



Data Health Components No.2

Deliverable D1.8

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B-GOOD

Giving Beekeeping Guidance by cOmputatiOnal-assisted Decision making



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Preface

In this report we present the deliverable **D1.8 Data Health Components No.2** by Month 36 of the project B-GOOD. This report contains the meta data of all raw data that were collected within Tier 1 in the first and second field year of the project (year 2020 and 2021), and of Tier 2 in its first field year (2021). The raw project data consist of different health components obtained in a classic, automated or semi-automated way, or by lab analyses, covering different biogeographic regions of the EU. The raw are being checked, double-checked, and cleaned whenever needed. The raw data will be uploaded in the data portal (**Milestone MS36 Website Portal Phase 1**) for further analyses within the B-GOOD project (e.g. in WP5 to compose the Health Status Index) and will become public in full alignment with the project's B-GOOD publication and data sharing policy.

Summary

In this report we give an update of deliverable **D1.3 Data Health Components No.1** and here describe

- 1) The set-up of the data collection infrastructure (i.e. the experimental set up) and how the data are collected.
- 2) How the data are stored and grouped and inspection sheets are produced for end users
- 3) A meta-data overview of all raw data collected (e.g. variables, type of measurement, frequency of measurement)
- 4) The data processing procedure that allows us to prepare the raw 'unfiltered' data for uploading to the data portal and further analyses
- 5) The data portal (summary of deliverable **D1.3 Data Health Components No.1**)

1. Introduction

B-GOOD stands for 'Giving Beekeeping Guidance by cOmputatiOnal-assisted Decision making'. The overall aim of the 4.5-year B-GOOD project is to pave the way towards healthy and sustainable beekeeping within the EU. A key to healthy beekeeping is the Health Status Index (HSI), inspired by [EFSA's Healthy-B toolbox](#). Honey bee health can be assessed by 'indicators' associated with colony attributes (e.g. amount of brood, disease load) and colony outputs (e.g. pollination service, honey harvest), and 'factors' associated with external drivers (e.g. resource providing units), which will be extended with a fourth set of components related to the honey bee gene pool (e.g. local adaption, subspecies, ecotype).

We will make this enhanced HSI operational by working towards an automated or semi-automated data flow from various sources into a common EU-wide bee health and management data platform, and by testing and validating (or discarding) each component thoroughly, eventually leading to the objective selection of the most promising and relevant components.

In the B-GOOD project, WP1 is responsible to facilitate and standardize large scale data collection on honey bee health indicators and genepool characteristics across the EU. This deliverable **D1.8 Data Health Components No.2**, is the second out of three deliverables, and gives an update of deliverable **D1.3 Data Health Components No.1**. This deliverable (**D1.8**) shows what kind of raw data is collected in WP1, and how it is processed and stored before further use in the B-GOOD project (by e.g. WP5 to perform context dependent risk assessment for bee colony management and to give guidance in decision making).

2. Data collection method

Data collection on colony (health) status related variables occurs according to a 3-Tiered process (Figure 1) that spans three bee seasons, where Tier 1 (blue) involves Pilot A and B at apiaries of research institutes of B-GOOD and runs for three years, Tier 2 (green) involves Field study A at EU apiaries of selected beekeepers guided by a local B-GOOD partner and runs for two years, and Tier 3 (yellow) involving Field study B at EU apiaries of randomly selected beekeepers, running for one year. With

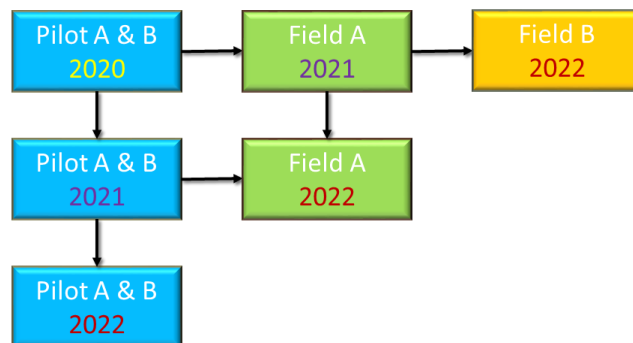


Figure 1. Data collection on colony (health) status related variables occurs according a 3-Tiered process that spans 3 bee seasons.

the progression of the Tiers more variables will come into place as the dimension of the testing shifts from a restricted local (institutional) EU country coverage level, via an EU country coverage level on a North South axis, to a pan-European level (with among other things, a larger variation in subspecies, ecotypes, gene pool, environment, beekeeping management and business model). For more information on the installation of Tier 1, see **Milestone MS1 Mini-Apiaries**, **Milestone MS2 Pilot & Field Study No.1.**, and **Milestone MS4 Pilot & Field Study No.2.**

This deliverable report **D1.8 Data Health Components No.2** contains the meta data of all raw data that were collected within Tier 1 in the first and second field year of the project (year 2020 and 2021), and of Tier 2 in its first field year (2021).

2.1. Data collection infrastructure

Within Tier 1 (2020-2021) we tested the full set of health components suggested by the [EFSA's Healthy-B toolbox](#) (all indicators with high relevance, high technical feasibility, and high priority). The data consist of different health components obtained in a classic, automated or semi-automated way, or by lab analyses, covering different biogeographic regions of the EU.

In Pilot A, there are eight apiaries installed, each with 8 honeybee colonies (hence they are called mini-apiaries). Each mini-apiary is kept by one of the eight partner institutes, across eight different countries, at specific locations (including WR, Figure 2). Each B-GOOD mini-apiary started the experiment with eight presumably healthy colonies (i.e. not sick and performing within normal parameters related to their purpose, e.g. honey harvest). These colonies within the apiaries are the main bodies of research within Pilot A of Tier 1 in WP1 to operationalize the [EFSA's Healthy-B toolbox](#) and to validate the B-GOOD (semi)automated monitoring tools that are technologically sufficiently ready for use (In the Grant Agreement described as technological readiness level >6).

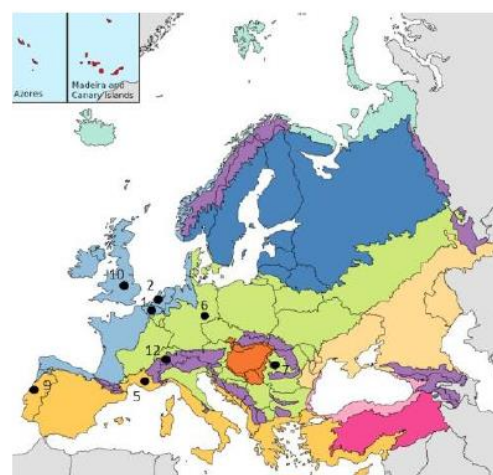


Figure 2: B-GOOD mini-apiary locations for partners UGENT (1), WR (2), INRA (5), MLU (6), UCLUJJ (7), UCOI (9), TNTU (10), and UBERN (11)

Pilot B involves one apiary at partner WR. It contains 25 colonies of honeybees, exposed to stressors in groups of five colonies (including five control colonies). Experimental stress exposures that were applied in 2020 were, induced change in: i) reproductive status, ii) natural parasite load, iii) exposure to the neonicotinoid acetamiprid, and iv) reduced pollen resource availability. In year 2 (2021) the pesticide exposure group was replaced by a groups of colonies that are *Varroa destructor* tolerant (a Dutch local selection line). Monitoring and data collection methods in Pilot Study B are similar to those of Pilot Study A.

In Field Study A (Tier 2), 40 beekeepers were selected over 5 countries, with each a coordinating partner institute (WR, MLU, UBERN, BSOUR, SML, Figure 3). In 2021 the data collection started. WR is responsible for the overall coordination. Each B-GOOD Tier 2 beekeeper started the experiment with presumably three healthy colonies (i.e. not sick and performing within normal parameters related to their purpose, e.g. honey harvest). Under guidance of the local B-GOOD coordinators, the beekeepers collected data in 2021 (conform the DoA) through automated and semi-automated systems, manual measurements (reduced compared to Tier 1) and data annotation. Also these Tier 2 beekeepers contribute to the operationalization of the HEALTHY-B toolbox and the validation of the B-GOOD (semi) automated monitoring tools that have a technological readiness level >6.



Figure 3: B-GOOD Tier 2 countries involved. Coordination by local B-GOOD partners WR (NL), MLU (D), UBERN (CH), SML (FI), BSOUR (IT).

2.2. Monitoring tools tested, protocols and workplans, and communication

For data collection in Tier 1 and Tier 2, a BEEP Base Sensor System was installed under each honey bee colony (89 systems in total for Tier 1, 120 systems in total for Tier 2) for automated measurements. The BEEP bases include sensors for weight of the hive, in-hive temperature and in-hive sound. A LoRa gateway was installed for wireless data transmission. In Tier 1, an additional local weather system was installed (not for Tier 2). No other tools were implemented yet, for validation purposes (for development in WP2, some accelerometers and knock devices were installed in 3 mini apiaries).

For collecting health components data of the all the participating B-GOOD apiaries of Tier 1 and Tier 2, we used scientific protocols and manuals that were adapted and optimised for the purpose of the B-GOOD project, including support manuals for using the BEEP digital logbook app and BEEP base, as described in deliverable **D1.1. Protocols No.1**, **D1.6. Protocols No.2**, and **D1.7 Protocols No.3**. Field observations and sampling for lab analyses on diseases were performed synchronously according to the retained (and described) procedures at all apiaries. Technical support was offered via the BEEP helpdesk (deliverable **D1.2 Helpdesk**).

To operationalize the HSI, some protocols were discarded for Tier 2, compared to Tier 1. For this new target group these discarded protocols were considered to be too laborious and too invasive for the bee colonies (e.g. Liebefeld measurements). In 2021, updated workplan and protocols were implemented for both Tier 1 and Tier 2 (see the different deliverable reports related to the protocols, for more information). Tier 2 protocols and workplan were translated by the partners in the native language of that specific country. To support and simplify protocol Top photo analysis (P3.2), a B-GOOD Tutorial was made [link](#).

Direct communication with all partners was made available using Microsoft Teams, with meetings on a monthly base to discuss project progression, tackle user problems and gain feedback. All partners were continuously involved in updates of the workplan and gave feedback on processes and content.

All Milestones and Deliverables for WP1 related to Tier 1 and Tier 2 have been met on time so far.

3. Data storage and digital visualisation

The BEEP digital logbook app (<https://beep.nl/home-english>) and the BEEP base measurement system (BEEP base) are used to collect inspection data and sensor information respectively. When data is entered in the logbook and saved it is immediately stored in the BEEP database. Via an administration module of the BEEP platform, data records can be consulted and downloaded by users (only their own data). The BEEP base collects sensor information which is transmitted to a time-series database wirelessly. For examples (screenshots) of the automated data collected, see deliverable **D1.3 Data Health Components No.1**. Both information sources are available for download for research, cleaning and subsequent analysis. Access to the data is organized via the B-GOOD publication and data sharing policy.

The current activity in the different Tiers on the BEEP digital logbook app is monitored and accessed via the research portal provided by partner BEEP (previously introduced in deliverable **D1.3 Data Health Components No.1**). This facility allows researchers to make tailor-made inspection lists to guide research participants while collecting data (Figure 4). The research feature also allows to share data in the B-GOOD research and provide consent to do so. See Figure 5 for a screenshot of the current B-GOOD research participation options in the BEEP app. Furthermore, a live data connection can be set up to automatically fetch data at a regular interval via an Application Programming Interface (API).































#	Name	Type	Description	# Categories	Actions
3200	1 Winter	beep_v1.1	B-GOOD - checklist 1	13	  
5564	10 Sampling	beep_v1.1	B-GOOD - checklist 10	24	  
3204	2 Varroa	beep_v1.1	B-GOOD - checklist 2	5	  
3206	3 Summer+	beep_v1.1	B-GOOD - checklist 3	481	  
3202	4 Summer	beep_v1.1	B-GOOD - checklist 4	478	  
3628	5 Health	beep_v1.1	B-GOOD - checklist 5	14	  
4311	6 Overwintering	beep_v1.1	B-GOOD - checklist 6	23	  
4313	7 Bee season	beep_v1.1	B-GOOD - checklist 7	75	  
4315	8 Bee Season+	beep_v1.1	B-GOOD - checklist 8	79	  
5562	9 Health	beep_v1.1	B-GOOD - checklist 9	22	  

Figure 4. Screenshot of inspection sheets prepared and implemented in the B-GOOD project. For the links between the inspection lists and the tiers, see figure 5.




Image	Name	Description	Type	Institution	Type Of Data Used	Timespan	Checklists
	B-GOOD tier 1 (ID: 1)	B-GOOD has the overall goal to provide guidance for beekeepers and help them make better and more informed decisions. In tier 1 B-GOOD partners collect bee data using the BEEP tools.	research-b-good	Wageningen University & Research	Hive inspections, hive settings, BEEP base measurement data	2019-07-01 - 2023-06-30	1 Winter, 2 Varroa, 3 Summer+, 4 Summer, 5 Health
	B-GOOD tier 2 (ID: 3)	B-GOOD has the overall goal to provide guidance for beekeepers and help them make better and more informed decisions. In Tier 2 selected beekeepers collect bee data using BEEP tools, share management actions and the outcome of a limited number of classical measurements. Data from participating beekeepers will be used in alignment with B-GOOD research purposes. Partners Wageningen Research, Aarhus University and your local B-GOOD Tier 2 coordinator will be able to view your personal data, as they have first access, for further use, your data will be anonymized. Data sharing will follow B-GOOD Publication and Data Sharing Policy.	research-b-good-t2	Wageningen University & Research	Hive inspections, hive settings, BEEP base measurement data	2021-01-01 - 2023-06-30	5 Health, 6 Overwintering, 7 Bee season, 8 Bee Season+
	B-GOOD tier 3 (ID: 5)	B-GOOD has the overall goal to provide guidance for beekeepers and help them make better and more informed decisions. In Tier 3 selected beekeepers collect bee data using BEEP tools, share management actions and the outcome of a limited number of classical measurements. Data from participating beekeepers will be used in alignment with B-GOOD research purposes. Partners Wageningen Research and Aarhus University will be able to view your personal data, as they have first access. For further use, your data will be anonymized. Data sharing will follow B-GOOD Publication and Data Sharing Policy.	research-b-good-t3	Wageningen University & Research	Hive inspections, hive settings, BEEP base measurement data	2022-01-01 - 2023-06-30	10 Sampling, 9 Health

Figure 5: Screenshot from BEEP research portal for Tier 1-3

4. Data collected (meta data)

In this chapter we show a meta-data overview of all raw data collected for Field year 1 and 2 (2020-2021) within the B-GOOD project (Table 1). For these field seasons, the data collection involves two tiers: Tier 1, with B-GOOD institutes (2020-2021), Tier 2, with selected beekeepers (2021). Table 1. shows all variables that we logged in our B-GOOD colonies. These variables involve sensor data, annotation data, experimental observations (logged via inspections), laboratory analyses, management actions, weather data, and their frequency. For management actions, due to the infinite amount of options available, we only show what actions have been registered over 2020 and 2021. The raw data underlying data for this report are being checked, double-checked, and cleaned where needed, and will be uploaded in the data portal for further analyses within the B-GOOD project (e.g. in WP5 to compose the Health Status Index).

Table 1. All variables and frequency of measurements that we logged in our B-GOOD colonies for Tier 1 and Tier 2, for the Field years 2020, 2021 (NA= not applicable). Updated version from D1.3 Data Health Components No.1

Variable	Category	Data / Units	Tier 1	Tier 2
Weight	Automated data	kg	15 mins	15 mins
Ambient temperature	Automated data	°C (Celsius degrees)	15 mins	15 mins
In-hive temperature	Automated data	°C (Celsius degrees)	15 mins	15 mins
Sound	Automated data	Frequency count (122-583hz)	15 mins	15 mins
Battery	Automated data	Volt	15 mins	15 mins
Signal strength (data transmission)	Automated data	dBm	15 mins	15 mins
Signal noise (data transmission)	Automated data	dB	15 mins	15 mins
Sufficient adult bees	Data annotation	Yes/no	7 - 30 days	7 - 30 days

Variable	Category	Data / Units	Tier 1	Tier 2
Brood in all stages	Data annotation	Yes/no	7 - 30 days	7 - 30 days
Presence of queen	Data annotation	Yes/no	7 - 30 days	7 - 30 days
Suitable space	Data annotation	Yes/no	7 - 30 days	7 - 30 days
Absence of stressors	Data annotation	Yes/no	7 - 30 days	7 - 30 days
Sufficient nutrition	Data annotation	Yes/no	7 - 30 days	7 - 30 days
General impression	Experimental observation	Good, average, bad (smileys)	7 - 30 days	7 - 30 days
Eggs	Experimental observation	Estimated number of cells	Every 21 days (beekeeping season)	NA
Larvae	Experimental observation	Estimated number of cells	Every 21 days (beekeeping season I)	NA
Bees	Experimental observation	Estimated number of cells	Every 21 days (beekeeping season)	NA
Pollen	Experimental observation	Estimated number of cells	Every 21 days (beekeeping season)	NA
Sealed honey	Experimental observation	Estimated number of cells	Every 21 days (beekeeping season)	NA
Pupae (capped brood)	Experimental observation	Estimated number of cells	Every 21 days (beekeeping season)	NA
Drone brood	Experimental observation	Estimated number of cells	Every 21 days (beekeeping season)	NA
Atypical behaviour	Experimental observation	Yes/no	Every 21 days (beekeeping season)	NA
Colony loss	Experimental observation	Yes/no	when necessary	When necessary
Dead bees	Experimental observation	Yes/no	Every 21 days (beekeeping season)	Every 30 days (beekeeping season)
Varroa natural fall	Experimental observation	mites/day	Once a week	optional
Clinical signs of disease	Experimental observation	Categorized by type	Every 21 days (beekeeping season)	Every 30 days (beekeeping season)
Presence of eggs	Experimental observation	Yes/no	Every 21 days (beekeeping season)	Every 30 days (beekeeping season)
Presence of larvae	Experimental observation	Yes/no	Every 21 days (beekeeping season)	Every 30 days (beekeeping season)

Variable	Category	Data / Units	Tier 1	Tier 2
Presence of pupae	Experimental observation	Yes/no	Every 21 days (beekeeping season)	Every 30 days (beekeeping season)
Queen presence	Experimental observation	Yes/no	Every 21 days (beekeeping season)	Every 30 days (beekeeping season)
Top photo analysis	Experimental observation	Estimated number of bees	Every 30 days during winter, and every 21 days during beekeeping season	Every 30 days
Queen cell presence	Experimental observation	Yes/no	Every 21 days (beekeeping season)*	NA
Queen cell type	Experimental observation	Supercedure, emergency, cup, swarm	Every 21 days (beekeeping season)*	NA
Brood pattern	Experimental observation	Brood spottiness rating. Scale 1-5	Every 21 days (beekeeping season)*	NA
Suppressed <i>in ovo</i> virus infection	Lab analyses	PCR data	Once every queen*	NA
<i>Varroa destructor</i>	Lab analyses	Mites/100 bees	3 times a year (spring, summer, fall)	3 times a year (spring, summer, fall)
Deformed wing virus - A	Lab analyses	PCR data	3 times a year (spring, summer, fall)	3 times a year (spring, summer, fall)
Deformed wing virus - B	Lab analyses	PCR data	3 times a year (spring, summer, fall)	3 times a year (spring, summer, fall)
Acute bee paralysis virus	Lab analyses	PCR data	2 times a year (spring, fall)	2 times a year (spring, fall)
Chronic bee paralysis virus	Lab analyses	PCR data	2 times a year (spring, fall)	2 times a year (spring, fall)
American Foulbrood	Lab analyses	PCR data	Once a year (fall)	Once a year (fall)
European Foulbrood	Lab analyses	PCR data	Once a year (fall)	Once a year (fall)
<i>Nosema ceranae</i>	Lab analyses	PCR data	2 times a year (spring, summer)	2 times a year (spring, summer)
<i>Nosema apis</i>	Lab analyses	PCR data	2 times a year (spring, summer)	2 times a year (spring, summer)
Sacbrood virus	Lab analyses	PCR data	3 times a year (spring, summer, fall)	3 times a year (spring, summer, fall)

Variable	Category	Data / Units	Tier 1	Tier 2
Black queen cell virus	Lab analyses	PCR data	3 times a year (spring, summer, fall)	3 times a year (spring, summer, fall)
Brood layers	Management actions	Number	When necessary	When necessary
Frames per layer	Management actions	Number	When necessary	When necessary
Honey super	Management actions	Number	When necessary	When necessary
Foundationless frame	Management actions	Yes/no	When necessary	When necessary
Drone brood removal	Management actions	Yes/no	When necessary	When necessary
Comb replaced	Management actions	# of combs replaced	When necessary	When necessary
Nutrition/sugar feeding	Management actions	Weight/volume	When necessary	When necessary
Swarming control	Management actions	Yes/no/#	When necessary	When necessary
Swarming prevention	Management actions	Method	When necessary	When necessary
Queen introduction	Management actions	Reason and method	When necessary	When necessary
Queen marking	Management actions	Colour	When necessary	When necessary
Queen cell removal	Management actions	Number	When necessary	When necessary
Colony split	Management actions	Yes/no	When necessary	When necessary
Colony united	Management actions	Yes/no	When necessary	When necessary
Colony feeding	Management actions	Volume/weight	When necessary	When necessary
Honey harvest	Management actions	Weight/volume	When necessary	When necessary
Varroa treatment	Management actions	Method	When necessary	When necessary
Temperature	Weather (from weather service)	°C (Celsius degrees)	60 mins or more often	NA
Wind speed	Weather (from weather service)	m/s	60 mins or more often	NA
Humidity	Weather (from weather service)	x100%RH	60 mins or more often	NA
Rainfall	Weather (from weather service)	mm/h	60 mins or more often	NA

* added in 2021

5. Raw data processing

In order to make the raw data ready for analyses, it needs further processing. The data cleaning process to make the raw 'unfiltered' data ready for uploading to the data portal and further analyses, involves the following steps:

1. Taking automatic measurements from the hives is done with the BEEP base, an autonomous wireless bee hive measurement system. It transmits its data via the ultra-low power LoRa network. Since wireless data reception can be intermittent due to bad weather, gateway, or power outages, the wirelessly transmitted data has been complemented with data downloads via Bluetooth from the internal memory of the BEEP bases.
2. Because there is no internal real time clock inside the BEEP base, the downloaded data has to be time-matched to the existing wirelessly transmitted data in the database to fit the missing data points to the right empty time slots. This has been done by a special built matching algorithm inside the BEEP webapp, in order to get as much as possible contiguous data sets. Since the new firmware update in 2021, a time stamp is automatically added for the log data.
3. After the wirelessly transmitted data has been complemented with the data from the measurement devices' memory, a 'data completeness' report is generated from the BEEP backend for each measured hive to check the amount of total data per year.
4. The research data in BEEP database, including automatic data, weather data, inspection data, is downloaded using the BEEP backend for a defined period. Several data files are generated after the downloading as below.
 - a. For every hive (with a BEEP base), a raw measurement data CSV file.
 - b. For every apiary, a raw weather data CSV file.
 - c. Excel file with meta data:
 - i. User consents
 - ii. User data
 - iii. Apiary data
 - iv. Hive data
 - v. Sample codes (for bee specimen)
 - vi. Inspection data
 - vii. Device (BEEP base) data
 - viii. Uploaded measurement data (via Bluetooth) details
 - ix. Raw measurement data (link to CSV file) for each measured hive
 - x. Weather data (link to CSV file) for each apiary
5. The downloaded data is processed by WUR to find missing data gaps and abnormal changes in the automatic data.
6. If the abnormal changes in the automatic data cannot be explained by inspection activities or missing data gap, the apiary manager will be contacted for further investigations. The abnormal changes will be fixed based on the inspection note and feedback from the apiary managers.
7. For inspection data, a check of the respect of the planned schedule is carried out (count Varroa, top photo, colony evaluation, etc). If any inspections appear to be missing, the apiary manager is contacted to determine if the inspection has not taken place or if the data has not been entered.
8. After these steps, the data from each apiary will consist of two csv files for a calendar year containing automatic data and inspection data respectively. In addition to these two files, each apiary has one csv file with weather data for a calendar year.

6. Data portal

The EU-wide bee health data web portal ('data portal' in short) is used to store and share B-GOOD datasets (**Milestone MS36 Website Portal Phase 1**). Honey bee colony health data is the main subject. The main purpose of the portal is to store raw and pre-processed data generated in the B-GOOD project. The processed data of 2020 has been uploaded and the data of 2021 (Tier 1 and Tier 2) will be uploaded onto the data portal (see figure 5). The portal is provided for by partner BEEP (latest update: Milestone 36). Uploading occurs in full alignment with the B-GOOD publication and data sharing policy.

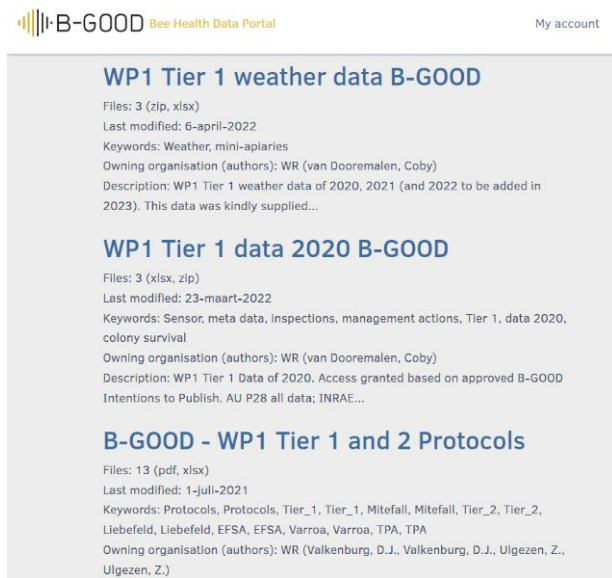


Figure6. The data uploaded to the portal of Tier 1, year 1. The B-GOOD data portal is available via <https://beehealthdata.org/>.

So far the following datasets have been uploaded to the portal in relation to WP1 Tier 1 and Tier 2

- Weather data Tier 1 (year 1 and year 2, 2020-2021)
- Tier 1 data year 1 2020 (year 2 and Tier 2 datasets are being processed at the moment)
- Tier 1 and Tier protocols (Tier 3 protocols are being added)
- Disease analyses Tier 1 data year 1 and 2 (2020 and 2021)
- Disease analyses Tier 2 data year 1 (2021)

7. Acknowledgements

We thank Tier 1 and Tier 2 partners (UGENT, INRA, MLU, UCLUJ, UCOI, TNTU, UBERN, SML, BSOUR, WR) for their continuous effort they put managing their apiaries and doing all the measurements, and/or and supporting their beekeepers. We thank BEEP, FLI, and SCIEN, for their constructive collaboration within WP1 on data collection and processing. We thank all reviewers for giving feedback on the protocols, for writing and for reviewing this deliverable.

8. References

BEEP digital logbook app <https://beep.nl/home-english>

B-GOOD data portal <https://beehealthdata.org/>

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