Deliverable D1.2

BeePlantCalendar 2.0

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Revision History

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1.0	30.05.2024	Dirk de Graaf, Lina De Smet, Kirsten Leufgen, Jozef van der Steen	Discussion and completion of deliverable. Final version, approved by the coordinator

Contents

Abbreviations, Participant short names

Abbreviations

CA	Consortium Agreement
DoA	Description of Action
GA	Grant Agreement
CS	Citizen science, citizen scientist

Participant short names

AU	Aarhus Universitet
COA	Co-Actions
IPB	Instituto Politécnico de Bragança
IRIAF	Instituto Regional de Investigación y Desarrollo Agroalimentario y Forestal de Castilla-La Mancha
IZSLT	Istituto Zooprofilattico Sperimentale delle Regioni Lazio e Toscana
KUL	Katholieke Universiteit Leuven
MLU	Martin-Luther-Universität Halle-Wittenberg
NB	Norges Birokterlag Forening [Non-governmental organisation
SCIPROM	SCIPROM Sàrl
TNTU	The Nottingham Trent University
UCOI	Universidade de Coimbra
UGENT	Universiteit Gent
UJAG	Uniwersytet Jagiellonski
UM	Université de Montpellier
USAMV	Universitatea de Ştiinţe Agricole şi Medicină Veterinară Cluj-Napoca
UU	Uppsala Universitet
VDSJ	Van Der Steen Jozef
WR	Stichting Wageningen Research

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Summary

Urbanisation, climate change and the loss of biodiversity due to the expansion of agriculture and livestock farming may force bees and other pollinating insects to share food sources.

Recording the different pollinating insects as a function of time and location will provide an overview of the quantities of food sources available and the nesting opportunities for bumblebees, solitary bees, hoverflies and other insects, and will therefore help us to understand the extent to which the environment is favourable to pollinating insects.

The platform Beeplants.eu is part of the Better-B Citizen science (CS) data collection and focusses on food sharing by pollinating insects on honey bee plants. The citizen scientists (CS) record pollinating insects on plants that are listed in the bee plant catalogue on www.beeplants.eu. By repeating this on the same flowers and same locations during the flowering period of the plants, they record the visiting insects as a function of location, date, observation period, time of the day, weather conditions and land use (EU land-use data). The data will be analysed by the University of Aarhus (DK).

So far, the platform is available in English, Danish, Dutch and Latvian. French, Finnish and Norwegian will follow next.

1. Beeplants.eu

1.1 Introduction

The aim of the Better-B work package pollinator ecology is to develop models to predict landscape-specific carrying capacities based on pollen and nectar phenology models, taking local context into consideration but creating European-wide coverage. This is supported by two approaches to supplement the data: firstly, through targeted literature research and experiments, and secondly, by creating a larger amount of data through citizen science (CS). To be able to conduct the CS study, the existing website The Danish BeePlantCalender was updated. This deliverable describes the new release of the free resource beeplants.eu, the website hosting the BeePlantCalendar vs 2.

Within the framework of this study, a CS study on the shared use of food sources on known nectar- and pollen-producing plants, which are considered 'bee plants' for honey bees and other pollinating insects, is to be developed and carried out. The reason for this specific study objective is to better understand the reduction in the number of food sources due to the decrease in biodiversity and the number of plants as a result of the increasing impact of agriculture, industrialisation, infrastructure and industrial activities on biodiversity.

This reduction of food sources may impact negatively the resilience of the honey bee colony and increase food source sharing with other pollinating insects. The food source foraging strategy of the honeybee colony is focussed on mass flowering, flowering constancy during a forage flight, and dance communication that direct honey bee foragers to these mass-producing nectar and pollen fields in a radius of about 3 kilometres around the hive, and preferably within 1.5 kilometres. Other pollinating insects such as bumblebees and wild bees do not have this communication strategy. Bumblebees collect their food on every bee plant that is found in a maximal 3-kilometre radius from the nest (like honeybees). In wild (solitary) bees some generalists collect food like bumblebees, on every bee plant, whilst specialists are restricted to specific plants, ranging from family specialists to species specialists, within a very restricted flight radius of up to a few hundred meters.

There is presently no information available, relating to food-source sharing by pollinating insects. There are studies in which food source sharing knowledge is an indirect outcome of the actual study objective, e.g., there are studies focused on parasite exchange on mutual food sources, studies on the impact of apiaries on bumblebee colonies and studies of extreme conditions where a large number of honey bees are located on a poor area after the ending of an agricultural mass flowering.

This CS approach will provide flowering times of bee plants, their bee-food value and their location.

1.2 Set-up of the CS data collection

CS is a method allowing data collection by layman scientists/citizens in numbers that cannot be achieved by specialist data collection, both temporally and spatially. The requirement for a successful CS study is curiosity, simplicity and reward. The interpretation of the term 'curiosity' is in explaining the study objective to the layman, so its scientific relevance strongly appeals to them, making their role in data collection highly exciting. The interpretation of the term 'simplicity' is in using a smartphone application of a https://beeplants.eu platform, in which CS can select a plant by common name and/or Latin name and record the associated pollinating insects. In this application, time and location are also inherently recorded, by default. The second interpretation of 'simplicity' is in the identification of pollinating insects, where the recording is restricted to the general recognition of honey bees, bumble bees, hoverflies, butterflies and other insects. For the latter, most "other insects" are wild bees that only can be identified by specialists.
The use of such a CS platform will result in data that reveals food sharing in general, which is the objective of this study. Further studies may possibly go a step further, e.g., in species recognition by molecular techniques in which the CS will collect material for laboratory analysis. The interpretation of the 'reward' is in that every participant makes their plant catalogue and has general access to the recording to see what plants are recorded elsewhere. The CS invited to participate in this CS study were initially beekeepers from the INSIGNIA project network. We are now extending the invitation through a general invitation on our dedicated webpage.
In summary, CS notice a plant that is visited by insects, open the beeplants.eu platform on their cell phone, register (only the first time) and report by selecting the relevant plant, and record the insects on it that can be identified in one glance. This requires review of and alignment with the bee plant catalogue and special features to record the insect type, and location and time.

1.3 The BeePlantCatalogue

The BeePlantCatalogue can be found on the website beeplants.eu and focusses on simple CS activities in the field with the focus on blooming time and food sharing of honeybees and other pollinating insects. Using observation of foraging bees, the network will identify shifts in patterns pointing to critical temporal (seasonal) and spatial (across Europe) periods of limited resource supply. These data will be used to identify when critical resource limits force foraging on less optimal forage and increase food source sharing with wild bees, and secondly will provide supporting data to estimate carrying capacities of landscapes in conjunction with the resource model.
Two measures will be monitored: 1) the blooming time of a bee flower and 2) the visiting pollinating insects. We use for this a plant catalogue on beeplants.eu. The citizen scientist and the scientists create a team to collect the blooming stages and pollinating insect data over Europe. These data are the base of any study on the carrying capacity of the environment for various bee species, hoverflies, and other insects.
Urbanisation, climate change, and loss of biodiversity, due to the scaling up of agriculture and livestock farming, may force bees and other pollinating insects to share food sources. Recording various pollination insects depends on the amounts of food sources available, and nesting possibilities for bumblebees, solitary bees, hoverflies, and "other insects". In other words, the bee friendliness of the environment.
The bee plant catalogue is a list of known honey bee plants, selected on known bee plant lists and the INSIGINIA data. The list is still not complete as the Southern Europe data will be added by the end of 2024. The list will be updated annually based on suggestions provided by the network. In Figure 1, the homepage of the beeplants.eu website is shown. The website is available in English, Dutch, Danish and Latvian.

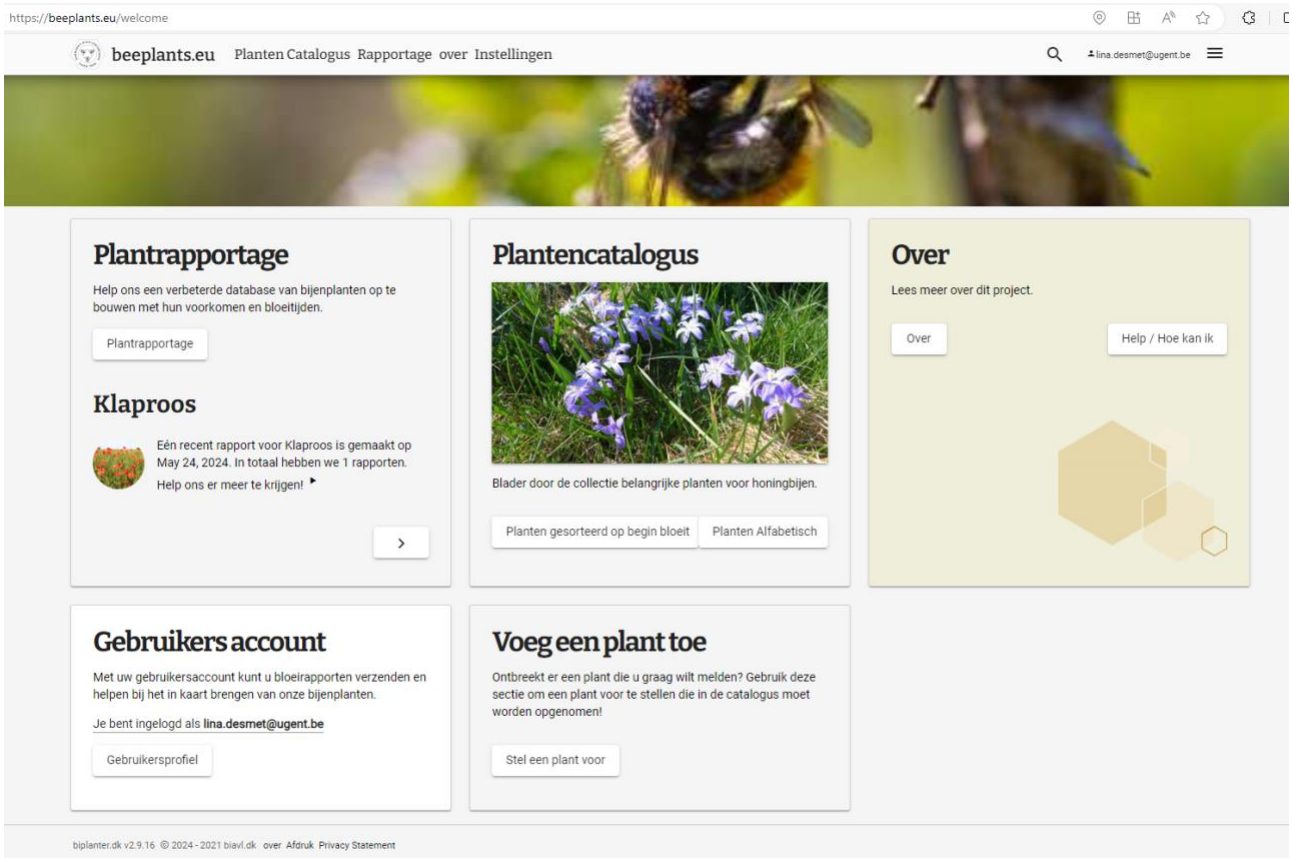


Figure 1: Screenshot of the homepage of the beeplants.eu platform

Registration is needed to start recording flowering times and insect visits. For registration, only the email address is mandatory for the communication. Names and family names are not mandatory. The citizen scientists are asked to count minimally 2 times a week, pollinating insects on plants on beeplants.eu and report each time. We ask them to stick to the same flowers and the same location during the blooming phase of that plant. In this way, we record the visiting insects as a function of location, time, observation period, time of the day, weather conditions and land use. They are also asked to estimate the flowering stage of the flower. In Figure 2 the observation report is shown. To start the observation, the plant should be selected. In Table 1 (supplemental material) an overview of the currently available plants in the beeplants.eu application is shown. Once the plant is selected the observation report pops up. number of honey bees, bumblebees, solitary bees, hoverflies, and other insects as such, that you can see in one glance.

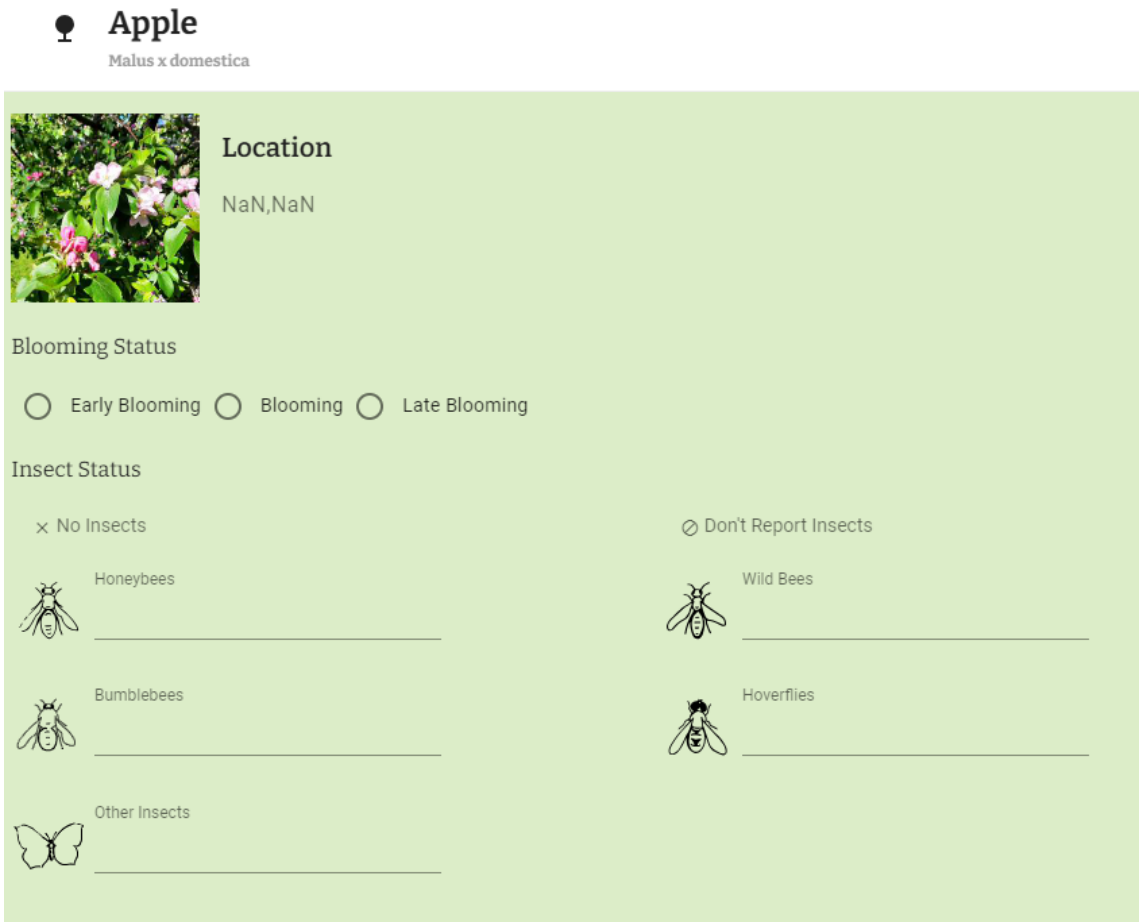


Figure 2: Observation form. After selecting the flower or plant, the CS is asked to complete the blooming status and the visiting insets.

To promote the CS approach and help the CS to discriminate between the pollinating insects on the flowers, a dedicated page on the Better-B website was put in place (Figure 3). This page can also be accessed from the Better-B learning platform . An introductory video and photos of honeybees, bumblebees, solitary bees, and hoverflies are posted there to instruct the participating CS. We have chosen as species *Apis mellifera* (honey bee) as we started with CS-beekeepers. The genus *Bombus* is considered as one group of "bumblebees", as are the general solitary bees and hoverflies. This simplification is an essential feature of the CS study, "keep it simple". Moreover, the study is about food sharing amongst pollinating insects and not among specific pollinating insect species.

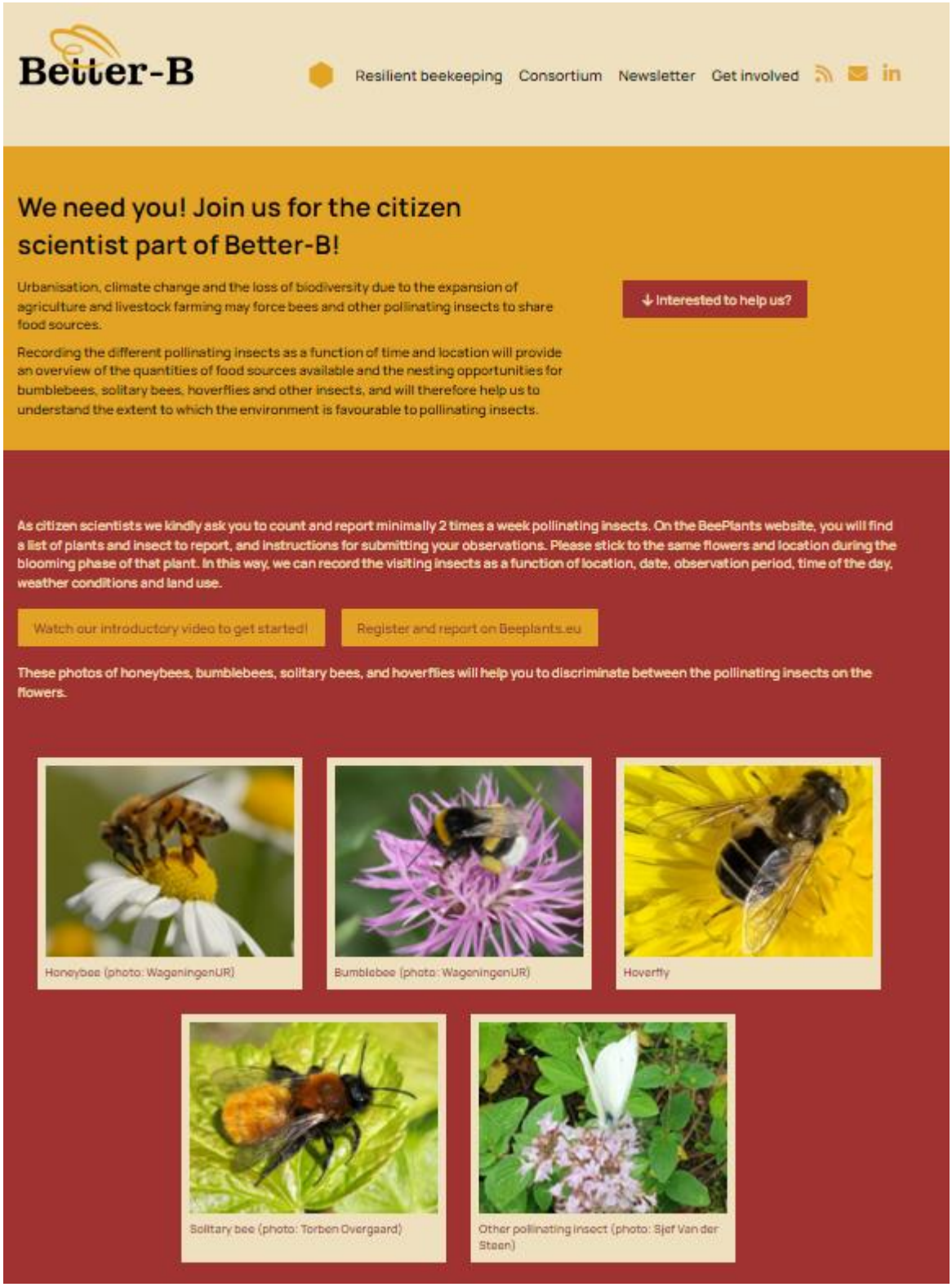


Figure 3: The CS webpage as part of the Better-B website and its learning platform.

The protocol (Figure 4) can be found on www.beeplants.eu in the menu “ABOUT” and next “Help/How-To”.

Protocol beeplants.eu

Please read this protocol till the end

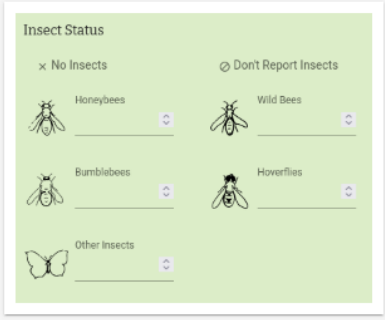
You have opened www.beeplants.eu.

1. Please select your language in the right top corner.
2. To start your observations and recordings please first register with your email address.
   Name and surname are voluntary and not mandatory.
   You find the registration fields when you scroll down to "User account"
3. Select "Catalogue of Plants"

Submit observations

In the bee plant catalogue, you will find the plants you are observing by their common name or their scientific name. And you can also find the plants in the month-selections by photo.

1. Then click on "Blooming stage and insect counts"
2. First click the box "early blooming, "blooming" and "end blooming"
3. Next, you give the number of honey bees, solitary bees, bumblebees, hoverflies, and other insects that you see at one glance, independent of the surface of the crop. No insects is also a very valid observation. **Please submit no insects with a 0 for each insect group.** When you see insects in the flowers you are observing, count the insects that you can see in one glance and give the numbers in the field.



4. Then click on "Report the observation"
   1. The location (GPS) + time + flower + insect recordings = **reporting spot**
   2. It is important to submit the data mentioned above in situ = at the location and time of the recording.
   3. The time of the day is important to record the foraging patterns of the pollinators in the day.
   4. Reporting spot reminders will be sent by email
5. Done.
6. In case of questions, do not hesitate to contact me via alveusab@outlook.com.

In "Insects on flowers" below, you will find a summary of the differences between the insects in Table 1 and below Table 1, you find short descriptions that will help you to see the differences between the honey bee, the solitary bees, the bumblebees, the hoverflies and the other insects.

In case you are not sure of the name of the plant, you can check this with the free apps Obsidentify , PlantNet or iNaturalist, and other tools you use to identify plants. Most apps are freely downloadable and work with picture recognition.

Insects on the flowers

Table 1. The significant differences between the honey bee, the solitary bee, the bumblebee and the hoverfly

Features	Honey bees	Solitary bees	Bumblebees	Hoverflies
Antennas	Segmented "real" antennas	Segmented "real" antennas	Segmented "real" antennas	Small club-like antennas
Eyes	Separate facet eyes left and right	Separate facet eyes left and right	Separate facet eyes left and right	The eyes touch each other
Size	Standard size	Smaller and sometimes bigger than the honey bee	The majority of the bumblebees are bigger and larger than the honey bee	
Flight pattern	smoothly	smoothly	smoothly	In straight lines and stand-stills in the airs
Typical features	Brown and bands over the abdomen	Some collect pollen in the belly side of the abdomen (scopa), and some have "a moustache". All look different from the honey bee	Bands over the abdomen in different colours	Clear stripes over the abdomen or coloured surfaces
Wings	4 wings	4 wings	4 wings	2 wings

Figure 4: The protocol on the website

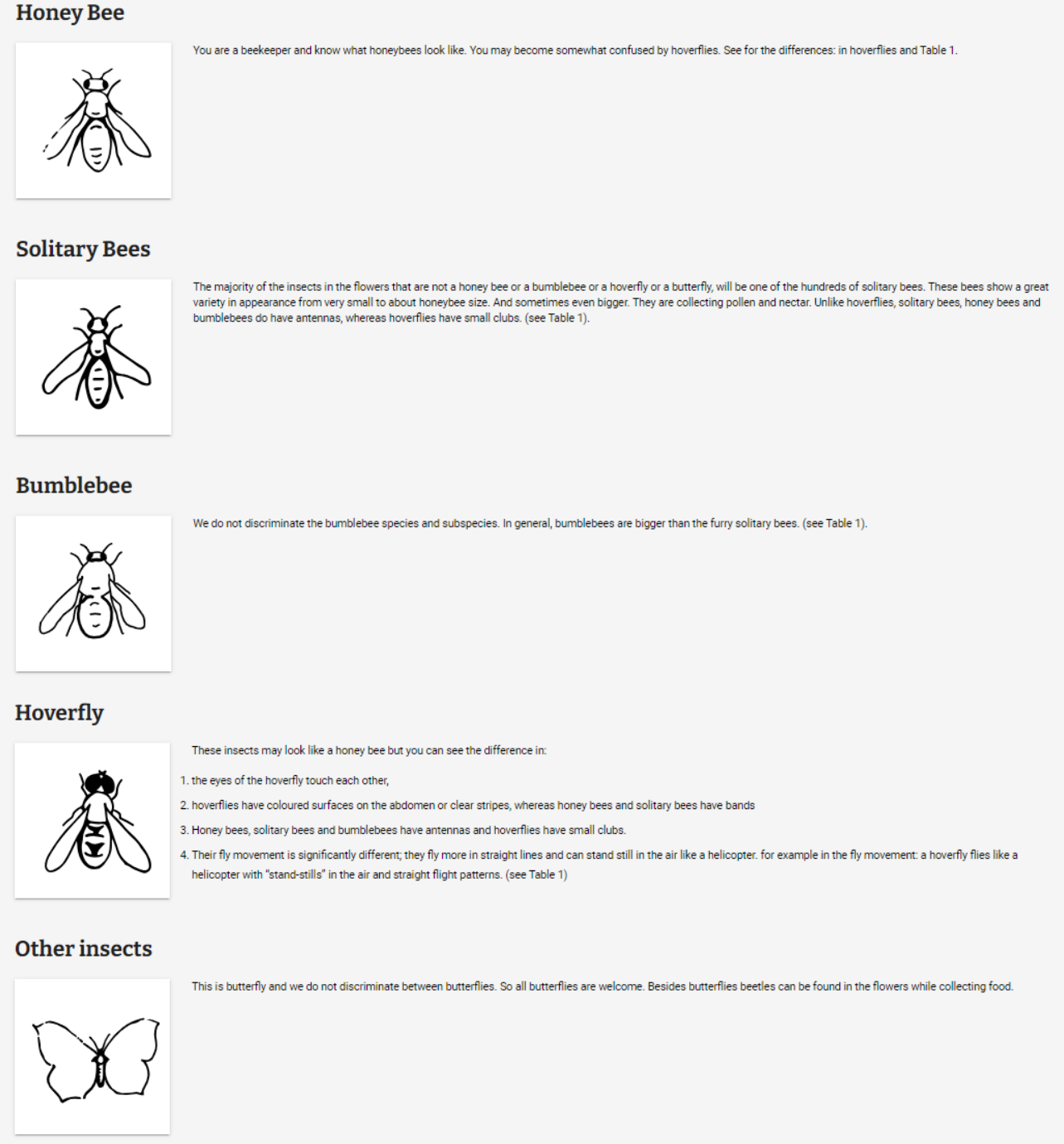


Figure 5: The protocol on the website (continued)

To the best of our knowledge, this is the first study that focusses on the sharing of food sources by pollinating insects.

www.beeplants.eu is a website that automatic fits to the screen of all newer cell phones. The CS do not need to download an application, but can just open your platform www.beeplants.eu on any browser of their choice.

This task is coordinated by Better-B partner VDSJ (Jozef van der Steen). The BeePlantCatalogue and website are developed with the Danmarks Biavlerforening (DBF) and Frey-it as subcontractors.

2. Supplementary materials

2.1 Beeplants catalogue

Table 1. Beeplants catalogue, version May 2024.

Latin Name	Type	en_US_name	EU_ bloom_start	EU_ bloom_end
Acer campestre	Tree	Maple, common	05-01	05-31
Acer platanoides	Tree	Maple, Norway	05-01	05-31
Acer pseudoplatanus	Tree	Maple, greater	05-01	05-31
Aesculus hippocastanum	Tree	Chestnut, horse	05-01	05-31
Amelanchier	Bush	Mespilus, snowy		
Anemone nemorosa	Perennial	Anemone, wood	04-01	05-31
Anemone tomentosa	Perennial			
Asparagus officinalis	Perennial	Asparagus	06-01	07-31
Borago officinalis	Herb	Borage	06-01	08-31
Brassica napus	Herb	Rapeseed	05-01	05-31
Buddleja spp	Bush			
Buxus sempervirens	Bush	Box, common	04-01	05-31
Calluna vulgaris	Bush	Heath, common	07-01	09-30
Cannabis sativa	Herb	Hemp		
Castanea sativa	Tree	Chestnut, Spanish	06-01	07-31
Centaurea cyanus	Herb	Binks, corn	06-01	09-30
Centaurea jacea	Herb	Knapweed, brown(-rayed)		
Centaurea scabiosa	Perennial	Centaurea, greater	07-01	09-30
C hamaenerion angustifolium	Perennial			
Chamerion angustifolium	Perennial		07-01	08-31
Cichorium intybus	Perennial	Chickory	04-01	09-30
Cirsium spp./Carduus spp.	Perennial		06-01	09-30
Clematis vitalba	Climbing plant	Beard, Old Man's		
Cornus sanguinea	Bush	Corneltree, female		
Corylus avellana	Bush	Cob-nut	02-01	04-30
Cotinus coggygria	Bush			
Cotoneaster spp.	Bush	Cotoneaster	05-01	07-31
Crataegus monogyna	Tree	Hawthorn	05-01	06-30
Crepis spp	Herb			
Crocus spp.	Perennial	Crocus	03-01	04-30
Dasiphora fruticosa	Bush			
Datura stramonium	Bush	Thorn-apple		
Echium vulgare	Herb	Blue devils	06-01	07-31
Epilobium spp.	Perennial	Willowherb	06-01	09-30
Eranthis hiemalis	Perennial		02-01	03-31
Erica spp	Bush			
Erica tetralix	Bush	Heather, cape	07-01	08-30
Eupatorium cannabinum	Perennial	Agrimony, hemp	07-01	09-30

Fagopyrum esculentum	Herb		07-01	08-31
Fagus sylvatica	Tree	Beech	05-01	05-31
Filipendula ulmaria	Perennial	Meadowsweet	06-01	08-31
Fragaria spp.	Perennial	Strawberry	05-01	07-31
Galanthus nivalis	Perennial	Snowdrop	02-01	03-31
Geranium spp.	Herb	Cranesbill	04-01	09-30
Gleditsia triacanthos	Tree	Locust, honey		
Hedera helix	Climbing plant	Bindwood	09-01	11-30
Helianthus annuus	Herb	Girasol	08-01	08-31
Helleborus spp.	Perennial	Bear's foot	12-01	04-30
Hepatica nobilis	Perennial	Hepatica	03-01	05-31
Heracleum spp.	Perennial	Bear's breech / Brankursine / Hogweed / Hogweed, giant / Keck	06-01	09-30
Hydrangea spp.	Bush	Hydrangea	06-01	08-31
Hypochaeris radicata	Herb	Catsear		
Impatiens grandifolia	Herb			
Knautia arvensis	Perennial	Scabious, field	06-01	08-31
Lamium album	Perennial	Dead-nettle, white	05-01	09-30
Lamium purpureum	Herb	Dead-nettle, red	04-01	10-31
Lavandula angustifolia	Bush	Lavender, garden	07-01	08-31
Ligustrum vulgare	Bush	Privet, common	05-01	07-31
Lupine spp	Herb			
Lythrum salicaria	Perennial	Loosestrife, purple	07-01	08-31
Mahonia aquifolium	Bush	Grape, Oregon	04-01	05-31
Malus x domestica	Tree	Apple	04-01	06-30
Malva spp.	Herb	Mallow	07-01	09-30
Melilotus alba	Herb		07-01	09-30
Muscari armeniacum	Perennial		04-01	05-31
Oenothera biennis	Perennial	Primrose, (common) evening		
Olea europaea	Tree			
Origanum vulgare	Perennial	Marjoram, wild	07-01	09-30
Papaver spp.	Herb	Poppy	06-01	08-31
Petasites spp.	Perennial	Butterbur	04-01	05-31
Phacelia tanacetifolia	Herb	Bluebell, Californian	06-01	09-30
Photinia glabra	Bush			
Pisum sativum	Herb	Pea		
Prunus avium	Tree	Cherry, wild	05-01	05-31
Prunus cerasifera	Tree	Mirabelle	03-01	04-30
Prunus domestica	Tree	Plum	03-15	04-30
Prunus laurocerasus	Tree			
Prunus spinosa	Bush	Blackthorn	05-01	05-31
Pyrus communis	Tree	Pear	05-01	05-31
Quercus coccifera	Bush	Oak, Kermes		
Quercus spp.	Tree	Oak	05-01	05-31
Raphanus raphanistrum	Perennial	Charlock, white	06-01	09-30

Ribes sanguineum	Bush	Currant, flowering	04-01	05-31
Ribes uva-crispa	Bush	Gooseberry	05-01	06-30
Robinia pseudoacacia	Tree		06-01	06-30
Rosa spp.	Bush	Rose	06-01	07-31
Rubus fruticosus	Bush		07-01	07-31
Rubus idaeus	Bush	Raspberry	06-01	07-31
Rubus spp	Bush			
Salix spp.	Tree	Willow	04-01	06-30
Scilla spp.	Perennial	Squill	02-01	05-31
Scorzoneroides spp	Herb			
Sedum acre	Bush	Pepper, wall-		
Senecio spp	Herb			
Sinapis alba	Herb	Mustard, white	06-01	09-30
Solidago spp.	Perennial	Golden-rod	07-01	10-31
Sorbus aucuparia	Tree	Ash, mountain	05-01	07-31
Symphoricarpus spp.	Bush		07-01	09-30
Tanacetum vulgare	Perennial	Bitterbuttons		
Taraxacum officinale ssp.	Perennial	Blowball	05-01	07-31
Thymus vulgaris	Perennial	Thyme, common	07-01	09-30
Tilia spp.	Tree	Lime	07-01	07-31
Trifolium hybridum	Herb	Clover, Alsike		
Trifolium incarnatum	Herb	Clover, crimson		
Trifolium pratense	Perennial	Clover, broad	06-01	09-30
Trifolium repens	Perennial	Clover, Dutch	06-01	09-30
Tussilago farfara	Perennial	Bull's foot	03-01	05-31
Ulex europeaus	Bush			
Vaccinium myrtillus	Bush	Bilberry	05-01	07-31
Vaccinium spp	Bush			
Verbascum spp.	Herb	Aaron's rod	07-01	09-30
Viburnum spp	Bush			
Vicia faba	Herb	Bean, broad	06-01	07-31
Zea mays	Herb	Corn, sweet	08-01	09-30

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