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Practice Abstracts No.1

Deliverable D7.8

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B-GOOD

Giving Beekeeping Guidance by cOmputatiOnal-assisted Decision making

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Preface

Deliverable 7.8 describes the first set of practice abstracts (PAs) prepared by members of the B-GOOD project during the first two years of the project. These documents are short summaries presenting the project as well as different results and are meant to be used by stakeholders to familiarize themselves with the project and its outcomes. The PAs will be submitted on the EPI-Agri platform (www.ec.europa.eu/eip/agriculture) in order to be broadly distributed to stakeholders. This way, the practice abstracts will facilitate interactions and dissemination of information in the EU agricultural knowledge and innovation systems and will help to inform a large audience about the project and its results. The PAs will be particularly useful documents to initiate the transition between dissemination of the results and their exploitation and will contribute to the visibility of the project and rewarding of the involved researchers' contributions.

Summary

This deliverable report details the first set of practice abstracts (PAs) of the B-GOOD project. Overall, 29 abstracts were prepared during the first two years of the project, and these were submitted in May 2021 on the EIP-AGRI platform (www.ec.europa.eu/eip/agriculture).
To prepare these abstracts, a brainstorming with B-GOOD consortium members was conducted during a dedicated B-GOOD internal meeting. Following this meeting, a list of potential PAs was created. Templates were designed, sent to, and used by the relevant B-GOOD members to prepare the PAs.

1. Introduction

1.1. B-GOOD Dissemination activities

B-GOOD stands for 'Giving Beekeeping Guidance by cOmputatiOnal-assisted Decision making'. This project aims at promoting sustainable and healthy beekeeping in Europe by following a scientific multidisciplinary approach to develop and test innovative technologies in order to guide beekeepers in their management practices.

B-GOOD aims at developing technologies that are both pertinent and practical for apiculture. Thus, keeping a constant dissemination activity to inform beekeepers and other stakeholders about the results of the project is key to ensure the adoption of these results, thereby leading to their successful exploitation (see **Deliverable 7.2 - Communication and Dissemination Strategy** and **Deliverable 7.3 - Exploitation Plan**). Keeping a high level of interactions with the different audience groups targeted by B-GOOD will indeed help maximising the impact of the project. For instance, as many technologies are directed to beekeepers, collecting their ideas and feedback will guarantee the development of pertinent and practical tools.

Within B-GOOD, the role of Work Package 7 "Communication and Exploitation" (WP7) is to organize and foster the communication, dissemination, and exploitation activities of the project by developing methods and by assisting the consortium members with their interactions with a diverse set of target audiences. As a key part of the dissemination activity of B-GOOD, WP7 organized the submission of practice abstracts on the EIP-AGRI platform. These abstracts present different activities and results of the project in an end-user friendly language, thereby promoting both, visibility, and accessibility of project developments and outcomes.

1.2. Organisation of the document

This report presents the first set of practice abstracts that was prepared and submitted by members of the B-GOOD consortium. First, the methodology used to find and select the different abstracts is presented. Then, an overview of the different topics is displayed. Finally, the complete list of practice abstracts with the submitted text.

Notably, more abstracts will be submitted throughout the course of the project, and a second deliverable report will document the following PAs (see **Deliverable 7.9 - Practice Abstracts No. 2**, due Month 48).

2. Practice abstracts

In this section, the different practice abstracts prepared by the members of the B-GOOD consortium are presented.

2.1. Preparation of the practice abstracts

To create a list of potential practice abstracts, an internal B-GOOD meeting was organized by members of WP7 in February 2021. During this meeting, involving representatives of all work packages of the project, a list of potential practice abstracts was created using a brainstorming approach based on a mind map (**Figure 1**). Following this meeting, instructions and templates were sent to relevant B-GOOD members (**Annex 1**).

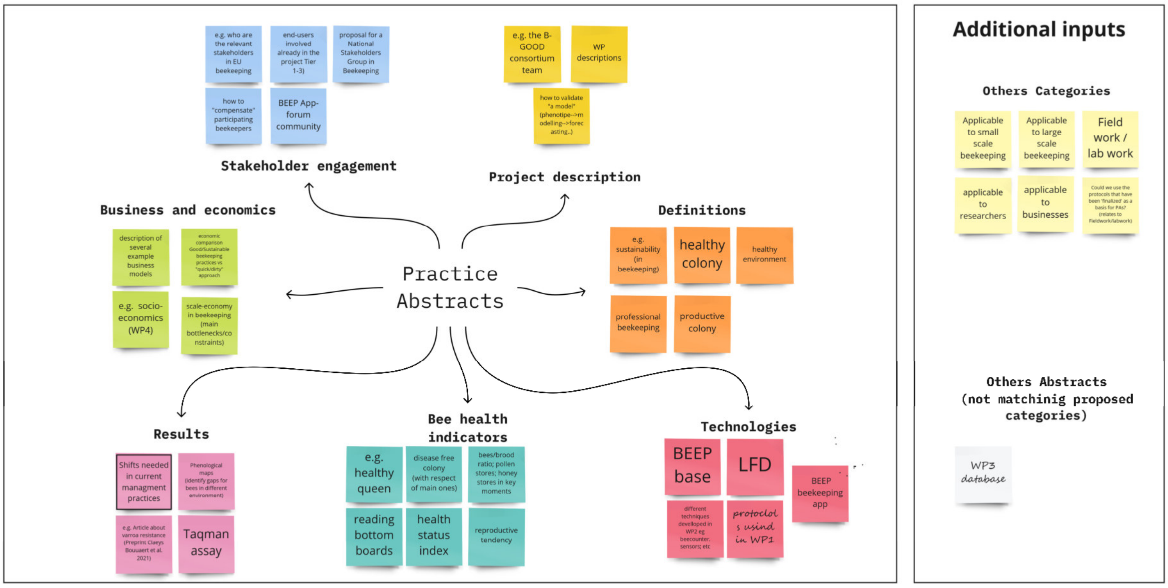

Figure 1 – Results of the brainstorming about B-GOOD Practice Abstract

Mind map created by B-GOOD members using a Miro Board (www.miro.com) to discuss and chose the most relevant items from the project to be used as practice abstracts.

The strategy related to the selection of abstracts involves a two-stepped approach. In the first step, mid-project the focus of the abstract lays at reporting about available and envisaged results and their potential value for stakeholders. In addition, abstracts about the project organization as well as theoretical views were prepared in order to give an overview of B-GOOD's conceptual framework and the project's members view on different aspects of direct relevance for beekeepers and other stakeholders. Notably, as B-GOOD was in its initial stages when preparing this first set of practice abstracts, most of the results planned are not yet available. With this first step, we primarily aim to familiarize stakeholders with the project and its outcomes.

Upon reception of the abstracts from the authors, one or two rounds of revisions were conducted. The abstracts were then stored and formatted to be submitted in May 2021, together with consent forms signed by respective authors.

For the second set of PAs (due M48), another topic selection round will be conducted as detailed above. By then, the project will have reached its final phase, and many more results will be available. Thus, the focus of the second batch of abstracts will be more on the results and their potential exploitation, thereby providing more practical details about the technologies and their implementation by end users.

2.2. Overview

A general overview of the practice abstracts, including their respective categories, topic and responsible institutions and authors is presented in Table 1.

The first set of practice abstracts includes 29 items and has been organized and co-decided during an online brainstorming organised by WP7 and conducted with the B-GOOD consortium members. We collectively decided to aim at six main categories in order to allow presenting the project results in a systematic way, thereby enhancing cohesion and standardization of the abstracts. These categories are:

- **Project description**: a set of 3 abstracts presenting general views of the project, directed at readers who are interested in knowing more about the project organization and members;
- **Engaging stakeholders**: a set of 2 abstracts that give an overview of the different analyses of B-GOOD about the different stakeholders of beekeeping in Europe, directed at readers who are interested in learning more about dissemination and project outreach;
- **Business and economics**: a practice abstract presenting the methodology and preliminary results of the socio-economics analyses of the project, directed at readers who are interested in learning more about socio-economics of beekeeping in Europe;
- **B-GOOD technologies**: a set of 11 abstracts that give an overview of the different tools developed by B-GOOD, principally directed at readers who are interested in the direct use of B-GOOD technologies;
- **Field protocols**: a set of 11 abstracts detailing the different field protocols that were chosen to be used by B-GOOD members to conduct analyses of colony health in the field, directed at readers interested in learning about and/or reproducing these field assays.

Table 1 – Overview of the first set of practice abstracts

Details about the submitted abstracts are provided, including the number, category, name, as well as authors and institutions. Hyperlinks directing to the abstracts details within this document are provided in the 'Abstract name' column.

#	Category	Abstract name
1	Project Description	The B-GOOD project
2		The B-GOOD consortium
3		Description of the Work Packages
4	Engaging stakeholders	Connecting with actors in the EU Beekeeping Sector
5		Knowledge exchanges within the EU Beekeeping Sector
6		Testing technologies and gathering feedback
7	Business and economics	B-GOOD identifies strengths, weaknesses, opportunities and threats facing beekeeping in the EU
8	The B-GOOD Technologies	General considerations
9		BEEP (1/2): the BEEP Bases
10		BEEP (2/2): the BEEP App
11		LFD (1/2): pesticide detection
12		LFD (2/2) virus detection
13		Vibration sensors
14		Temperature sensors
15		Bee counters
16		Taqman assay
17		ApisRAM: Developing a digital twin of a colony
18		B-GOOD creates a database of flower resources at European scale targeting the development of habitat suitability maps for honeybees
19	Field protocols	General overview of the work conducted in WP1
20		Presence of queen & brood
21		Colony dynamics
22		Top photo analysis
23		Mite infestation level
24		Sampling for Lab analyses
25		Atypical worker behaviour
26		Clinical signs of disease
27		Sampling drone brood eggs
28		Queen cell presence
29		Brood pattern consistency

2.3. Detailed abstracts

This section provides the complete list of abstracts that were submitted on the EIP-AGRI platform (www.ec.europa.eu/eip/agriculture/).

Category: Project description
Abstract 1 - The B-GOOD project
Dirk de Graaf & Lina De Smet (UGENT)
The overall aim of the 4-year B-GOOD project is to pave the way towards healthy and sustainable beekeeping within the European Union by following a collaborative and interdisciplinary approach. The project aims to test and implement a common index for measuring and reporting honey bee health status (= Health Status Index, HSI). This index will aid risk assessors, authorities and the plant protection and veterinary medicines industries to measure honey bee health status in real time and across geographical locations, as well as evaluating the effect of (beekeeping) management decisions and actions. It is an essential building block for the development of targeted guidance for healthy and sustainable beekeeping. Semi-automated and/or automated hive monitoring will add to its utility by reducing workload and colony disturbance. The main objectives of B-GOOD are: • Facilitate decision making for beekeepers and other stakeholders by establishing ready-to-use tools for operationalising the HSI • Test, standardise and validate methods for measuring and reporting selected indicators affecting bee health • Explore the various socio-economic and ecological factors beyond bee health • Foster an EU community to collect and share knowledge related to honey bees and their environment • Engender a lasting learning and innovation system (LIS) • Minimise the impact of biotic and abiotic stressors For more information about this, please visit: www.b-good-project.eu

Category: Project description
Abstract 2 - The B-GOOD consortium
Dirk de Graaf & Lina De Smet (UGENT)
The B-GOOD consortium has a multidisciplinary membership. Prof. de Graaf from Ghent University coordinates the B-GOOD project with 17 different institute members. Eight bee research labs (UGENT, WR, INRAE, MLU, UCLUJ, UCOI, TNTU, UBERN) guarantee a network to monitor honeybees in a research setting and have excellent relationships with national beekeeper associations, which provide a base for participant recruitment and dissemination during the project. The reinforcement with two institutions closely linked to beekeeping (SML in the north and BSOUR in the south) enlarge the north-south axis. We additionally brought together socio-economists (UGENT, UCOI) and ecologists (UCOI, UJAG), allowing us to identify viable and sustainable business models for EU beekeepers and providing a dynamic landscape model across the EU. Furthermore, the multi actor approach of B-GOOD is facilitated by AU. In the latter institution, modelers help in understanding the relationship between environmental, biological and management drivers and bee health. Moreover, as data is gathered in an automated way, the SME BEEP, with their bee hive sensor systems, is participating. In addition to this, new features like the application of accelerometers to monitor honeybee colony activity (TNTU) and the bee counter system (INRAE) are being further developed. Two National Reference Laboratories perform routine bee disease diagnosis (FLI, SCIEN). The bees' genetic profile is being studied by MLU and UGENT. Finally, exploitation and dissemination of the research results is provided by PENSOFT and UBERN, and SCIPROM will assist with the management. For more information about this, please visit: www.b-good-project.eu/partners

Category: Project description

Abstract 3 - Description of the Work Packages

Dirk de Graaf & Lina De Smet (UGENT)

The B-GOOD project is composed of ten integrated and interconnected work packages (WPs), where each WP has a set of specific and clearly defined objectives.

WP5 is establishing the relationship between environmental, biological and management drivers and bee health status, to be incorporated into a holistic predictive simulation model of bee colonies in a range of agricultural landscapes.

In order to achieve this, WP5 receives data originating from other WPs:

- WP1: bee health indicators from the colony
- WP3: digital phonological maps of pollen and nectar resources for major land-use types
- WP4: socio-economic data and business models for sustainability of beekeeping.

In WP1, data acquisition occurs preferentially in an automated way, using the BEEP pro remote sensor device, in addition to manual data entry and laboratory analyses. Novel tests and tools for health monitoring are being developed in WP2. In WP6 we utilise and further expand the classification of the open source IT-application for digital beekeeping, BEEP, to streamline the flow of data related to beekeeping management, the beehive and its environment (landscape, agricultural practices, weather and climate) from various sources. This feeds the EU-wide bee health and management data platform that is being established. WP8 focusses on the engagement of and the collaboration between multiple actors from various beekeeping systems within the EU. In order to maximize the impact of research WP7 is dedicated to dissemination and exploitation of the results of B-GOOD. Finally, coordination and project management resorts under WP9, and WP10 is dealing with ethical issues.

For more information about this, please visit: www.b-good-project.eu

Category: Engaging stakeholders

Abstract 4 - Connecting with actors in the EU Beekeeping Sector

James Henty Williams (AU)

A core component of the B-GOOD project is its multi-actor approach. The project sets out to engage with and integrate the expertise and interests of a wide range of relevant actors, from scientists to bee keepers, within the EU bee keeping sector. We want to avoid science and innovation taking place in a bubble, by bring the right people together to generate innovative and practical solutions to ensure healthy honey bee colonies.

As part of the project's actor engagement activities, we established the B-GOOD Multi-Actor Forum (MAF), a platform for knowledge exchange and dialog. MAF members are people who represent the varied interests within the EU beekeeping sector e.g. beekeeping associations, environmental NGOs, public authorities, farming associations, veterinary services and honey processors.

Restrictions and disruptions caused by Covid-19, has meant that the MAF has not meet physically, but other ways to interact have been realized. MAF members have attended, so far, two virtual project meetings in June and December 2020. These project meetings provided an opportunity to disseminate details of project progress and results. In addition, MAF members actively contributed by asking questions and providing feedback, helping to guide project developments.

MAF involvement has been a success and their input appreciated. Holding meetings on-line has provided an opportunity to extend the reach of the project's engagement activities, enabling many people to participate from different locations. The use of on-line tools and platforms will be exploited for the remaining period of the project to further our engagement with a variety of actors.

For more information, please visit: www.b-good-project.eu

Category: Engaging stakeholders

Abstract 5 - Knowledge exchanges within the EU Beekeeping Sector

James Henty Williams (AU)

The EU beekeeping sector is very diverse with many organizations associated with it. We undertook a study to investigate and understand the structure of the EU bee keeping sector.

We carried out in-depth of interviews with people representing organizations belonging to the EU Bee partnership, asking them to provide details of organizations / individuals they interacted with for technical knowledge. In total 41 interviews were undertaken (January and April 2020). From these interviews, we have begun to map networks for technical knowledge exchanges.

Our analysis indicated there are several organizations that are well-connected, with links to 3 or more other organizations. Of these organizations, EFSA, BeeLife and PAN would seem to be central. EFSA and BeeLife seem to have prominent positions sought for their knowledge. PAN has numerous links, but these are both ‘receiving’, and ‘giving’ ties suggesting an influencing position, sought both for their knowledge as well as disseminating it. There several other interconnected veterinarian and technical advisory organizations e.g. EU Reference Laboratory for Bee Health (ANSES), French National Centre for Scientific Research (CNRS), Food and Agriculture Organization (FAO) and APIMONIDA.

Our analysis presented here is not a complete network analysis of the EU beekeeping sector, it represents the networks of the people we interviewed. However, it has highlighted some of the key organizations that B-GOOD will endeavor to engage with for expert knowledge, but who are also likely to be key in influencing honey bee related technical and policy developments within Europe.

For more information, please visit: www.b-good-project.eu

Category: Engaging stakeholders

Abstract 6 - Testing technologies and gathering feedback

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

A key element of the B-GOOD project is to provide end-users with high quality tools in order to gain insight on the health of honeybee colonies. For this purpose, protocols for hive monitoring are evaluated within the project by end-users (i.e., beekeepers). The aim of the evaluation framework is to produce protocols to 1) give adequate insights of the (health) status of a colony, 2) refrain from disturbance of the bees, and 3) be user friendly.

There are two pathways set-up within the framework for evaluation. First, yearly sessions are held with end-users to assess methods of data collection. In parallel to evaluation sessions, feedback is being continuously gathered by end-users via the BEEP helpdesk (see **PA#16 - BEEP app**) set up by the project. Based on the feedbacks, protocols are updated and implemented within the project for further testing. Improvements on BEEP based on evaluations are directly implemented in the BEEP app and available to the public throughout the project. This feedback process allows for constant improvements, engaging with end-users and quality check.

For more information about this, please visit:
https://beepsupport.freshdesk.com/nl/support/solutions/

Category: Business and economics

Abstract 7 - B-GOOD identifies strengths, weaknesses, opportunities and threats facing beekeeping in the EU

Wim Verbeke (UGENT)

Socio-economic researchers within B-GOOD completed 41 depth interviews with a diversity of stakeholders involved in the EU beekeeping sector. One of the aims of these interviews was to identify strengths, weaknesses, opportunities and threats – also called SWOT-elements.

Twenty-four internal characteristics of the beekeeping sector were identified and evaluated in a scoring survey completed by another sample of 28 stakeholders. In a similar vein, 29 external factors shaping the technological, natural, political, economic and sociocultural environment for beekeeping in the EU were identified and evaluated.

The analysis yielded a consensus set of five strengths, five weaknesses, nine opportunities and nine threats. These were consecutively confronted with each other to yield 18 key attention points for policy and strategy development aiming at healthy and sustainable beekeeping in the EU.

One example of the identified key attention points states that the EU beekeeping sector might strive to capitalise on the fact that locally produced honey has a favourable image as a high quality and premium product (strength) for which consumers show an interest and are willing to pay premium prices as a healthy, sustainable, natural and locally produced food (opportunity). This strength is to be carefully protected, notably the image of local honey as a healthy, sustainable and natural product.

Advancements in product quality assessment and analysis – another important external factor identified as an opportunity – can help in this respect, e.g. by providing services to the beekeeping sector (quality control and certification aiming at consumer reassurance).

For more information about this, please visit: www.b-good-project.eu

Category: The B-GOOD technologies

Abstract 8 - General considerations

Martin Bencsik (TNTU)

The B-GOOD project comprises of a specific work package, WP2, dedicated to exploring innovative technologies to monitor honeybee colonies, and their health.

In this work package, scientists are exploring the usefulness of monitoring (i) the vibrations originating from within a honeybee colony, (ii) the temperature all around the volume of the colony and the gases released in it, (iii) the absolute numbers of bees leaving and entering the hive at any point in the time of the day, (iv) specific pesticides in the colony's matrix, (v) specific viruses in the colony, (vi) mutations in the honeybee genome related to varroa tolerance.

The scientific work is taking place into a small selection of thoroughly monitored colonies (the 'Tier1' mini-apiaries, including eight apiaries of eight colonies each across institutes of the B-GOOD consortium, in eight separate countries).

The explorations demonstrated to be useful to the beekeeper are being tested into larger group of users, the 'Tier2' group followed by the 'Tier3' group (add links to practice abstracts of WP1).

For more information about this, please visit: www.b-good-project.eu

Category: The B-GOOD technologies

Abstract 9 - BEEP (1/2): the BEEP Bases

Marten Schoonman (BEEP)

The BEEP base is a multi sensor, autonomous and energy efficient measurement system for beehives. The bases are placed under the beehive. The built-in scale, temperature sensor and microphone measure every 15 minutes and send the values to the BEEP app.

The sensors provide a range of possibilities for practical and research purposes. For example: how much nectar and pollen do the bees collect, how much do they use, are there swarming or robbery events going on, how much brood is present, what is the flight activity, and so on.

The custom-built computer is very energy efficient and the two AAA batteries last 1.6 years in average when using standard measurements settings. Data is transmitted wirelessly via LoRa (Long Range) data connection. The standard installation uses a free network called TTN (The Things Network). Both the sensor system and the free app are shared under an open source license and an API (Application Programming Interface) is available, allowing to make adjustments to the system to make it fit their own (research) needs.

In the B-GOOD project, the BEEP bases and app are being extended and improved based on a European collaboration between beekeepers and scientists. A total of 384 bases are field-tested in 12 countries across Europe.

The BEEP systems can be ordered via the BEEP webshop (see below).

For more information about this, please visit: https://beep.nl/home-english

https://www.beep-shop.nl/en_GB/a-61266000/products/beep-base-complete

Category: The B-GOOD technologies
Abstract 10 - BEEP (2/2): the BEEP App
Marten Schoonman (BEEP)
The BEEP app is a digital checklist app in which users can register inspections. It is a digital alternative to the paperwork that is part of beekeeping. It can be used to manage information on multiple apiaries and hives using a mobile phone, laptop, computer or tablet. Typical information include observations when inspecting a colony and management actions performed on hives. The beekeeper has an overview, can share data and connect hive sensors. The BEEP app can be applied in research projects such as B-GOOD. It eases data collection. Key features include: set up of research projects including inspection checklists, data consent by beekeepers and export features including via an API (application programming interface). The available, optional data categories are very structured and standardized, which facilitates (scientific) data processing. Some key figures: The app is available in nine languages and other languages can easily be added, thousands of users are using the app already, three research projects use the BEEP platform, and a multilingual knowledge base is available to support users. The BEEP app can work in conjunction with the BEEP base, a multi sensor, autonomous and energy efficient measurement system for beehives (add link to PA about BEEP bases), or other sensor systems. BEEP is GDPR compliant. And both the app and the system are shared under an open source license. For more information about this, please visit: https://beep.nl/home-english

Category: The B-GOOD technologies

Abstract 11 - LFD (1/2): pesticide detection

Mang Xu (WUR)

The application of pesticides including fipronil, neonicotinoids, avermectin, pyrethroid and chlorpyrifos are suspected to harness honeybees. Standardized instrumental analysis for detecting these pesticides is expensive and time consuming.

At Wageningen Food Safety Research (WFSR) we develop rapid, simple, robust strip tests (Lateral Flow Devices, LFDs) for on-site detection of the bee-harming pesticides and validate these tests in bee-related matrices (e.g. honey, pollen…). This enables fast on-site screening of hazardous pesticides by beekeepers themselves.

In WFSR, we focus on the development and validation of pesticide LFDs. We developed and validated neonicotinoid LFD prototypes (from our Chinese partner), for application in plants, pollen, honey, bee bread and bees. We also aim to develop and validate such on-site user-friendly LFDs for other pesticides, including avermectins, pyrethroids, chlorpyrifos and fipronil.

With fast, simple and cheap LFD screening of the pesticides in bee related materials, beekeepers can frequently and efficiently monitor the apiary environment at the point-of-need.

For more information about this, please visit:
https://b-good-project.eu/news/2789_lateral-flow-device-for-neonicotinoid-contamination-screening-(instructional-video)/

https://www.youtube.com/watch?v=eZQQakPxEFE

Category: The B-GOOD technologies

Abstract 12 - LFD (2/2) virus detection

Anne Dalmon (INRAE)

Symptoms of numerous trembling bees in front of the hives, unable to fly, can be caused by pesticide exposure or may result from high virus infection with honey bee paralysis viruses.

Current detection of these viruses requires samples to be sent for laboratory analysis using quantitative PCR methods, molecular methods that are expensive, time-consuming and need specific equipment.

In order to discriminate pesticide exposure and virus infection, B-GOOD members are developing a rapid diagnostic kit that can be used in the field by beekeepers or technicians. This research aims at developing a serological test, based on antibodies raised against the main paralysis virus species. Specificity and sensitivity of this method is being assessed and compared to the current qPCR methods. If suitable for virus detection, a ready-to-use kit (Lateral Flow Device) will be set up.

B-GOOD is expected to provide the proof of concept: a simple crude extract to be tested for the presence of paralysis viruses when visiting the colonies, without complex lab experiments.

For more information about this, please visit: www.b-good-project.eu

Category: The B-GOOD technologies

Abstract 13 - Vibration sensors

Martin Bencsik (TNTU)

Honeybees are known to communicate with pheromones, volatile molecules that are released in air, for a vast range of different purposes. They are also known to communicate with the waggle dance, and other cues often comprising of vibrational signals.

In the B-GOOD project, we place vibration sensors (accelerometers) in the centre of colonies, in order to record the vibrations originating from honeybees taking place within the honeycomb. This allows us to pick up previously known, as well as new, vibrational pulses released by individual honeybee individuals passing the vicinity of the sensor. Notably, we focus on collecting and analysing worker pipes, clear worker bee vibrational signals that typically last just under a second, the function(s) of which is/are not yet known.

Together with the array of other data collected on the colonies that we are monitoring (links to other PAs), we are aiming to correlate frequent instances of worker pipes with one or more particular colony condition (e.g., requeening). This way, new light will be shed on the meaning/function of the worker pipes, and a new tool might arise for the beekeeper to find out about his/her colony status, without having to open it.

For more information about this, please visit: www.b-good-project.eu

Category: The B-GOOD technologies

Abstract 14 - Temperature sensors

Martin Bencsik (TNTU)

Honeybees are known to sustain their brood at 35 degrees, at anytime of the year. This can require considerable expenditure of available resources, particularly in colder weather.

In B-GOOD, we aim to better understand the use of resources that honeybees make, by measuring the distribution of the temperature all over the colony. To do so, we have built a hive with 48 temperature sensors per frame, for all 10 frames. The system has been tested and is about to be given a live colony of bees.

We will track the evolution of the temperature of the colony, over the entire hive, for more than a year.

The data will be fed to our research partner in Denmark, developing the APISRAM model (see **PA#23 - ApisRAM: Developing a digital twin of a colony**), for them to further understand the colony's sophisticated use of resources depending on the external weather, available resources, presence of brood, size of the colony, etc..

Eventually the work will yield deeper understanding of the colony's ability to sustain difficult, stressful times, to indicate to the beekeeper the important parameters that make a colony fail or succeed.

For more information about this, please visit: www.b-good-project.eu/

Category: The B-GOOD technologies

Abstract 15 - Bee counters

Cédric Alaux (INRAE)

Honeybees are currently under the threat of growing anthropogenic pressures. Consequently, the monitoring of their population is crucial for developing sustainable protective policies and foster the conservation of these important pollinators. Yet, tracking the impact of environmental pressures on honeybees is a demanding research challenge due to large gaps in monitoring capacity and accuracy. In the B-GOOD project, we therefore propose to develop a bee counter providing a real-time recording of bee activity at the hive entrance (in- and out- activity of bees).

The automatic recognition of different bee castes (worker, queen and drone) and pollen foragers is targeted. At the end of the project, a ready-to-use bee counter should be available for the *in situ* monitoring of daily bee activity and mortality rates. By allowing to compare different estimates of colony dynamics (e.g., difference between exiting and re-entering honeybees), such tool will greatly improve and benefit the monitoring of honeybee colonies and environmental risk assessment by stakeholders, policymakers, beekeepers and scientists.

For more information about this, please visit: www.b-good-project.eu/

Category: The B-GOOD technologies

Abstract 16 - Taqman assay

David Claeys Boúúaert (UGENT)

The varroa mite is one of the main causes of honey bee mortality. An important mechanism by which honey bees increase their resistance against this mite is the expression of suppressed mite reproduction. This trait describes the physiological inability of mites to produce viable offspring and was found associated with eight genomic variants (mutations in the genome of the honey bee) in previous research.

With our research team, we developed and validated an accurate assay for discriminating these eight genomic mutations. This enables us to screen genotypically for the presence of the suppressed mite reproduction trait. In comparison with the standard phenotypic test, screening genotypically is not dependent on elaborate testing and is thus easier to organize and faster.

Within the B-GOOD project we will screen colonies genotypically across Europe for the presence of suppressed mite reproduction. This information will then be compared with indicators on the health status of each colony and with the presence of varroa in each colony. Performing this research will increase our understanding on the link between the genotype and the phenotype of the trait and might open the way for marker assisted selection.

For more information about this, please visit: www.b-good-project.eu/

Category: The B-GOOD technologies

Abstract 17 - *ApisRAM*: Developing a digital twin of a colony

Christopher John Topping and Xiaodong Duan (AU)

ApisRAM is a mechanistic, agent-based honey bee colony model for risk assessment that explicitly considers interactions and feedbacks among various components including bees, colony, pesticide, Varroa, Nosema, disease, weather, bee resources in the landscape and bee keeping practices, of which effects on individual bees are linked through effects on their vitality index.

ApisRAM is a model within the (Animal Landscape and Man Simulation System) ALMaSS, a landscape scale simulation system for modelling the impact of management on animals using detailed agent-based models. ALMaSS provides a detailed dynamic environment where bees develop and perform activities at an individual level based on interactions and feedbacks. Together with the landscape model component, it allows the evaluation of impacts of bee resource availability and farm management on bees.

The goal of ApisRAM is to copy the reality as closely as possible in silico. With ApisRAM in silico experiments, the model should be able to:

(1) predict colony development using landscape information, farming practicing, weather information and bee keeping practice,

(2) assess the risk of pesticides to honey bee colonies at landscape level with multiple stressors.

ApisRAM development was funded by EFSA and continues as part of B-GOOD, the first version should be available in 2022 with a fully working version planned for 2025

For more information about this, please visit: www.b-good-project.eu/

ApisRAM: www.projects.au.dk/sess/projects/apisram/

ALMaSS: www.projects.au.dk/almass/

Category: The B-GOOD technologies

Abstract 18 - B-GOOD creates a database of flower resources at European scale targeting the development of habitat suitability maps for honeybees

Paulo Sousa (UCOI)

Healthy bee colonies depend on abundant and diverse flower resources that they need to forage for pollen and nectar. Having this as a key driver for heathy bees, two of the goals of B-GOOD project are to develop a dynamic landscape model across the EU capturing the major floral resources for bees, and to construct landscape suitability maps for honeybees and beekeeping at EU scale.

To achieve these goals, B-GOOD scientists have classified over 8000 plant species according to their “bee-friendliness” value (mostly in terms of pollen and nectar contents) using information from beekeepers, from databases (i.e., pollination trait syndromes) and pollinator visitation rates. All this information was then used to create a unique database containing spatially explicit data on the important plant species used as resources in different landscape elements (using the EUNIS habitat classification), followed by ranking of habitats in terms of potential to provide abundant and diverse resources.

This database is the base for the ongoing development of a dynamic resource model with the ability to predict the spatial and temporal dynamics of flower resources for major habitat types at regional and national scales across Europe, and for the construction of suitability maps for honeybees and beekeeping.

These will be key tools not only for beekeepers, but also for decisionmakers allowing a better planning of the implementation strategies for apiaries at their territories (considering the carrying capacity of a particular region) and/or a better planning of changes in land-use and land-management and still maintain or improve the desired beekeeping potential.

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 19 - General overview of the work conducted in WP1

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

The aim of B-GOOD is to develop support for beekeepers in order to keep honey bee colonies healthy in a sustainable way, preferably through autonomous hive monitoring to minimize beekeepers' labour as well as disturbance on the hive. To facilitate and optimize this process, the project is divided into several Work Packages.

In Work Package 1 (WP1), the overall aim is to contribute to the operationalization of the Health Status Index (HSI) by collecting data of different health components. The main tasks of Work Package 1 are i) collection of data on honeybee health indicators and ii) validation of tools developed within the project by end-users.

WP1's infrastructure follows a 3-tier approach, which consists of a step-by-step expansion of participating apiaries, calling successively on partner research institutions (Tier 1), selected beekeepers (Tier 2), and the broader beekeeper community (volunteers, Tier 3). This structure allows to use outcomes from the previous year(s) and tier(s) to improve and fine-tune protocols for the following year(s). To do so, protocols and manuals are continuously updated, and new information is added according to needs and new developments. Alternatively, information may be discarded if it is found to be not sufficiently useful, and/or bee-friendly and/or user-friendly in implementation.

By developing structured and standardized protocols, monitoring is becoming more automated with the passing of years of the project. Once the project is finished, tools can be made available to end-users.

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 20 - Presence of queen & brood

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum.

For this purpose, we developed protocols for field observations and data management. These protocols are selected by reference work and key scientific publications and contribute to the operationalization of the Health Status Index (HSI). They are continuously evaluated by end-users, give adequate insights of the (health) status of a colony, refrain from disturbance of the bees, and are user friendly. Protocols found to be sufficient will be made publicly available to end-users at the end of the project.

In this protocol, the presence of queens and brood in all stages (i.e., eggs, larvae, and pupae) are examined. Presence and health status of the queen guarantees for healthy colonies, while presence of worker brood gives information on queen fecundity, viability of worker force and the ability of the colony to rear the eggs until adulthood.

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 21 - Colony dynamics

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum.

The 'Colony dynamics' protocol relies on two methods to estimate the colony demography and resources: 1) Digital photography method and 2) Liebefeld. The number of honeybees within colonies and the amount of food resources (honey and pollen) and brood size are key determinants of colony development and survival. For this measurement, colony traits that are estimated are: colony size (honeybees), pollen stores, capped honey, capped and open brood, eggs and drone brood.

The first method uses the DeepBee software to automatically detect cells and classify their contents in comb images from digital photographed frames [1]. The software is capable of reaching a high level of accuracy and is therefore less observer biased compared to the Liebefeld method. The Liebefeld method uses a grid, etched in square centimeters, where observants visually sum the surface area of bees, brood and food resources, making this method less invasive and less time consuming [2].

For more information about this, please visit: www.b-good-project.eu/

[1] https://doi.org/10.1016/j.compag.2020.105244

[2] https://www.tandfonline.com/doi/ref/10.3896/IBRA.1.52.1.03?scroll=top

Category: Field protocols

Abstract 22 - Top photo analysis

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum. For this purpose, we developed protocols for field observations and/or data management. These protocols are selected by reference work and key scientific publications and contribute to the operationalization of the Health Status Index (HSI).

The 'Top photo analysis' protocol is designed for estimating colony size. With this method, colony size is estimated by taking a photo of the topside of the hive. Estimates are made by calculating the ratio of bees covering the top frame and the overall area available in the box. There are several benefits of this method. Notably, it is more user-friendly for end-users because it requires less labour for the beekeeper compared to traditional methods that estimates colony sizes. In addition, the colony is hardly disturbed, and it can be used in winter as well when temperatures are too low for removing frames in honeybee colonies. The results of this protocol can also be compared to other measurements of colony size taken during the season.

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 23 - Mite infestation level

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum.

For this purpose, we developed protocols for field observations and data management. These protocols are selected by reference work and key scientific publications and contribute to the operationalization of the Health Status Index (HSI). They are continuously evaluated by end-users, give adequate insights of the (health) status of a colony, refrain from disturbance of the bees, and are user friendly. Protocols that are found to be sufficient will be made publicly available to end-users at the end of the project.

The 'Mite infestation' protocol aims at determining the mite infestation level of the parasitic mite *Varroa destructor*, of each colony by quantifying the naturally falling mites. Although we apply standard Varroa control measurements in the project, it is important to measure mite infestation levels of the hive as Varroa is considered to be one of the most harmful stressors for honeybees and treatments against it are not 100% effective. This is done by placing a bottom board underneath colonies, with the a sticky surface facing up and covering the entire bottom, catching falling mites from the colony. For accurate data, the bottom boards need to be inspected weekly, throughout the whole year. The total amount of mites is be scored as mite fall per day.

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 24 - Sampling for Lab analyses

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum.

The current protocol documents the sampling bees for lab analysis on genotyping and diseases. Samples by project participants are collected three times a year (spring, summer and autumn) and sent to European Reference Labs for analysis. Diseases of main interests are: Varroa mites, Deformed Wing Virus (DWV), Nosema spp., American foulbrood (AFB), European foulbrood (EFB), Acute Bee Paralysis (ABPV) and Chronic Bee Paralysis (CBPV), sacbrood virus (SBV). These honey bee diseases are known to be mostly wide spread in all colonies. Once a colony is weakened due to a variety of circumstances (i.e. old queen, bad weather conditions, forage/food shortage), pathogens may become more prevalent and can have devasting consequences on bee health.

Genotyping is mostly done to seek for genetic make-up and differences in bee samples. Using molecular tools, currently being developed in WP2, we aim to find genetic variations associated with Varroa-resistance of the colony. The results of these analyses are shared with apiary owners.

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 25 - Atypical worker behaviour

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum.

For this purpose, we developed protocols for field observations and data management. These protocols are selected by reference work and key scientific publications and contribute to the operationalization of the Health Status Index (HSI). They are continuously evaluated by end-users, give adequate insights of the (health) status of a colony, refrain from disturbance of the bees and are user friendly. Protocols that are found to be sufficient will be made publicly available to end-users at the end of the project.

The ‘Atypical worker behaiour’ protocol aims at identifying atypical behaviour in colonies. Atypical behaviour by workers is one of the first signals of diminished health within the colony as it may indicate e.g., presence of diseases or starvation. This measurement is done by visual inspections of worker bees. It assumes a basic level of normal typical behaviour of honeybees. Some examples of atypical behaviours include running quickly over the comb for long periods, trembling (aside from the trembling dance) or shaking.

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 26 - Clinical signs of diseases

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum.

In the 'Clinical signs of diseases' protocol, clinical symptoms are being monitored for potential diseases. Honeybees are being threatened by a variety of pests and pathogens. Most of the pathogens create clinical signs within a colony that can be recognized by inspections. Potential diseases that may be observed in colonies are: varroosis (Varroa mites are visually present on honeybees or on bottom boards), American Foulbrood (caused by the bacteria *Paenibacillus larvae* and causes sticky brood), European Foulbrood (*Melissococcus plutonius,* a bacterium that create hail shot pattern in brood), nosemosis (*Nosema spp.* that affects the mid gut), and the viruses Acute Bee Paralysis Virus, Chronically Bee Paralysis Virus (shivering), Black Queen Cell Virus (affects the Queen cells), Deformed Wing Virus (damaged wings) and Sacbrood Virus (larvae) and maybe (but hopefully not) small hive beetle (*Aethina tumida*).

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 27 - Sampling drone brood eggs

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum.

For this purpose, we developed protocols for field observations and data management. These protocols are selected by reference work and key scientific publications and contribute to the operationalization of the Health Status Index (HSI). They are continuously evaluated by end-users and give adequate insights of the (health) status of a colony, refrain from disturbance of the bees and be user friendly. Protocols that are found to be sufficient will be made publicly available to end-users at the end of the project.

The 'Sampling drone brood eggs' protocol details how to conduct the sampling of drone brood eggs. The purpose is to identify and analyze the 'suppressed in ovo virus infection' (SOV) trait in honeybee colonies. The SOV trait describes the virus free state of drone eggs. Recent research found that this trait is heritable and that colonies expressing it are more resilient to virus infections as a whole, with fewer and less severe DWV infections in most honeybee developmental stages, especially in the male caste (De Graaf, et al. 2020).

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 28 - Queen cell presence

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum.

This protocol documents how to categorize the presence of queen cells. For this measurement, colonies are visually inspected for queen cells. The presence of queen cells in colonies provides insight on reproduction (swarming tendency) and/or queen quality. The type of queen cells that are identified are:

1) Queen cup: It is a small cup, with an opening on the bottom. For the purposes of the project, we define queen cups as empty queen cells (without eggs or larvae)

(2) Swarm cells: Are built when the colony is preparing to reproduce and swarm. These cells are usually present on the edges of a comb.

(3) Supersedure cells: Are built when the colony wants to replace the current queen. These cells are generally found on the center of a comb.

(4) Emergency cell: Are built if the old queen is dead. Like supersedure cells, they are usually found on the center of a comb.

For more information about this, please visit: www.b-good-project.eu/

Category: Field protocols

Abstract 29 - Brood pattern consistency

Coby van Dooremalen, Dirk Jan Valkenburg and Zeynep Ülgezen (WR)

An essential task of Work Package 1 is to optimize and standardize data collection methods for identifying and monitoring the health status of honeybee colonies. We strive for all actions to be harmonized, and that differences due to the manipulator and/or the procedure are brought to a minimum.

For this purpose, we developed protocols for field observations and data management. These protocols are selected by reference work and key scientific publications and contribute to the operationalization of the Health Status Index (HSI). They are continuously evaluated by end-users, give adequate insights of the (health) status of a colony, refrain from disturbance of the bees, and are user friendly. Protocols that are found to be sufficient will be made publicly available to end-users at the end of the project.

The current protocol is about estimating brood pattern consistency. This measurement gives information about the quality of the brood in a colony. If the brood is 'spotty', this may suggest the presence of disease, or low sperm quality. This measurement is visually estimated by inspecting brood frames in colonies and rating the overall brood pattern consistency based on a 5-point scale based on the percentage of empty cells in areas with sealed brood.

For more information about this, please visit: www.b-good-project.eu/

3. Submission and follow-up

3.1. Submission of the Practice abstracts

The submission of the abstracts displayed above, as well as of the upcoming second set of abstracts, will take place from May 2021 onwards on the B-GOOD page of the EIP-AGRI platform.

3.2. Measuring impact

The Practice abstracts are designed to enhance visibility and favour interactions between B-GOOD members and stakeholders relevant stakeholders (e.g., beekeepers, advisors…). In order to help preparing and to improve the second set of abstracts that will be produced during the second half of the project, the impact of the different abstracts submitted in this deliverable will be measured and compared using the EIP platform analytical tools.

4. Acknowledgements

The authors want to thank all B-GOOD members who contributed to this work by participating to the brainstorming and/or by writing the different abstracts reported here. The authors also want to acknowledge the B-GOOD internal reviewers for their constructive comments and fruitful suggestions that helped improving this report.

5. References

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6. Annexes

Annex 1 – Template for the creation of practice abstracts

Annex 1 – Template for the creation of practice abstracts

Practice Abstracts template

The EIP common format consists of a set of basic elements characterising the project and includes one or more "practice abstract(s)". The format was developed with two main objectives:

- to enable contacting partners and incentivise efficient knowledge exchange, and
- to disseminate the results of the project in a concise and easy understandable way to practitioners.

We recommend including the following elements (please note that they are not, however, obligatory):

- Audiovisual materials, useful and attractive for practitioners (e.g. YouTube link, videos, other dissemination material);
- Links to the project website of the project (URL);
- Links to other website(s) hosting information on the project (results) that are available after the project has ended, by preference using the existing local/regional/national communication channels that practitioners most often use.

Additionally, we have listed a few practice abstracts examples that you may find useful:

- https://ec.europa.eu/eip/agriculture/en/find-connect/projects/pan-european-assessment-monitoring-and-mitigation
- https://ec.europa.eu/eip/agriculture/en/find-connect/projects/homed-holistic-management-emerging-forest-pests
- https://ec.europa.eu/eip/agriculture/en/find-connect/projects/recovery-and-utilization-nutrients-4-low-impact

Annex 1 – Template for the creation of practice abstracts (continued)

Practice Abstracts

Short title:

Less than 150 characters

....

Short summary for practitioners in English on the (final or expected) outcomes:

1000 – 1500 characters, word count – no space

This summary should at least contain the following information:

- Main results/outcomes of the activity (expected or final)
- The main practical recommendation(s): what would be the main added value/benefit/opportunities to the end-user if the generated knowledge is implemented? How can the practitioner make use of the results?

This summary should be as interesting as possible for farmers/end-users, using a direct and easy understandable language and pointing out entrepreneurial elements, which are particularly relevant for practitioners (e.g. related to cost, productivity etc). Research oriented aspects which do not help the understanding of the practice itself should be avoided.