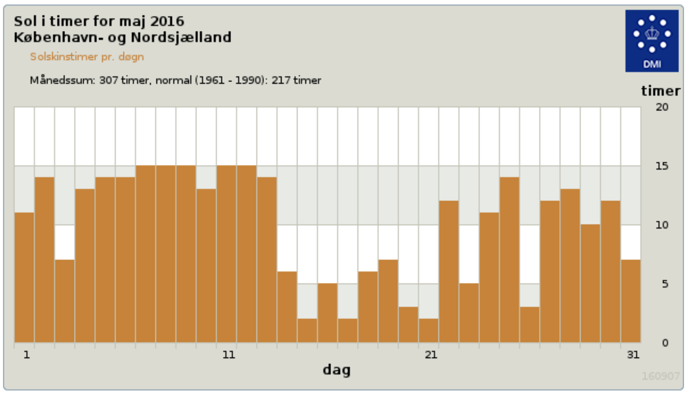


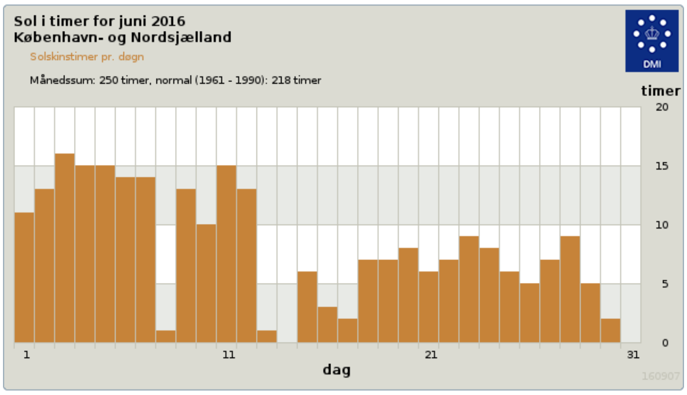


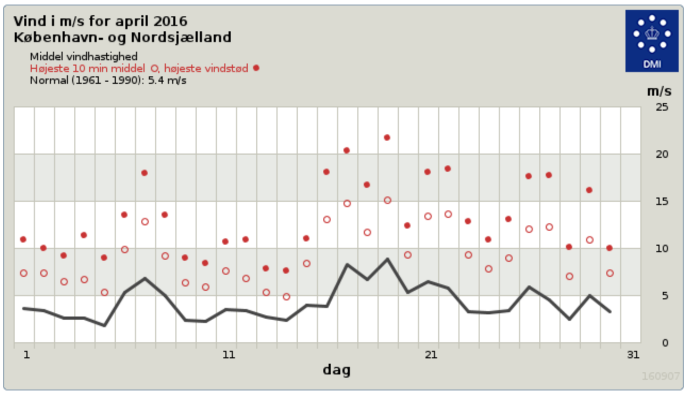


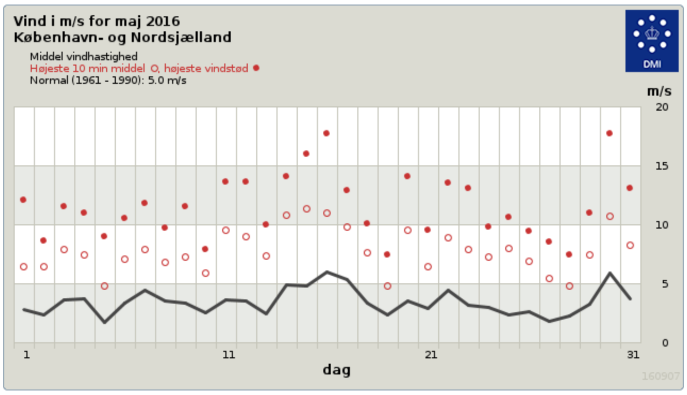


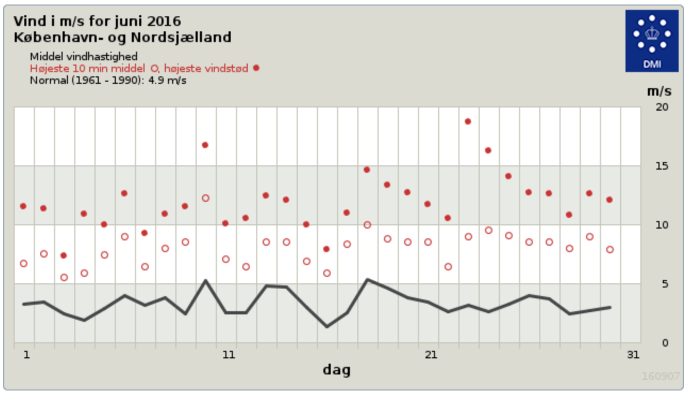












Appendix 6

All ANOVA graphs done in Graphpad Prism ver. 7.01

Table analyzed	V.C. species in total					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	71.32	<0.0001	****	Yes		
Location	7.513	0.1736	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value

Time	1254	5	250.9	F (5	20) = 13.48	P<0.0001
Location	132.1	4	33.03	F (4	20) = 1.775	P=0.1736
Residual	372.3	20	18.61			
Number of missing values	0					

Table Analyzed	V.C. Individuals in total					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	57.17	0.0003	***	Yes		
Location	13.48	0.0947	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	25867	5	5173	F (5	20) = 7.792	P=0.0003
Location	6098	4	1525	F (4	20) = 2.296	P=0.0947
Residual	13278	20	663.9			
Number of missing values	0					

Table Analyzed	V.C. species of bees					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	73.19	<0.0001	****	Yes		
Location	8.621	0.087	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	776.6	5	155.3	F (5	20) = 16.1	P<0.0001
Location	91.47	4	22.87	F (4	20) = 2.37	P=0.0870
Residual	192.9	20	9.647			
Number of missing values	0					

Table Analyzed	V.C. species of hoverflies					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	45.5	0.011	*	Yes		
Location	9.166	0.4253	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	73.47	5	14.69	F (5	20) = 4.015	P=0.0110
Location	14.8	4	3.7	F (4	20) = 1.011	P=0.4253
Residual	73.2	20	3.66			

Number of missing values	0					

Table Analyzed	V.C. individuals of bees					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	55.75	0.0004	***	Yes		
Location	14.52	0.0804	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	20290	5	4058	F (5	20) = 7.498	P=0.0004
Location	5283	4	1321	F (4	20) = 2.44	P=0.0804
Residual	10824	20	541.2			
Number of missing values	0					

Table Analyzed	V.C. individuals of hoverflies					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	40.67	0.0315	*	Yes		
Location	6.732	0.6402	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	375.4	5	75.07	F (5	20) = 3.093	P=0.0315
Location	62.13	4	15.53	F (4	20) = 0.6399	P=0.6402
Residual	485.5	20	24.27			
Number of missing values	0					

Table Analyzed	Ref. meadow species in total					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	47.22	0.0519	ns	No		
Location	23.99	0.0483	*	Yes		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	194.4	5	38.89	F (5	10) = 3.28	P=0.0519
Location	98.78	2	49.39	F (2	10) = 4.166	P=0.0483
Residual	118.6	10	11.86			
Number of missing values	0					

Compare column means (main column effect)	Ref. meadow species in total

Number of families	1							
Number of comparisons per family	3							
Alpha	0.05							
Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value			
Control location vs. V.C. meadow	-5.5	-10.95 to -0.05051	Yes	*	0.048			
Control location vs. ref. meadow	-4.167	-9.616 to 1.283	No	ns	0.1404			
V.C. meadow vs. ref. meadow	1.333	-4.116 to 6.783	No	ns	0.7852			
Test details	Mean 1	Mean 2	Mean Diff.	SE of diff.	N1	N2	q	DF
Control vs. V.C. meadow	3.667	9.167	-5.5	1.988	6	6	3.913	10
Control vs. ref. meadow	3.667	7.833	-4.167	1.988	6	6	2.964	10
V.C. meadow vs. ref. meadow	9.167	7.833	1.333	1.988	6	6	0.9485	10

Table Analyzed	Ref. meadow individuals in total					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	44.66	0.1017	ns	No		
Location	19.66	0.1114	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	8328	5	1666	F (5	10) = 2.503	P=0.1017
Location	3667	2	1834	F (2	10) = 2.756	P=0.1114
Residual	6654	10	665.4			
Number of missing values	0					

Table Analyzed	Ref. meadow species of bees					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	35.87	0.1547	ns	No		
Location	29.31	0.0472	*	Yes		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	98.44	5	19.69	F (5	10) = 2.06	P=0.1547
Location	80.44	2	40.22	F (2	10) = 4.209	P=0.0472
Residual	95.56	10	9.556			
Number of missing values	0					

Compare column means (main column effect)	Ref. meadow species of bees							
Number of families	1							

Number of comparisons per family	3							
Alpha	0.05							
Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value			
Control vs. V.C. meadow	-5	-9.892 to -0.1076	Yes	*	0.0453			
Control vs. ref. meadow	-1.333	-6.226 to 3.559	No	ns	0.7421			
V.C. meadow vs. ref. meadow	3.667	-1.226 to 8.559	No	ns	0.1496			
Test details	Mean 1	Mean 2	Mean Diff.	SE of diff.	N1	N2	q	DF
Control vs. V.C. meadow	3.333	8.333	-5	1.785	6	6	3.962	10
Control vs. ref. meadow	3.333	4.667	-1.333	1.785	6	6	1.057	10
V.C. meadow vs. ref. meadow	8.333	4.667	3.667	1.785	6	6	2.905	10

Compare column means (main column effect)	Ref. meadow individuals of bees							
Number of families	1							
Number of comparisons per family	3							
Alpha	0.05							
Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value			
Control vs. V.C. meadow	-28.33	-55.7 to -0.9666	Yes	*	0.0427			
Control vs. ref. meadow	-3.833	-31.2 to 23.53	No	ns	0.9226			
V.C. meadow vs. ref. meadow	24.5	-2.867 to 51.87	No	ns	0.0797			
Test details	Mean 1	Mean 2	Mean Diff.	SE of diff.	N1	N2	q	DF
Control vs. V.C. meadow	5	33.33	-28.33	9.983	6	6	4.014	10
Control vs. ref. meadow	5	8.833	-3.833	9.983	6	6	0.543	10
V.C. meadow vs. ref. meadow	33.33	8.833	24.5	9.983	6	6	3.471	10

Table Analyzed	Ref. meadow individuals of hoverflies					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	24	0.4464	ns	No		
Location	29.78	0.0832	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	12033	5	2407	F (5	10) = 1.039	P=0.4464
Location	14929	2	7464	F (2	10) = 3.221	P=0.0832
Residual	23171	10	2317			
Number of missing values	0					

Table Analyzed	Ref. forest species in total					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	54.17	0.0419	*	Yes		
Location	15.28	0.1317	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	171.8	5	34.36	F (5	10) = 3.546	P=0.0419
Location	48.44	2	24.22	F (2	10) = 2.5	P=0.1317
Residual	96.89	10	9.689			
Number of missing values	0					

Table Analyzed	Ref. forest individuals in total					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	40.87	0.1483	ns	No		
Location	20.28	0.1224	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	5828	5	1166	F (5	10) = 2.104	P=0.1483
Location	2892	2	1446	F (2	10) = 2.61	P=0.1224
Residual	5540	10	554			
Number of missing values	0					

Table Analyzed	Ref. forest species of bees					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	39.73	0.12	ns	No		
Location	26.09	0.0586	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	74.28	5	14.86	F (5	10) = 2.325	P=0.1200
Location	48.78	2	24.39	F (2	10) = 3.817	P=0.0586
Residual	63.89	10	6.389			
Number of missing values	0					

Table Analyzed	Ref. forest species of hoverflies					
Two-way ANOVA	Ordinary					
Alpha	0.05					

Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	27.21	0.3647	ns	No		
Location	28.47	0.0837	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	25.17	5	5.033	F (5	10) = 1.228	P=0.3647
Location	26.33	2	13.17	F (2	10) = 3.211	P=0.0837
Residual	41	10	4.1			
Number of missing values	0					

Table Analyzed	Ref. forest individuals of bees					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	27.01	0.3956	ns	No		
Location	26.07	0.1098	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	805.6	5	161.1	F (5	10) = 1.152	P=0.3956
Location	777.4	2	388.7	F (2	10) = 2.778	P=0.1098
Residual	1399	10	139.9			
Number of missing values	0					

Table Analyzed	Ref. forest individuals of hoverflies					
Two-way ANOVA	Ordinary					
Alpha	0.05					
Source of Variation	% of total variation	P value	P value summary	Significant?		
Time	22.75	0.452	ns	No		
Location	32.95	0.062	ns	No		
ANOVA table	SS	DF	MS	F (DFn	DFd)	P value
Time	2904	5	580.9	F (5	10) = 1.027	P=0.4520
Location	4207	2	2104	F (2	10) = 3.719	P=0.0620
Residual	5657	10	565.7			
Number of missing values	0					

Appendix 7.1

Table with short description of phenology and biology of bees.

Family	Genus	Species	Sociality	Nesting habits	Tongue length	Adult habitat	Adult food source	Flight period	Special properties
Colletidae	*Colletes*	*daviesanus*	Solitary	Dry soil, in walls. Large aggregations.	Short, bilobed	Variety of habitat	Pollen only from composites.	Juli-August	-
	Hylaeus	*brevicornis*	Solitary	Hollow bramble twigs and pithy stems.	Short, bilobed	Lowland habitats, like chalk grassland.	Polylectic.	Juli-August	Possibly bivoltine.
		communis	Solitary	Holes and cavities.	Short, bilobed	Lowland habitat like gardens.	Polylectic.	Juli-August	Possibly bivoltine.
		confusus	Solitary	Holes and caveties. Also seen burrowing.	Short, bilobed	Various inland and coastal.	Polylectic.	Juli-August	-
		hyalinatus	Solitary	Light soils, walls, cliff faces, holes in dead wood.	Short, bilobed	Various inland and coastal.	Polylectic.	Juli-August	-
Andrenidae	*Andrena*	*chrysosceles*	Solitary	Slopes and hedge banks.	Short.	Variety of habitat	Polylectic.	March-June.	-
		fulva	Solitary	Managed lawns and flowerbeds. Large aggregations.	Short.	Variety of habitat	Spring-flowering shrubs and herbaceous plants.	March-June.	-
		haemorrhea	Solitary	Grassy slopes and banks.	Short.	Variety of habitat	Spring-flowering shrubs and herbaceous plants.	March-July	-
		helvola	Solitary	Woody locations with plenty of sunshine.	Short.	Open structured woodland.	Spring-flowering shrubs and herbaceous plants.	April-June	-
		nigroaenea	Solitary	Bare ground, short-cropped truf, walls.	Short.	Variety of habitat	-	March-July	Sometimes partially bivoltine.
		praecox	Solitary	Light soils.	Short.	Willow-rich habitat.	Primarily short-leaved willow	February-May.	-
		minutula	Solitary	Dry soil.	Short.	Open wooded habitats.	Polylectic.	March-May, June-September	Bivoltine
		subopaca	Solitary	Wood bank and slopes with short sparce vegitation.	Short.	Variety of habitat	Polylectic.	April-August	Peaks between the two generations of A. Minutuls.
Halictidae	*Halictus*	*tumulorum*	Solitary	Underground in light soil.	Short, pointed.	Open habitats including grassland.	Polylectic.	March-October.	-
	Lasioglossum	*albipes*	Solitary	Underground in light soil.	Short, pointed.	Variety of habitat	Polylectic.	March-September.	-
		calceatum	Solitary	Underground in light soil.	Short, pointed.	Variety of habitat	Polylectic.	March-October.	-

		leucopus	Solitary	Poorly known (probably like *L. Morio*)	Short, pointed.	Variety of habitat	Polylectic.	May-October	-
		minutissimum	Solitary	Underground in light soil, sometimes large aggrigations.	Short, pointed.	Preferably sandy soil.	Polylectic.	March-October.	-
		morio	Solitary	Underground in slopes, faces, walls. Often in large aggrigations.	Short, pointed.	Open habitat.	Polylectic.	March-October.	-
		*nitidulum**	Solitary	Underground.	Short, pointed.	-	Polylectic.		-
		punctatissimum	Solitary	Underground in slopes and vertical faces.	Short, pointed.	Sandy habitat.	Polylectic.	April-October.	-
		*quarinotatum**	Solitary	Poorly known, but presumed in sandy ground.	Short, pointed.	Heathland and acid grassland.	Polylectic.	April-September	-
		sexstrigatum	Solitary	Sandy ground. Sometimes large aggrigations.	Short, pointed.	Heathland and sandpits.	Polylectic.	April-October.	-
		villosulum	Solitary	Underground in cliff faces and bare or sparcely vegitated slopes. Sometimes large aggrigations.	Short, pointed.	Great variety of habitat	Polylectic.	March-October.	-
	Sphecodes	*crassus*	Solitary	Other bees nests	-	Open habitat.	Parasitic.	April-September	Cleptoparasite from *L. punctatissimum.*
		geoffrellus	Solitary	Other bees nests	-	Open habitat.	Parasitic.	April-September	Cleptoparasite from *L. morio, L. leucopus.*
Megachilidae	*Chelostoma*	*florisomne*	Solitary	Pre-existing holes in dead wood. Sometimes massive aggregations.	-	Meadows close to woods or hedges.	Pollen: Buttercups. Nectar: for example Common Valerian, speedwells and roses.	May-July	-
	Osmia	*bicornis*	Solitary	Pre-existing holes and cavities.	-	Urban settings ect.	Polylectic.	March-July	-
		caerulescens	Solitary	Pre-existing holes and cavities above ground.	-	Urban settings ect.	Pollen: legumes, labiates and snapdragon. Nectar: Knapweed, hawk's beard and speedwells.	April-July	Sometimes second generation
	Hoplitis	*claviventris*	Solitary	Hollow tvigs and stems, less often in holes or ground.	-	Variety of habitat	Typically bird's-foot-trefoils.	May-September	-
	Megachile	*centuncularis*	Solitary	Dead wood, cavities in walls.	-	Variety of habitat	Polylectic.	June-September	-
		willughbiella	Solitary	Holes, cavities, ground, bee hotels.	-	Variety of habitat	Polylectic.	May-August	-
	Coelioxys	*elongata**	Solitary	Nests of other bees.	-	Varied, low human population levels.	Parasitic.	June-August	Cleptoparasite from *M. willughbiella*
Apidae	*Nomada*	*fabriciana*	Solitary	Nests of other bees.	-	Like the main host.	Parasitic.	March-June, June-August	Cleptoparasite mostly on *A. Bicolar*, but also on *A. Nigroaenea* and *A. Chrysosceles*.

		ferruginata	Solitary	Nests of other bees.	-	Willow-rich habitat.	Parasitic.	March-May.	Cleptoparasite from *A. Preacox*.
		fulvicornis	Solitary	Nests of other bees.	-	Heathland and sandy brownfield.	Parasitic.	March-May, July-late August.	Cleptoparasite A. Bimaculata, A. Pilipes and A. Tibialis.
		marshamella	Solitary	Nests of other bees.	-	Variety of habitat	Parasitic.	April-June	Cleptoparasite *A. Scotica*, *A. Trimmerana*, *A. Rosae* and *A*, *ferox*.
	Anthophora	*quadrimaculata**	Solitary	Sandy soils.	-	Urban settings ect.	Mainly labiates and cultivated catmints and lavender.	June-August	-
	Bombus	*hortorum*	Social	Underground and among dense vegitation.	Exeptionally long tungue.	Variety of habitat	Polylectic.	April-Juli.	50-120 workers.
		hypnorum	Social	Typically aerial situations.	Relatively short-tongued	Urban settings ect.	Polylectic.	April-August	Sometimes two generations. 80-400 workers.
		lapidarius	Social	Under and above ground	Short.	Variety of habitat	Polylectic.	April-August	100-300 workers.
		norvegicus	Social	Nests of other bees.	Short	-	Polylectic.	May-August	Cleptoparasit of *B. Hypnorum*.
		pascuorum	Social	Surface amongst dense vegitation and above ground.	Long	Variety of habitat	Polylectic.	April-October	Two generations. 60-150 workers.
		pratorum	Social	Undergroung, surface and birds nests.	Short.	Variety of habitat	Polylectic.	April-July	Two generations. 50-120 workers. Nectar-robber.
		terrestrisk cf	Social	Undergroung, rarely above ground.	Short.	Variety of habitat	Polylectic.	March-August	Can produce third, winter-active generation. Nectar-robber. 100-600 workers.
		sylvestris	Social	Nests of other bees.	Short.	Wooded habitat.	Parasitic.	April-August	Social parisite on *B. pratorum*. Two generations.
	Apis	*meliffera*	Social	Mostly artificial hives, ferril bees in hollow trees and roof spaces.	-	Variety of habitat	Polylectic.	All year.	Domesticated.

Appendix 7.2

Table with short description of phenology and biology of hoverflies.

Tribe	Genus	Species	Larvae habitat	Larvae food source	Adult habitat	Adult food source	Flight period	Special properties and classification
Melanostomini	Melanostoma	scalare	Herbs	Aphids etc.	Damp, open and urban habitat.	Primarily pollen from grass and sedges (more than 50 different species in Sweden)	May-October	Active at temperatures as low as +8 C^{o} in the shade Semi. specialist and stationary
		mellinum	Herbs	Aphids etc.	Open and urban habitat.	Primarily pollen from grass, sedges and other plants (more than 40 different plant species in Sweden)	May-November	Active at temperatures as low as +8 C^{o} in the shade Multible generations per. year. Generalist and mobile (not migratory)
	Platycheirus	albimanus	Herbs, shrubs and trees	Aphids	Cearings in woods or near shrubbery, urban habitat.	Primarily herbs with yellow or white flowers (more than 70 different plant species i Sweden)	April-October	Multivoltine
		scutatus cf	Herbs, shrubs and trees	Aphids	Among herbs	Assorted flowers.	May-October	Multivoltine
Syrphini	Episyrphus	balteatus	Herbs, shrubs and trees	Aphids	Most habitat.	Most flowers.	March-October	Migratory
	Eupodes	corollae	Larger herbs, shrubs and trees	Aphids	Open fields.	Mostly umbellifers.	May-September	Egg-fly: 11 days.
	Syrphus	ribesii	Herbs, shrubs and trees	Aphids	Most habitat.	Mostly umbellifers and Coneflowers.	May-October	-
		torvus	Herbs, shrubs and trees	Aphids	Open woods.	*Bistorta vivipara, Geranium sylvaticum, Leucanthemum vulgare* and *Taraxacum* spp. Ect.	June-September	-
		vitripennis	Herbs, shrubs and trees	Aphids	Most habitat.	Mostly umbellifers and Coneflowers.	April-December	-
Chrysogastrini	Neoascia	interrupta	Wetlands and muddy banks	Dead organic material	Open, sunny lowland lakes and dams.	Mostly umbellifers.	May-July	-
		meticulosa	Wetlands and muddy banks	Dead organic material	Muddy, sunny wetlands.	Assorted flowers.	April-July	-
		podagrica	Wetlands and muddy banks	Dead organic material	Moist, open habitat.	Most flowers.	April-October	-
		tenur	Wetlands and muddy banks	Dead organic material	Wetland.	Most flowers.	May-August	-
	Anasimya	lineata	Idle or slow flowing water	Dead organic material	Wetland.	Most flowers.	May-September	-
		tranfuga	Idle or slow flowing water	Dead organic material	By lakes and dams.	*Cardamine amara, Roeippa amphibia, Cicuta virosa, Ranunculus repens,*	May-September	-

						Sonchus arvensis, Sorbus aucuparia and *Taraxacum* spp. Ect.		
	Eristalis	arbustorum	Pools of water	Dead organic material	Most habitat.	Mostly umbellifers.	May-September	-
		intricaria	Pools of water	Dead organic material	Wetland.	Most flowers.	May-September	-
		pertinax	Pools of water	Dead organic material	Most habitat.	Most flowers.	May-October	-
		tenax	Pools of water	Dead organic material	Most habitat.	Most flowers.	May-October	Overwinters occationally.
	Helophilus	hybridus	Small pools of water	Dead organic material	Wetland.	Most flowers.	May-August	Stationary.
		pendulus	Small pools of water	Dead organic material	Moist to wet habitat.	Most flowers.	May-October	-
		trivittatus	Small pools of water	Dead organic material	Moist, open habitat.	Assorted flowers.	June-October	-
	Myathropa	florea	Trees (wet cavities)	Dead organic material	Most habitat.	Mostly umbellifers.	May-September	Can make a characteristic piping sound.
	Parhelophilus	frutetorum	Aquatic	Dead organic material	Moist habitat.	Mostly shrubs.	May-September	-
		versicolor	Aquatic	Dead organic material	Wetland.	Mostly umbellifers and shrubs.	May-August	-
Eumerini	Merodon	equestris	Bulbous plants	Plants	Urban habitat.	*Ranunculus acris, Rubus ideaus, Knautia arvensis, Cirsium palustre* ect.	May-August	-
Pipizini	Pipizella	viduata	Herbs	Aphids	Herb-rich habitat.	Most flowers.	May-August	-
Xylotini	Chalcosyrphus	nemorum	Deciduous trees	Sap	Moist habitat.	*Angelica sylvestris, Cirsium oleraceum, Taraxacum* spp. Ect.	May-August	-
	Syritta	pipiens	Many different habitats, even compost and dung	Dead organic material	Most habitat.	Most flowers.	May-October	-
	Tropidia	scita	Aquatic	Dead organic material	Wetland.	Mostly herbs and shrubs.	May-August	-
	xylota	sylvarum	Trees	Dead organic material	Habitat with rotting wood.	Mostly pollen from leafs	May-September	-