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Final Report

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Final Report

PROJECT FINAL REPORT

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Name of the scientific representative of the project's coordinator and organisation:	Prof. Kaspar Bienefeld LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV
Tel:	+49 3303293830
Fax:	
E-mail:	kaspar.bienefeld@rz.hu-berlin.de
Project website address:	http://www.smartbees-fp7.eu/

Final Report

Please note that the contents of the Final Report can be found in the attachment.

4.1 Final publishable summary report

Executive Summary

Global apiculture is currently facing a deep crisis, characterized by increasing parasite and pathogen pressure in combination with a rapid loss of biodiversity.
Against this background, SmartBees has assessed the state of European honeybee biodiversity, based on a newly-established reference collection of >2.200 samples from all subspecies present in Europe. The DNA- analysis of these samples has permitted the identification of thousands of genetic markers that allow the differentiation of the four evolutionary lineages, of subspecies within each lineage, and partly even of subpopulations within subspecies. The most informative markers were integrated into a genotyping tool allowing breeders and researchers to assess the subspecies affiliation of any colony easily and affordably.
In order to highlight the value of honeybee biodiversity and protect it, we carried out a poll on European beekepers' attitudes towards local bees and their information needs, which was answered by almost 5.000 participants. An online toolbox was developed that addresses the issues brought up.
To strengthen our knowledge base for the protection of honeybee diversity, we have estimated the minimum required population size required for conservation, and determined the levels of biod iversity in island populations of endangered subspecies. We have also inventoried the different con servation initiatives in place on our continent, and created a network between them.
An important step to further the use of local bee populations was the initiation of 23 groups of beebreeders in 15 European counties, working with 10 different subspecies. Intensive training was provided in the form of on-site courses and high-quality technical documents translated into up to 20 lan¬guages. Breeders of all subspecies were given access to modern quantitative genetics like the BLUP-based genetic evaluation. Nearly 1.900 breeding values of performance-tested queens were cal¬cu¬lated and provided at the new designed website www.beebreed.eu.The network of breeders thus created led to the foundation, in 2018, of the "International Association for Honeybee Breed-ing".
A major goal of SMARTBEES has been to identify and characterize genetic variants affecting varroa resistance, notably the ability of bees to detect and remove infested brood. The results are truly im pressive, and we have, across several subspecies, identified and validated a considerable number of genomic loci with highly significant effects upon the resistance trait. Genetic markers from this study have been included into the SmartBees SNP-panel/chip and can now be used to accelerate selection for Varroa resistance in European honeybees.
Our project also revealed the complex interplay between varroa, honeybees, and viruses, including the protein repertoire of varroa saliva and its role in immunosuppression of bees and virus transmis sion. Neonicotinoid insecticides and food deprivation accentuated the negative effects of varroa and viruses on bee health, but this could be mitigated by dietary supplements. The diversity of viral se quences accross the continent was characterized and we demonstrated how viral sequences adapt to either the mite or the bee host.
Overall, the project has led to 16 peer-reviewed publications, with many more still in the pipeline. Results have been disseminated to a wide audience through 48 publications in beekeeper and popular media, as well as through the 6 regional SmartBees-conferences and 6 project newsletters. Con sequently, we are convinced that SmartBees will have a lasting impact on the sustainability of European beekeeping

Summary description of project context and objectives

The project is divided into 10 work packages (WPs)
WP1, Gene discovery of resistance traits, aimed to phenotypically characterize different European subspecies of A. mellifera regarding traits that confer resistance to parasites and viruses, and to elu cidate the transcriptomic and genomic basis to these.
Varroa and its most frequently associated virus, deformed wing virus (DWV) have been responsible for millions of honeybee colony losses and the virtual eradication of feral honeybees from large parts of Europe. In recent years, it has become increasingly clear that resistance towards the Varroa mite can be heritable, meaning that genetic variation affecting the trait is present in the population. A ma jor goal of SMARTBEES has been to identify and characterize such genetic variants affecting hy gienic behaviour, i.e. the ability of bees to detect and destroy infested brood. With state-of-the-art se quencing methods to facilitate rapid screening of paired pools of individuals containing extreme ex amples of a trait e.g. resistance and susceptibility, we aimed to identify SNPs, InDels, and CNVs with differentially representation in phenotypic pools. Supported by transcriptional analysis and bioinformatic annotation, genetic markers were to be selected for supporting selection for increased Varroa resistance across multiple subspecies, using molecular tools.

In WP2, Tools and strategies for sustainable breeding, we aimed to create methods for the breeding of resistant and diverse bees, based on local stock. One of these tools is the web-based bee breeding service BeeBreed.eu which allows local breeders to benefit from the use of modern quantitative ge netics. While existing before SmartBees, it had to be extended to be suitable for many countries, sub species and the breeding situations in the participating countries. A second tool is the BLUP-based breeding model, the basis of breeding values. A third tool is a simulation software of bee breeding as an extremely valuable tool to develop sustainable breeding strategies.
Another aim of WP2 was to develop a DNA genotyping kit for honeybee breeders and producers. This genotyping kit could be used to improve selection results regarding hygienic traits towards the parasitic mite Varroa destructor (Varroa), heterozygosity at the CSD locus and subspecies specificity. In the course of the project, it was decided to split the DNA genotyping kit into three kits, to give breeders more flexibility in the use of the product.

The aim of WP3 (Assessing honeybee biodiversity in Europe) was to create a unique and large-scale dataset to describe and characterize European honey bee diversity, using pool sequence data from a comprehensive and representative sampling effort of honey bees across all of Europe and adjacent re gions. This collection represents all subspecies occurring in Europe and sufficiently characterizes the genetic diversity of Apis mellifera on the continent, at the same time providing valuable reference samples for future work.
By way of including data obtained with morphometric or microsatellite analysis, we planned to make it possible to link these newly generated genomic markers to known and published reference data and to historic subspecies descriptions. Based on the comprehensive genomic dataset, informative SNP makers were to be selected to allow assignment of honey bee samples to their subspecies of origin. The informative SNPs should be validated using advanced biostatistical techniques. Based on these markers, we aimed to provide the means of rapid and cost-effective identification of honey bee samples.

WP4 - Promoting honeybee diversity in Europe: To raise awareness for honey bee diversity among beekeepers in Europe, their thoughts about honey bee subspecies and conservation was to be assessed on the European scale for the first time. The data generated were expected to provide the basis for fu ture activities to promote conservation efforts.The presence and key management data of existing conservatories for indigenous populations of honey bees across Europe were to be reviewed and sum

marised. A network of conservation areas on the SmartBees website was planned, and guidelines for the size and definition were to be developed and published. To avoid negative effects of inbreeding and genetic drift, the minimum effective population size of honey bees in conservation areas had to be estimated via a comparison of several populations of A. m. mellifera across Europe. We also aimed to monitor several nature reserves and national parks in three European countries for the pres ence of wild colonies.

The main purpose of WP5 (Development of new extension methods for sustainable apicultural pro duction and maintained diversity) was to suggest new extension tools and communicative strategies for sustainable management of resilient bee populations on the European level. We aimed to achieve this by identifying today's information and learning needs across Europe, describe regional Know ledge and Innovation Systems within the beekeeping sector, and finally by developing a web-based tool-box for advisory services in apiculture and development extension. Through these activities, SmartBees should enable regional actors (within the knowledge and innovation system) to combine methods and tools into adapted regional strategies for knowledge development, involving beekeepers and breeders. WP5 was structured around three main tasks which create a strong foundation for an extension tool-box. The first task was to survey bee-keepers and bee-breeders in specific regions of Europe to identify similarities as well as differences in their perception of knowledge gaps, methods used and future information needs. The second task was to conceptually describe how different re gions in Europe have chosen to organize the bee-keeping sector's knowledge and innovation system, which we call a B-KIS. As part of this work we aimed to adapt and test a methodology developed in other EU-projects (eg., PRO-AKIS). Finally, the third task was to analyze how the beekeepers' and advisors' needs could be met through a new web-based extension tool-box, also containing informa tion to enable national and regional actors across Europe to adapt universal knowledge within exten sion and communication science to existing structures for knowledge development and dissemina tion. In total the ambition of WP5 was to support all actors involved in knowledge development, dis semination and transfer to improve their skills in enabling learning and to implement new know ledge, developed both within the SmartBees-project as well as from other sources.

The focal point of WP6 (Field testing and selection on local bee populations) was to initiate and sup port breeding activities for the preservation of local honey bee populations across Europe by genetic improvement of commercially relevant traits with special attention on Varroa resistance. With the in tegration of elements of local adaptation and selection, the SmartBees breeding initiatives should fur ther "Preservation via utilization" and encourage beekeepers across Europe to utilize and preserve their local stock. Moreover, we aimed to further the integration of beekeepers into the genetic im provement of honey bee stocks through a "bottom up" extension and communication structure where beekeepers' awareness is of prime importance. Thus, the demon-stration of the usefulness of modern cocepts such as the www.beebreed.eu database for estimation of breeding values, a sustainable and systematic long-term breeding concept should be established.
The work package's ultimate goal was to expand breeding programs for genetic improvement and preservation of local honey bee populations specially in those European regions where selective breeding practices were absent or neglected. To reach this goal, the SMARTBEES extension pro grams (joined forces with WP7) combined practical aspects (on-field training, testing protocols and kits etc.) and sophisticated interactive tools, such as smartphone apps and platforms, through which continuous communication and transfer of knowledge among all stockholders in the breeding struc ture was ensured.
An additional activity of WP6 was the determination of locally adapted Varroa infestation threshold values that are going to be incorporated in regular beekeeping practice in order to establish an inte-grated pest management model with restricted use of therapeutics. The threshold values strongly de pend on population's specific features (colony development, resistance mechanisms etc.), envi-

ronment and applied beekeeping practices and that is why it should be tested under different condi tions and regions across Europe. Finally, the detected Varroa infestation threshold values should be approved and disseminated among the beekeepers and used as indicators for applying Varroa control measures.

The overall objective in WP7 (Dissemination) was to increase the awareness of the value of locally adapted bees and to combine and disseminate the results from the project to various user groups and stakeholders. The dissemination should be adapted and targeted to achieve cost- efficient transfer of knowledge and implementation of new strategies, tools and technologies as discovered in WP 5. Fur thermore, WP7 participated in the effort to launch breeding programmes in WP 6 by establishing net works of breeders to run performance tests. It also aimed to promote participation in other project activities.

WP8 (Elucidating and enhancing honeybee resistance mechanisms to parasitic diseases) centres on understanding the interplay between the honey bee's immune response and the Varroa or DWV (deformed wing virus) that would give insight into potential susceptible and resistance mechanisms that may be exploited in some breeding programme. The immune genes and pathways involved in DWV-resistance were to be investigated by extensive comparative transcriptomic analysis of experi mentally DWV-infected honey bees. The key genes involved in the innate immunity and pathways involved in DWV-resistance were to be revealed and then provided to WP2 for inclusion in the ge netic selection for bees with increased resistance. Another aim was to test the hypothesis that the saliva of the varroa contains bioactive factors able to subvert the bee's immune system. To this end, the protein repertoire (proteome) of varroa saliva (132 proteins) was to be determined. Finally, the WP aimed at determining how honeybee nutrition interacts with parasites and pathogens.

The study of the DWV-mutants is at the core of WP9 (Determining present and future pathogen threats). DWV is a honeybee virus which generally persists in honeybees as a covert, non-pathogenic state. However, in the presence of the V. destructor mite, DWV become virulent notably by increas ing in viral load. We hypothesized that changes in genome sequence are caused by the bee-adapted DWV-variants also becoming mite-adapted. Genomic and phenotypic changes of DWV were studied in vitro and in vivo by alternative change of host between honeybee and V. destructor. Moreover, the population structure and virulence of DWV viral strains collected from different European countries was monitored. Altogether, WP9 better characterized the changes in the genome of DWV that impact its virulence.

WP10 (Project management) finally encompassed the management of the project, facilitation of inter actions between partners and the fulfilment of obligations towards the European Commission. The objective of this work package was to ensure that all working steps and the planned objectives could be achieved, through an effective management structure with clear responsibilities.
Furthermore, the project manager ensured a productive collaboration between the partners, monitored the project progress and reporting, filed amendments and supported partners in questions concerning legal changes, financial and scientific reporting.

Description of main S & T results/foregrounds

WP1 Gene discovery of resistance traits
In order to identify honey bees with enhanced Varroa resistance/tolerance we have phenotyped indi vidual workers for their ability to uncap Varroa-parasitized brood using an established bioassay. For each family tested, we have marked approximately 2,000 worker bees after hatching, and transferred them onto an infrared illuminated observation comb where their behavior against artificially infested brood cells was video-observed. We have carried out these observations on 4 different subspecies of

A. mellifera (mellifera, carnica, caucasica, and macedonica) and subspecies hybrids, as well as on A. cerana, which is known to be resistant to Varroa. For each queen/family analyzed, we have sampled hygienic bees (=bees showing removal of infested brood), and non-hygienic (control) sister individu als. Altogether more than 120.000 bees have been tagged and individually evaluated for hygienic be havior. For all families producing a sufficient number of hygienic bees, we extracted DNA and per formed largescale sequencing of the corresponding pools. We have thus sequenced more than 75 pools with a maximum of 100 workers per pool. Each pool was sequenced to a coverage of approx imately 1x/bee except for queens which were sequenced to approximately 30X coverage to robustly identify genetic variants, thereby allowing for separation of maternal and paternal effects in the sub sequent SNP-analysis. Across all families, more than 2 million SNPs were evaluated for significant association with a particular hygienic group. An example of the data is shown in Figure 1.1 in the Annex I, where Fet values (Fisher exact test) are plotted against the genomic position (x-axis). We identified 93 peaks across all families, altogether harboring 2017 SNPs.

Interestingly, several families had overlapping peaks and 440 SNPS were common between four fam ilies. We subsequently annotated the SNPs for changes in protein coding potential and potential amino acids changes. These SNPs are of particular interest as being potentially causative of differ ences in hygienic behavior. The filtered and prioritized list of SNPs was used in Workpackage 2 to establish a SNP genotyping panel, supporting efforts to enhance disease resistance through marker-assisted breeding.

Moreover, to support the annotation and interpretation of the results from the pool-seq association study, gene expression profiling using RNA-seq was performed. Across multiple families, more than 1362 genes and 199 non-coding RNAs were found to be significantly differentially expressed in a least one family while a smaller set of genes (106) were significantly expressed in 2 or more families.

Apart from identifying SNPs, Pool sequencing also lead to the identification of different structural variants such as insertions and deletion (INDELs) and copy number variants (CNVs). Although less useful as genetic markers, these types of genetic variants are able to affect gene expression and func tion and are as such candidates for being causative relative to the hygienic trait. Altogether, we iden tified 629 INDELs harboured within the “QTL-peak regions” defined by PoolSeq. The list of SNPs in addition to the list of INDELs and CNVs was used in WP2 efforts to establish a SNP genotyping panel.

In order to validate results from the pool-seq analysis, we performed a separate study in which 3450 individual bees (phenotyped for the behavioral trait) were genotyped using the SmartBees-chip de veloped in WP2. This study included bees from families who had undergone pool-seq analysis as well as new families. We used Transmission Disequilibrium Testing (TDT) which measures associ ation of genetic markers in nuclear families by transmission from parent to offspring. If an allele in creases the risk of having a disease then the allele is expected to be transmitted from parent to off spring more often in populations with the trait. The analysis was made both within queen family as well as for all the families combined. In our preliminary analysis of these data, we found that at least 37 of the genomic regions identified in the pool-seq analysis are validated by one or more significant SNPs in the marker-based association study. This is an extraordinary number compared to similar studies. When performing a combined analysis of bees from all phenotyped families (also families without pool-seq data) and applying the highly conservative Bonferroni correction, we identified 10 regions which are associated with hygienic behavior. Further analysis of the data will be performed, and the inclusion of queen genotype data will lead to an even more accurate finemapping and haplo type definition within significant loci.

The validation results thus confirm our findings from the pool-seq analysis, presenting strong evi- dence of association with hygienic traits in multiple genomic positions. Furthermore, they might sug gest a mainly oligo-genic basis for this particular behavioral trait, making it highly amenable to mark er-based selection.

In our attempts to identify potential causal genetic variants, we have performed functional clustering, annotation and gene-enrichment tests of the genes harboring the most highly significant SNPs. Out of 133 SNPs within the validated regions, 78 SNPs could be annotated to gene IDs of which 9 were non-coding RNAs (Lnc RNAs) and the rest protein coding genes. Our gene ontology reveals, among our candidate genes, several genes involved in neural development/function and olfactory pathways. Several studies have suggested that that hygienic behavior is mediated by olfactory cues. More than 150 olfactory genes were located in the candidate peak intervals from the pool-seq analys is. These genes are now being studied in more detail and the SNPs annotation within them is ongo ing.
To sum up, the validated SNPs, InDels and CNVs in genomic regions significantly associated with hygienic behavior offer insight into the genetic basis of hygienic behavior and will definitely improve our knowledge of the molecular basis of honeybee hygienic behavior and varroa resistance.

Another objective of work package one was to identify and compare resistance factors unrelated to hygienic behavior. One such potential resistance factor is the inhibition of varroa reproduction by characteristics of the honeybee brood. We compared different European subspecies of A. mellifera for this trait (in the absence of worker bees). More than 110 pieces of brood from four subspecies were used for these tests. No difference in mite reproductive success was found between the subspe cies. Another trait potentially conferring resistance to varroa is grooming behavior. Through a co operation with partners in Nepal, we compared different types of grooming of European (Apis mel lifera) and Asian (A. cerana) bees, in order to see whether grooming could explain the known differ ence in mite resistance between the two species of bees. We also included mites of the genus Tropilaelaps in this study, which are currently absent from Europe but which will possibly become a problem to European beekeeping in the future. These studies confirmed the fact that Asian bees more strongly express grooming, but they also showed that resistance behavior to Tropilaelaps-mites does exist in European bees.

Taken together, work package one has significantly advanced our understanding of honeybee resist ance to varroa mites.

WP2 Tools and strategies for sustainable breeding
The service BeeBreed.eu provided by LIB is a comprehensive system which covers the collection and refinement of performance data through a web interface, the calculation of breeding values with a BLUP-based model, and the distribution of breeding values and supporting documents as well as tools to aid the selection process through the web interface. The first aim of Task 2.1 was the adapta tion of the existing service BeeBreed.eu to more countries, subspecies, and bee populations and the extension of the performance testing protocol. The main accomplishments are (i) the multi-language support of BeeBreed.eu, (ii) the implementation of an international bee nomenclature, (iii) the integ ration of an extended test protocol, (iv) the restructuring of the data model together with the neces sary adaptation of the calculation software and web interface, and finally (v) various breeding model developments for the situations in new breeding programs.
One of the distinctive cornerstones of BeeBreed.eu is that the individual breeder can enter the breed ing and performance data himself, which has big advantages for data quality and the identification of breeders as part of a breeding program. As often breeders are not sufficiently able to read English or German, the multi-language support is essential to expand this concept to more countries. As the best experts for the correct translation of specific beekeeping terms are the national coordinators (often scientists and beekeepers at the same time), a powerful tool was implemented to put the coordinators in the position to translate the web site in context. The coordinators translated BeeBreed.eu which is now available in 14 languages.

The basic idea of the structured nomenclature od breeding queens, originating early in the 20th century, is that it should not only unambiguously identify a queen but also inform about the birth year, the breeder, and the association. With the internationalization of bee breeding, a straightforward continuation is that the country should be apparent as well. This has many advantages, not the least political, as often the national governments or beekeeping associations are the main sponsors of bee breeding.

Before SmartBees, BeeBreed collected only the final evaluation score for each property which required that each individual breeder must have a separate system of hive recording. In WP6, a performance testing protocol was developed on the basis of traditional test parameters with several extensions and BeeBreed.eu now implements the input of the full protocol, including measurements of individual beehive inspections. This has many advantages not only for the new breeding groups. The breeder is relieved from the task to have a separate recording system, the breeding administrator has a better insight into the testing process of the individual breeder which creates a new tool for efficient collaboration.

Among the many changes to the data model, the new layer of "bee population" has the most far-reaching consequences. Among the breeding queens of a subspecies there are isolated subpopulations, between which no comparison can be drawn because there is no comparative testing. Here, the breeding values would pretend a false comparability. This is highly relevant in SmartBees, where there are several separate breeding groups within A.m.carnica, A.m.mellifera and A.m.macedonica. Thus, for any breeding value to be displayed, the population has to be selected first – and among the queens in a population, breeding values are comparable. This also solved the problem that certain bee populations are (naturally) hybridized or simply unknown.

Assumptions valid for the Central European breeding population for which BeeBreed.eu was developed can no longer be taken for granted and had to be modified for the new breeding programs. Mainly, the marked winter period with no brood, where the number of bees, and critically, of Varroa mites is reduced, does not exist in Mediterranean Europe. Normally, swarmed colonies can be discarded from further breeding, but in some SmartBees breeding groups they were used as their loss could not be compensated. This prompted developments of the breeding model to cope with these situations. In the SmartBees testing protocol colony strength is assessed by counting the number of frames with bees, the number of frames with brood, and brood density while previously only evaluation marks for overall colony strength, spring development, and overwintering were recorded. To relate the quantitative assessment of the SmartBees protocol to final evaluation marks, a mathematical model was developed for the breeding value estimation of colony strength. The installation of mating control is difficult for a starting breeding group, therefore a model was developed for unknown paternal ancestry which considers regional bee pools from which drones are taken. The publication of the model in comparison to the current approach is under preparation.

Stochastic simulation studies are a valuable tool in predicting the potentials and risks of different animal breeding schemes. We have developed software to perform such studies while taking the biological and genetic peculiarities of the honeybee into account. Doing so, we succeeded to define new standards for reliable long-term simulation studies. In particular, we established that long-term studies should be based on genetic models with finite numbers of loci rather than Fisher's infinitesimal genetic model as only the finite locus models show a realistic decay of genetic variance over time. A scientific paper on these results is submitted.

Our studies further underlined that an introduction of mating control is crucial to generate genetic gain over more than just one generation and that breeding schemes without mating control are always ineffective in the medium term. Especially, when a small breeding population faces a large unselected rest population, close to no genetic response could be generated with uncontrolled matings. We could also show that in areas where there is no danger of hybridization, insecure mating stations that cannot fully guarantee for the descent of present drones can nevertheless achieve good breeding success.

We performed various series of simulations to find the optimal selection strategy for honeybee breed ing schemes. For a small population we established an optimal sister group size of four queens and that the number of mating stations should be between 5% and 10% of the number of breeding colon ies. For larger population sizes more validations will have to be carried out but the existing data sug gests that similar numbers will hold. As the establishment of secure mating stations is not possible everywhere, artificial insemination should be used in areas where the geographic conditions do not allow for isolated mating stations.
In task 2.2 of WP2, three completely new honeybee genotyping kits were designed. The aim of this part of the SmartBees-project was to develop a genotyping tool for honeybee breeders. The tool should provide information about the presence or absence of genetic factors leading to hygienic beha vior against the parasitic mite Varroa destructor (Varroa), information about the allelic status of the CSD locus, and subspecies specific markers for European honeybees.
Through collaboration with SmartBees-partners in WP1, we received a list containing 2325 SNPs for hygienic behavior against varroa. In our own WP, 2134 specific probes were identified in the hyper variable region (HVR) of the CSD locus. Through collaboration with SmartBees-partners in WP3 a list of 4197 SNPs was created representing 12 different subspecies found in Europe. A total of 8656 SNPs was used in the design. The Infinium XT beadchip genotyping platform designed by Illumina Inc. was selected. This is a very robust genotyping platform, often used for genotyping of large num bers of samples in the Agricultural segment.
After designing the genotyping panels, the genotyping results from the InfiniumXT beadchip were validated by genotyping more than 10.000 honeybees collected by SmartBees-partners. For valida- tion of the selected SNPs a Machine Learning Algorithm was employed. In order to build a model to classify and predict assignment of out-of-sample data, a LinearSVC model was created. Cross- validation was performed to estimate the accuracy of the model. This method was used for the WP1 and WP3 data. The HVR is a very complex region, so for the validation of the WP2 data, raw data was analyzed. Using this method, it was possible to determine unique allele probes within the drones.
Simultaneously a sampling method was developed. This method should fit into the daily manage- ment of the bee hives, as sampling should be easy to handle. Historically honeybees have been sampled using small tubes with ethanol. In this new system, the thorax of the honeybee is cut out and transferred directly into a small tube containing a conservation buffer. This method will always give the same size of sample material, and it is very easy to handle on robotics in the laboratory.

WP3 Assessing honeybee biodiversity in Europe
Reference collection of European honey bees
We compiled a comprehensive collection of honey bees from locations across Europe that comprises more than 2200 samples, representing all subspecies present on the European continent. It suffi ciently characterizes the genetic diversity of Apis mellifera on the continent and provides valuable reference samples for future work.
Population genetic structure of European honey bee subspecies
Based on whole genome sequence data of 22 pools representing 12 subspecies, the population genet ic structure of European honey bees was investigated using average genome-wide population differ entiation (pairwise FST). Overall, the 22 pools grouped into four main branches corresponding to the well-known evolutionary lineages (M, C, O and A) (Figure 3.1, in the Annex I). While FST values between subspecies of different evolutionary lineages averaged at 0.333, FST within the same lin eage reached 0.063. The lowest FST was found between two A. m. iberiensis pools (FST = 0.016), while the highest value was observed between the A. m. mellifera pool from Ireland and the A. m. caucasica population (FST = 0.534). (see Figure 3.1 Annex I)

Selection of ancestry-informative SNPs

In addition to FST, Principal Component Analyses (PCA) were used to select ancestry informative markers (AIMs) based on the allele frequencies for each SNP in each pool and subsequently selecting the top SNPs with the highest contributions to the significant principal components (PCs). For a visu al representation of the method, 100 individual genotypes were simulated using the allele frequencies of the selected SNPs in a PCA. Using this approach, the evolutionary lineages M, C and O were well separated with the first two PCs (Figure 3.2A, see Annex I), while lineage A can be differentiated with the third component (not shown). Based on a sufficient number of specific SNPs, resolution could be improved, and it was also possible to separate subspecies within the same lineage (Figures 3.2B-D see Annex I).
Together with markers that were developed in WP1 and WP2, an Illumina Infinium XT BeadChip was designed for genotyping. The final number of SNPs from WP3 contributing to this genotyping panel was 4165 SNPs.

Validation of selected markers
The selected AIM SNPs were validated in a two-step system employing machine-learning algorithms and involving both samples with known origin and new and independent ones. Based on the predic tions of the selected validation model, the Linear Support Vector Classification (LinearSVC), it could be shown that the subspecies assignment of the unknown samples could be predicted on average 98% correctly (Figure 3.3, see Annex I).
Selective Sweeps due to Varroa introduction
Our sampling contained several populations that have been exposed to the parasitic mite Varroa de structor for different time periods during the expansion of mite range from east to west after shifting hosts from A. cerana to A. mellifera in far eastern Asia, more than one hundred years ago. We com pared SNP variation in the A. m. mellifera population from Russia, where Varroa had been present at last since the 1940's (that is for more than 70 years) to variation in populations where the parasite had arrived more recently – A. m. mellifera from Denmark and from Switzerland. In addition, we also acquired samples from the Isle of Man in Great Britain that is even today still Varroa-free. Two concurring peaks were found in all these comparisons, located on chromosomes 7 and 8. However, no correlation was found between these results and markers obtained from WP1 in association to Varroa sensitive hygienic behavior. Further investigations are necessary to understand the functional role of the genes found within the sweep regions and to investigate what other factors could lead to the identified signals.

WP4 Promoting honeybee diversity in Europe
Stengthen beekeepers' involvement in conservation activities
Via a questionnaire, beekeepers' knowledge and their thoughts about honey bee subspecies and con servation were assessed on the European scale for the first time. The results show a huge diversity of knowledge and interest in conservation issues and provide the basis for future activities to promote conservation efforts.
Conservation areas
Hybridisation due to increased movement of bees for honey production, pollination and overwinter ing in more favourable regions as well as trade with honeybee queens are currently the main threats to the diversity and conservation of locally adapted populations. We have reviewed and summarised the presence and key points about the number of colonies and size of the protected area of existing conservatories for indigenous populations of honey bees across Europe and created a network on the SmartBees website. In addition, guidelines for the size and definition of such areas were developed. The results are currently being processed and prepared for publication.
Effective population size
The effective population size is a critical measure relevant to conservation efforts, allowing detecting

signs of genetic drift in small populations and determining minimum population size necessary for ef fective conservation and avoiding inbreeding. A comparison of several A. m. mellifera populations of varying size from across Europe, based on genome-wide SNP variation (figure 4.1, see Annex I), ap pears to indicate that a population of 100 colonies or more may be sufficient for sustaining the neces sary genetic diversity within a population, but this number requires validation. Additional data are ex pected to be available soon to further clarify this question.

Status of feral or wild populations in Europe.
A search for feral honeybees yielded a few colonies that were sampled with support from managers in nature reserves and national parks and scientific colleagues from Greece and Germany, in the last year of the collection period. In spite of many contacts to protected areas, no samples could be ob tained from Spain.
Analysis of the Greek samples revealed high similarity to samples representing A. m. macedonica from Bulgaria and samples collected on the island of Crete, that appear to be hybridised with A. m. macedonica to some extent (figure 4.2, see Annex I). Thus, feral and managed honey bees appear to freely exchange genes with each other, enhanced by the fact that in all three countries surveyed (Greece, Germany and Spain), there are no legal restrictions against beekeeping activities inside the protected areas. In conclusion, there is no reason to distinguish the two populations as separate units, the honeybees kept by beekeepers are representing the local population of honeybees.

WP5 Development of new extension methods for sustainable apicultural production and maintained diversity
Sustainable bee-keeping involves both biological, technical and economic challenges. Nonetheless, it is not until people change or implement best practices and new knowledge that real improvements can be measured. In the diverse processes of knowledge development and transfer within the bee-keeping sector in Europe, extensionists and advisors play a central role. Strategies to develop bee-keeping in Europe must therefore include issues related to communication, learning and behavioral change. In the SmartBees project this has been done in an integrated way; through training and dis semination activities, but also by a specific work package aiming to develop a web-based resource for communicators and advisors within the bee-keeping sector. This has been the main purpose of WP5 and the new homepage was launched at the EURBEE-conference in Ghent in September 2018; http://www.bee-extension.org
But an extension tool-box must be adapted to the specific needs and pre-conditions within the bee-keeping sector. Consequently WP5 started with a survey of bee-keepers and bee-breeders in several regions of Europe, focusing on their information needs as well as preferences regarding learning methods and tools. Understanding the target group is important but not enough. We also need to know more about how different parts of Europe have chosen (consciously or not) to organise their knowledge and innovation system within the bee-keeping sector (what we call a regional B-KIS). We approached this issue in a conceptual way, describing eight regions in Europe using the same meth od. This resulted in a report and a better understanding of what specific challenges different regions have if and when developing regionally adapted strategies to improve extension and advisory ser vices.
The ongoing professionalization of the beekeeping sector in Europe will force us to focus more on the quality of the services provided to the beekeepers. New findings, higher competence, societal de mands and new technologies will put pressure on trainers and educators to work more consciously with communication planning. It is within this context that one should understand the aim of WP5 in SmartBees. Bee-extentionists and advisors will be able to use the web-based extension tool-box as a resource when planning and evaluating educational and communicative activities. By this we aim to strengthen the sector by bridging the so called implementation gap; moving from theory to practice more effectively.

The final result, the URL: http://www.bee-extension.org, will be administrated by the National Com petence Centre for Advisory Services at the Swedish University of Agricultural Sciences (SLU). On the new homepage communicators and educators will find guidelines, helpdesk and best practices, but also possibilities to deepen their theoretical knowledge on extension through in-depth texts. The models presented are adapted to the specific challenges within bee-keeping, with a large number of bee-keepers not used to pay for advisory services, and building their competence development on in formal learning among peers. The aim has been to tap into existing pre-conditions, while at the same time adding insights from extension theory and advisory services from other sectors in agriculture. Lack of effective communicative skills and strategies might become a threshold for not only a sus- tainable and increased production from honey bees, but also society's ability to strengthen and devel op new ecosystem services based on pollinators. WP5 within SmartBees has created the precondi tions to make such thresholds as low as possible.

WP6 Field testing and selection on local bee populations

The implementation of WP6, "Field testing and selection of local bee populations", entirely achieved the objectives set in the SmartBees project proposal. Thus, during the period of 48 months, a system atic sequence of actions was taken towards the establishment of a self-sustainable breeding structure and practice, relevant for different regions in Europe. In some aspects, we went even beyond the ob jectives set out in the proposal. Our report is structured into three main activities undertaken during the project duration:

I. Breeders' identification, dissemination and capacity building

Identification of the target group (beekeepers, breeders and relevant specialists) was a crucial step in initiating activities and ensuring sustainable project development. Several steps were taken for the identification of competent and enthusiastic breeders, beekeepers and specialists from regions with endangered and/or neglected European honey bee populations. In total, we published 46 peer-re viewed and popular articles, abstracts, book chapters and posters that contained relevant information concerning project aims, activities, timeframe, the possibilities of involvement of breeders as well as results and achievements. To boost the accessibility, the materials were translated into up to 13 lan guages and published in 38 proceedings and beekeeping journals across Europe. In addition, the over all communication and dissemination of information was enhanced by giving talks and participating in more than 130 events (seminars, workshops, local training, conferences, symposia etc.) as well as by contacting the already established and well-recognized international and regional beekeeping and academic networks and initiatives.

The competences of the engaged partners are a fundamental standing point for ensuring adequate im plementation and realization of breeding initiatives. To improve the overall understanding concerning honey bee breeding and also to improve breeders' technical skills for the application of the recom mended methods for testing, an extended capacity building program was implemented all over Europe. The first step was the preparation of the tailor-made "Performance Testing Protocol, A guide for European honey bee breeders", in cooperation with the project partner LIB-B (Annex 6.1, English version). The protocol describes the basic requirements, recommendations and timeframe for setting up and maintaining testing stations and development of regional and/or national breeding structure. In addition, this document contains detailed and step-by-step descriptions of twelve (12) methods and tests for assessment of traditional and Varroa related traits. The document was translated into 20 lan guages and published online (http://SmartBees.eu/Extension/Performance/).

The above-mentioned protocol and method descriptions were visualized (videos, gif animations) and made more accessible to the beekeepers by the development of smartphone and tablet application "Virtual Testing Apiary". This freeware application, available on www.testbees.eu, provides main in formation and details for standardized assessment and test of the traits of interests as well as calculat ors that assist breeders to improve the quality of data collection. In addition, the standardization of

the methodology for testing colonies under different environmental and beekeeping conditions and consequent adequate estimation of the breeding values improved with the development and distribu tion to SmartBees breeders of an innovative “Performance Testing Kit” that contains tools and equip ment for correct application of the testing methods.
The success and sustainability of the breeding activities significantly depend on the technical know ledge and experience as well as the organizational capacity. That is why in WP6 we devoted signific ant efforts towards the enhancement of beekeepers’ understanding of breeding and im-provement of their management and communication capacity. During the project period, we orga-nized and con ducted 21 on-field practical and theoretical training sessions entitled “Contemporary honey bee breeding” in 17 countries (Figure 6.1; see annex), in which more than 400 beekeepers actively parti cipated. During the aforementioned trainings, the breeders were instructed how to use the mentioned methods and kit.

The central role in organizing the training events, data collection and management of the regional breeding groups was taken by 23 coordinators (http://SmartBees.eu/Extension/Performance/Breed-Coord/) who, through a series of five seminars (Figure 6. 1, see annex) had a chance to exchange knowledge and experience, gained during the test ing under different environmental conditions, and to report about challenges. Towards the end of the project, as a consequence of such intensive communication and collaboration, the idea to establish an “International Honey Bee Breeding Network” was born. It was formalized during the last seminar on 19 October 2018 in Hohen Neuendorf. This achievement of WP6, beyond the project’s objectives and expectations, may help to ensure sustainability and perpetuation of the breeding activities to wards genetic improvement and preservation of the European honey bee populations.

II. Testing and data collection for propagation of locally adapted honey bee stock
The establishment of testing apiaries around Europe started in 2015, right after the first training events and publishing of the performance testing protocol. In total, more than 130 apiaries (bee-keepers) from 19 countries (Figure 6.1) were involved in the testing and collection of data from more than 3000 colonies from different regions in Europe. Till the project’s end date, in close cooper ation with the project partner LIB, breeding values for 1895 queens from 15 countries and 10 European honey bee subspecies were estimated (Figures 6.2 & 3, see Annex I). The estimated breed ing values are regularly published online on “Virtual Testing Apiary” for further propagation in the broader population as well as for the next testing generations. In the meantime, additional capacities across Europe are testing colonies from consecutive generations. For six subspecies, A. m. iberiensis, A. m. macedonica/carpatica, A. m. ruttneri, A. m. adami, A. m. cecropia and A. m. caucasica, the first-ever breeding values were estimated by the project.

Special support was provided to breeding efforts for the preservation of the endemic honey bee sub species A. m. ruttneri in Malta (Malta Case Study), including an extensive training program for breeders, laboratory support for identification of the best available genotypes (collaboration with WP3), research activities, communication with the authorities in Malta (meetings with the Ministry, the President of the country etc. in collaboration with WP3, WP4 and WP2) and raising public aware ness through a serial of popular and scientific articles. As a consequence of these actions, the Min istry for Sustainable Development, Environment and Climate Change of Malta recently initiated ac tions for the conservation of A. m. ruttneri. Having in mind the urgency of protecting the population of Maltese honey bees, this is one of the foremost achievements of WP6.
During the implementation of WP6, we identified challenges related to the initiation and mainte-nance of honey bee breeding programs in different regions in Europe. Thus, besides the evident dif ferences in the environmental conditions and variations in biological features of honey bee popula tions, the cultural and traditional differences among the European beekeepers play a signifi-cant role

for the success of running breeding programs. The experience and the knowledge gained during the implementation of the activities certainly contributed to the adjustment of the methods and are incor porated into the second version of the improved “Performance Testing Protocol”.

III. Detection of locally adapted Varroa infestation threshold values

Significant research progress was done for the estimation of regional Varroa threshold levels. In col laboration with partners within and outside of SmartBees from Romania, Poland, Denmark, Moldova and Croatia data were collected from 217 colonies from summer 2015 to Early Spring 2017 for five parameters relevant for the estimation of the regionally adapted Varroa threshold levels. The evalu ation of the different infestation parameters shows high correlations between the adult bee infestation and natural mite mortality during the entire period indicating that each parameter can be used as a good indicator of colony infestation level. The decision for one of those methods should be based upon beekeepers’ experience and preferences. Our data show that the infestation of adult bees is suf ficiently indicative of the infestation level of the whole colony and in the same time most convenient for the appliance. Furthermore, the results show that the differences in Varroa infestation among the colonies from different groups (threated/removed, lost in winter, overwintered below economic size and overwintered economic size) are getting more distinct as the season proceeds. Thus, in week 38 (mid-September) a biological threshold level (colonies survived until next spring) of 9.3 mites per 10 g of bees was found. However, the estimated economic threshold value (survivor colonies with eco nomic size i.e. maximum capacity for honey production in the forthcoming season) was 3.2 indicat ing that lower infestation in week 38 might not affect colony performance for the forthcoming sea son. Based on the data from the parameter “Natural mite mortality” the biological threshold was 14.4 mites per day and the economic threshold below 5 mites per day. Finally, the brood infestation of 21.3 % in week 38 was identified as a biological threshold and the infestation of below 12.3 % as an economic threshold. All these outcomes were communicated to the beekeeping and scientific com munities during the project closing seminars organized by WP7 and will be published in a scientific article that is under preparation.

WP7 Dissemination

In WP7 we established a website for the project where we presented the project aims and the consor tium partners. The website has been used to inform about project achievements, to post a biannual newsletter and to establish contact with stakeholders.

Breeding and conservation networks and dissemination to governmental and non-governmental or ganisations: SmartBees established a network of beekeepers and bee breeders that were subcontrac ted to carry out performance testing of local honeybee popu-lations. This network covered all subspe cies of European honeybees. SmartBees has also supported conservation activities of various kind throughout Europe. For example, SMART-BEES partners have been strongly involved in the conser vation efforts to save the honeybee subspecies Apis mellifera ruttneri on Malta. To facilitate the con tinuation of the selective breeding to improve the local honey bee populations after SmartBees came to an end, we initiated and supported the establishment of a new organisation: International Honey Bee Breeding Network (IHBBN). The aim of the organization is to aid to the genetic improvement of local honey bee stocks and the conservation of the different subspecies of the honey bee within their native range.

Newsletter: During the project period, we have published 6 newsletters. The newsletters have been posted at the project website as well as sent to subscribers that registered them-selves at the project website.

Articles in beekeeping magazines: Beekeeper magazines were regarded to be a dissemina-tion chan nel that would reach a large proportion of the beekeepers in Europe. We have writ-ten 5 manuscripts in English aimed for beekeeper magazines. The English manuscripts have been translated into many national languages by the SmartBees partners and the manu-scripts have also been sent to the editors

of beekeeper magazines in the European Bee-keeper Associations with an invitation to translate and publish the manuscripts in their own language.
Scientific dissemination: SmartBees consortium partners have presented their work orally at many in ternational congresses, conferences and symposia. Until now, 16 scientific papers have been pub lished and a lot of manuscripts are under review in different scientific jour-nals. As in most research projects data accumulates during the project period and numerous additional scientific publications based on the research in SmartBees are expected in the coming year.

WP8 Elucidating and enhancing honeybee resistance mechanisms to parasitic diseases
Honey bees are equipped with a highly efficient immune system capable of protecting themselves against a wide range of infectious agents. However, Apis mellifera is susceptible to varroa infesta tion, in which case the deformed wing virus (DWV) becomes a markedly more virulent infection. But, what is the underlying mechanism(s) that allow varroa to have such a long and intimate associ ation with the bee without eliciting any robust and effective immune response and what are the im mune genes and pathways involved in responses to DWV infection? Neither the viral immune resist ance mechanisms nor how varroa infestation affects the bee/DWV equilibrium are understood. It is also not clear how stressors such as abnormal temperature, xenobiotics (like pesticides) and poor nu trition affect the bee's immunecompetence.
To analyze immune genes and pathways involved in DWV-resistance, we performed an extensive comparative transcriptome analysis of experimentally infected honey bees. To this end, we infected honey bee pupae and drone larvae with DWV and analyzed the transcriptomes of infected and naïve bees with RNAseq to reveal the precise cellular mechanisms affected. The results from DWV-in fected worker bees clearly showed that the key genes of the honey bee innate immune system (abaecin, apidaecin, hymenoptaecin defensin 1 and defensin 2) were significantly up-regulated. Fur thermore, we identified genes of neuronal and muscular development which were significantly dis-regulated in infected honey bees in response to an infection with virulent DWV. We confirmed our RNAseq data by gene expression analysis of individual genes using RT-qPCR. Furthermore, we con firmed our molecular data by experimental infection of honey bee pupae. Thus, key genes involved in innate immunity and pathways involved in DWV-resistance were confirmed. The key genes were provided to WP1/2 for inclusion in the genetic selection for bees with increased resistance.
Varroa infestation is the trigger that changes DWV from a benign, covert viral infection to an overt, pathological state with disastrous consequences for the individual bee and the colony. One hypothesis is that the saliva of the varroa contains bioactive factors able to subvert the bee's immune system al lowing both the prolonged feeding of the varroa and greatly increasing the virulence of DWV. Var roa saliva micro-injected into honey bee pupae greatly increased the DWV titre far more than DWV injected with whole mite homogenate. This result supports the hypothesis that some factor in the saliva allows DWV to become established at a higher titre in naïve bee brood. The proteome of both the saliva (138 proteins) and salivary gland (1302 proteins) was determined by LC-MS/MS and bioinformatics analysis using transcriptome and genome databases of varroa, ticks, predatory mites and parasitioid wasps. Many putative bioactive factors in the saliva proteome were identified and several of them were demonstrated to be either exclusively or predominantly expressed in the salivary glands relative to other varroa tissues. The importance of six of these putative bioactive factors was investigated by creating varroa that were deficient in each of these bioactive factors by specific gene-knockdown and then assessing their phenotype after feeding on bee pupae. Several of these bioactive factors were demonstrated to be important in the bee-varroa relationship with in creased varroa mortality and changes in bee immune gene expression when the bioactive factors were absent.
The ability of honey bees to adequately respond to varroa and DWV infestations is affected by vari-ous stressors which can compromise the immunocompetence of the bee. In order to pinpoint heritable

traits influencing the vulnerability of the bee to different abiotic stresses we investigated the effect of food deprivation, pesticide contamination and other stressors including abnormal temperatures on rel evant bee response genes. Food deprivation and sub-lethal doses of the neonicotinoid clothianidin ap peared to trigger DWV replication by affecting the honey bee immune competence, whereas results on temperature were not conclusive. According to our results, both nutrition and certain pesticides (i.e. the neonicotinoid clothianidin) can affect immune-response and in turn viral proliferation and, thus, survival. Therefore, we propose that the external stressors affecting immune-competence to ward DWV-infection are, in order of importance: the neonicotinoid clothianidin, and related pesti cides impacting antiviral defence and poor nutrition.

Nutrition can play a key role in the immune response of honey bees. We examined the effect of sup plementation with essential amino acids on the ability of adult worker bees to suppress amplification of deformed wing virus (DWV) in laboratory bioassays. The laboratory feeding bioassays demon strated that there was no significant difference in the viral copy number between bees injected with DWV fed on sugar solution alone or sugar solution supplemented with essential amino acids. There fore, under the conditions of the test the presence of essential amino acids did not boost the adult worker bee's ability to suppress levels of DWV. Investigations into the effect of dietary pollen on the survival of mite–infested bees were also performed in caged bee studies. Pollen supplementation had a positive effect on survival of mite-infested bees and reduced DWV titres. Further investigations demonstrated that the survival of mite-infested bees was enhanced by dietary supplementation of the apolar (lipid) fraction of pollen, whereas the polar fraction of pollen did not appear to be protective. Taking these findings out into the field, colonies supplemented with pollen at the end of the active season had reduced bee mortality and a reduced percentage of bees exhibiting the characteristic symptoms of overt DWV infections. Thus, our findings indicate that bee keepers should supplement their colonies with dietary pollen to mitigate the effects of varroa infestation and DWV infection to decrease their overwintering colony losses.

WP9: Determining present and future pathogen threats
Since the worldwide spread of V. destructor, deformed wing virus (DWV) has become one of the main threats to honeybee colonies. Several closely related variants of DWV have been characterized including DWV-A, DWV-B (also named Varroa destructor virus 1 - VDV-1), recombinant between DWV-A and DWV-B variants and the less documented DWV-C. The vectorization of DWV by V. destructor to the bees implies the selection of virulent variants. These modifications in virus popula tion were studied in order to better anticipate the evolution of DWV and the threat it represents.
To understand the changes in DWV when it switches between Insecta and Acari it is not only desir-able but also necessary to have access to cell culture systems from both the original and intermedi-ate hosts for virus propagation. Unfortunately, there are no V. destructor cell lines, nor even proto-cols for obtaining V. destructor primary cell or tissue cultures, but more than 40 established cell lines from closely related ticks (Acari: Ixodidae and Argasidae) are available (Bell-Sakyi et al., 2012). We therefore infected a panel of 21 ixodid and argasid tick cell lines with purified DWV-isolates and screened them for replication of DWV. We also infected honeybee primary cells and heterologous in sect cell lines with DWV. We found eight tick cell lines in which increasing or constant levels of DWV RNA were detected by RT-qPCR over a six-day period after infection. We also screened the cell lines for replication of DWV-A variants and for the DWV-B variants and found that the tick cells constitute better host cells for the latter V. destructor-adapted variants. However, further in vitro-infection experiments revealed that DWV cannot be propagated in tick cell lines, primary cells or lepidopteran cells in terms of generating high virus titres which can be purified quantitatively for NGS. Therefore, we could not use these cells for DWV-production or for analysis of variant clouds. To analyse the shift of the DWV-variant cloud when DWV switches from the honeybee to the V. de structor mite, we therefore focused on experimental infections of honeybees and honeybee pupae.

DWV-A and DWV-B both undergo a bidirectional passage between bees and V. destructor. To in vestigate how these two variants are transmitted between an insect (i.e. honeybee) and an acarine (i.e. V. destructor), we developed molecular diagnostics able to accurately differentiate both DWV-A and DWV-B. Using an artificial feeding system developed for V. destructor, we studied how these two DWV variants are transmitted from V. destructor to the "artificial bee". Remarkably, there was only 1% of the original DWV–A remaining in the V. destructor within a 2 days but DWV-B levels greatly increased reflecting the much higher rate of replication of DWV-B than DWV-A in V. destructor tis sues. It would seem most of the DWV-A reported in V. destructor in other studies is within its gut contents and is defaecated rather than transmitted into the bee. Overall, we take these results to indic ate that DWV-B is better adapted to the Acari (i.e. V. destructor) environment than is DWV-A.
Next, we investigated the establishment and replication of DWV-A and DWV–B in bee pupae with extremely low levels of initial DWV. DWV-A infections went shooting up within a few hours and peaked by 60 hours with a 1 million-fold increase of DWV-A after V. destructor infestation, whereas DWV-A in pupae without V. destructor increased just 3½ -fold. DWV-B levels did not increase at all in the absence of V. destructor, but increased by 30-fold in the presence of V. destructor – which is massively different from the 1-million fold increase for DWV-A. Overall, we take these results to in dicate that DWV-A is better adapted to the Insecta (i.e. honeybee) environment than is DWV-B.

We investigated if there were changes in DWV-A and DWV-B as they are transmitted between V. destructor and bees. The bee pupae and their haemolymph, the associated V. destructor and its salivary glands and saliva all from the same brood cell (i.e. a host-parasite pair) were studied. DWV-A was by far the predominant strain (>95%) within the whole pupal bee and its haemolymph. However, the V. destructor salivary gland and the saliva contained much higher proportions of DWV-B. Our results indicate that DWV-B is favoured and selected for within the V. destructor. Nuc leotide sequence analysis of the DWV populations in each of the tissues showed that the DWV popu lation within the bee pupae was markedly different from that of the V. destructor salivary glands and saliva suggesting some selection and filtering mechanism within the V. destructor before transmis sion to the bee.
In an alternative approach, V. destructor mites were allowed to feed on artificial feed packets for 5 days containing an isolated and specified DWV inoculum. The DWV populations in both the feed packets and the V. destructor were analysed. In particular, two viral genes were analysed in detail in the V. destructor and were determined to be more similar to the DWV-B than the DWV-A variant in dicating that DWV-B is the more mite-adapted DWV variant.
Our hypothesis is that DWV exists as a quasispecies and DWV-isolates represent mutant clouds that change their relative sequence-space master sequence when moving between honeybees and V. de structor mites. The virus mutants are considered bee-adapted when they are circulating in the bee host only (DWV-A mutants) and mite-adapted when they are replicating in the mite (DWV-B mutants). Following this hypothesis, moving of DWV between the bee and the mite host might be ac companied by shifts in DWV sequence-space master sequence and virulence. Our results showed that DWV-B is favoured and selected for within the feeding V. destructor mites although they imbibed al most only DWV-A from bees, indicating a shift in the DWV mutant cloud. Further, DWV-B can sub sequently be transmitted back to the bees because DWV-B was detected in the diet after the DWV-B replicating mites fed on the feed packets. Moreover, when we infected honeybee pupae with the mite adapted DWV-B and re-isolated the DWV particles therefrom we observed again a genetic shift in the DWV master sequences, namely the re-isolated DWV master sequence was closer related to the bee adapted DWV-A variant, than to the more virulent DWV-B variant. This genetic shift was mainly driven by the sequence change in the L-protein gene and the RdRp (RNA-dependent RNA-polymerase) gene as revealed by further analysis beyond the funding period. Furthermore, this genet ic shift was indeed accompanied by a shift in virulence. DWV-B showed a significant higher vir ulence than DWV-A for honeybee pupae (read out: mortality) and adult bees (read out: neurotropism

and cognitive impairment). These results clearly proved our hypothesis that DWV master sequences change when the virus moves between its hosts, the mite and the honeybee. Moreover, we identified the L-protein gene and the RdRp gene as a possible sequence signature of DWV virulence (Gisder et al., Environ Microbiol, manuscript accepted in Nov 2018).

V. destructor mite infestation (varroosis) of honeybee colonies is now worldwide spread including all over Europe. Little is known about the genomic and virulence diversity of the DWV closely related variants in Europe. We collected samples from 121 honeybee colonies across 15 European countries. DWV-B variants were detected in samples from all countries and exhibited a higher detection level than DWV-A variants. Particularly, DWV-B variants were detected in the samples from France, Spain, United Kingdom, Germany, Croatia, Macedonia, Greece and Serbia. DWV-A variants were detected in samples from Italy, Moldova, Croatia and Romania and Serbia. Lastly, recombinant vir uses were found in samples from Spain, France, Macedonia, United Kingdom and Italy. Among the DWV-A/DWV-B recombinant viruses detected, we observed new recombinant-genomes that will re quire further investigations about their virulence. The analysis of virulence of two variants on honey bee pupae showed no major differences between DWV-A and DWV-B suggesting that more than the variant-type, it is the injection of virus by the mite to the pupae that is responsible for wing deformit ies.

All together, we developed new methods and made significant observations that will contribute to better understand the evolution of DWV variants and the threat they represent.

Potential impact and main dissemination activities and exploitation results

Impact with regard to the selection of varroa-resistant lines of honeybees: Varroa destructor is seen as the most frequent cause of colony losses throughout Europe. Our project has led to the identifica tion of thoroughly validated genetic markers for hygienic behavior, which is seen as maybe the most important trait conferring resistance against this parasite. These markers have been integrated into a genotyping tool that will allow breeders to assess the “hygienic potential” of prospective breeding queens much faster and with less effort than with traditional methods of measurement of the trait. This achievement can therefore be expected to greatly increase the speed of selection of bees resist ant to varroa.
Another achievement that almost certainly will help to speed up the production of varroa-resistant bees is the identification of varroa threshold values for different European climates. This knowledge allows breeders to judge at which level of infestation colonies should be excluded from the breeding process but can still be saved by treatments in order to preserve their productive potential. Finally, the project has allowed to train numerous beekeepers, participating in the local breeding groups, to perform selection for resistance traits in their local populations. This puts varroa resistance breeding on a much broader level, and hopefully will help to avoid a scenario where a small number of highly-bred resistant lines from only one or two subspecies of A. mellifera are distributed all over the contin ent, thereby accelerating the loss of biodiversity.
The project has also led to a more comprehensive understanding of how varroosis and viruses dam age honeybees. This encompasses the identification of genes involved in resistance towards the var roa mite and towards DWV, of mite-derived factors suppressing host immunity, and a wholistic view of mite-virus-bee interactions. It also includes an understanding of DWV-adaptability to its hosts. Some of this research is of broader importance for the understanding of host-pathogen/host-parasite relationships, also outside the apicultural sector. Description of the virus diversity in Europe can help to anticipate their evolution and estimate the emergence of new threats. The study on dietary influ ences of bee susceptibility is contributing to a scientifically-grounded understanding of optimum nu trition to enhance the resistance of bees to DWV. Our characterisation of molecular resistance mech anisms is a large step towards the selection of V. destructor- and/or virus-resistant bees. Ultimately,

this research will contribute to reducing colony losses.

Impact with regard to the preservation of honeybee biodiversity: In order to preserve biodiversity, it first has to be assessed. The data collected by SMARTBEES permit a sound assessment of the present state of intraspecific diversity of European honey bees, which is a) based on the most compre hensive collection of bee samples existing to date, and b) an analysis of genome-wide genetic vari ation in populations across Europe. Based on these data, specific genetic markers for subspecies dia gnosis of honey bee samples of unknown origin have been developed and a genotyping panel featur ing Illumina Infinium technology has been designed. With this tool, an accurate, rapid and cost-efficient subspecies diagnosis of unknown samples of honey bees is now for the first time possible. Such a tool will be not only of high value for genetic monitoring programs in protection and conser vation areas, but it will also enable breeders of endangered lines to have their breeding stock evalu ated and thus help to promote their conservation efforts. Breeders all over the continent can now be nefit by verifying that the bees they are breeding are the bees that they want to breed.
A second precondition to preserving bee diversity is to give local breeders the means to effectively select their bees for the traits which render them amenable for “conservation through utilization”. In this regard, an important achievement was the enlargement of the internationally-used breeding plat form beebreed.eu to include bees of all European subspecies, and the fact that local breeders are now given the opportunity to benefit from modern quantitative genetics to calculate breeding values for their queens.
A third precondition to preserving biodiversity is to raise awareness of its value. In this field, the SmartBees-questionnaire on beekeepers’ attitudes towards local bees has shown that much remains to be done. Still, we have been able to motivate and mobilize breeders from 17 European countries to actively get involved in the conservation of their own local bees, and this is a great success. The es tablishment of the “International Honeybee Breeding Network” by some of these breeders can be seen as an indication that this effort will have a lasting impact. Another most noteworthy and con crete result of these efforts is the involvement of beekeepers on the island of Malta in conserving the subspecies A. m. ruttneri. This subspecies is restricted to the Maltese archipelago and must be con sidered as critically endagered. SmartBees has taken part in meetings with local authorities to help local beekeepers to create a legal framework for the protection of their honeybees. The work to create a mating station on the smallest island Comino was started with the help of SmartBees, and in addi tion, much support from WP6 was provided to test their local bees and set up a breeding program. Across Europe, beekeepers are now expressing their desire to use locally adapted honey bees, fre quently also to use the original subspecies. For instance, a new association is being formed in Den mark for the dark honeybees, in Italy the San Michele all’Adige declaration to protect the endemic honeybees has been published, and a book on protection of local bees has been published in the UK. Numerous European colleagues involved in protection and conservation activities have already in dicated an interest to use the genetic tools developed in WP3, thereby demonstrating that the desire to protect local honey bees is on the rise.
Finally, SmartBees has also allowed for a greater level of coordiantion of public and private conser vation efforts accross Europe. The network of initiatives inthis sector that was set up will hopefully llow to exchange experiences and tackle common problems like the lack of sufficiently efective ways of mating control. The project has also been ale to bring about a first estimation of the effective popu lation size that is required for sustainably conserving a population, and this information is evidiently of great value for any activity in this field.

IV.2 Dissemination of results and capacity building

Capacity building: An important part of SmartBees has been devoted to the training of beekeepers and –breeders, with the aim of enabling them to become involved in the conservation of their local bees, as well as in the selection of productive and disease-resistant stock. More than 30 on-site train ing events on breeding techniques were organized, and breeding groups initiated in 17 countries. This has had a direct and lasting impact on the technicity of European beekeepers, as illustrated by the fact that some of them have decided to perpetuate the work initiated within the project through a new in ternational association. Another part of project's legacy is the collection of high-quality technical documents, available online in up to 20 languages, which are distributed and used far beyond the frontiers of the EU.
Another important element of capacity building is the conceptualization of the ways in which inform ation is produced and transmitted within the European beekeeping sector. The project has produced exemplary descriptions of the knowledge- and information-systems of European countries, which can now guide future efforts to bring about necessary reforms or efficiently spread technical progress. Through an understanding of bee-keepers and bee-breeders needs and existing knowledge and in formation systems within the beekeeping sector, it is now possible to suggest relevant extension tools and implementation strategies. A web-based extension tool-box is part of an effort to strengthen the knowledge and innovation system by supporting advisors and educators in implementing new know ledge and best practice.

Dissemination of results: The spreading of knowledge produced has been a priority throughout the implementation of the project. Four different channels were chosen, targeting the scientific com munity, the beekeeping sector, and the general public.
The beekeeping community was mainly addressed through articles in beekeeper journal, through the project website, and through the 7 regional conferences organized by the consortium. More than 48 articles appeared that explained e.g. the value of honeybee biodiversity, ways to effectively breed for varroa resistance, and the importance of bee nutrition for resilience. Members of the consortium col laboratively translated these manuscripts into many languages. The project website was created early on during the project phase and has been continually updated. It has been extended ever since and visited by >3.000 persons in the last year alone. Notably, it has served as download source for many of the technical documents produced. The regional conferences were held in different places accross the EU and were hosted by regional partners. The main effect here was to inform local multiplicators of our findings, such as the heads of breeding associations, but also members of the local administra tion and public service. Moreover, project representatives gave at least 50 presentations in various as semblies of beekeeper associations and other events. The six newsletters produced by the consortium also contributed to the dissemination of results.
The scientific community was and is being addressed through 17 peer-reviewed publications, with many more still to come. Until today, members of the consortium also contributed at least 60 Smart Bees-related presentations to scientific events like Apimondia, EURBEE and other congresses. A book on honeybee conservation is at the final stage of editing.
From the beginning, SmartBees has enjoyed a great amount of interest from popular media. Dozens of articles have been written about the project, some of them appearing in major newspapers like "Die Zeit" (Germany), and radio stations have broadcasted reports about the project. SmartBees was also represented at the Shanghai Science Festival, and featured in TV-clips.

Address of project public website and relevant contact details

http://www.smartbees-fp7.eu/

4.2 Use and dissemination of foreground

Section A (public)

Publications

LIST OF SCIENTIFIC PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
No.	Title / DOI	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Date of publication	Relevant pages	Is open access provided to this publication ?	Type
1	A mutualistic symbiosis between a parasitic mite and a pathogenic virus undermines honey bee immunity and health 10.1073/pnas.1523515113	Gennaro Di Prisco , Desiderato Annoscia , Marina Margiotta , Rosalba Ferrara , Paola Varricchio , Virginia Zanni , Emilio Caprio , Francesco Nazzi , Francesco Pennacchio	Proceedings of the National Academy of Sciences of the United States	Vol. 113/Issue 12	National Academy of Sciences	United States	22/03/2016	3203-3208	Yes	Peer reviewed
2	Proteome Analysis of the Hemolymph, Mushroom Body, and Antenna Provides Novel Insight into Honeybee Resistance against Varroa Infestation 10.1021/acs.jproteome.6b00423	Han Hu , Kaspar Bienefeld , Jakob Wegener , Fred Zautke , Yue Hao , Mao Feng , Bin Han , Yu Fang , Abebe Jenberie Wubie , Jianke Li	Journal of Proteome Research	Vol. 15/Issue 8	American Chemical Society	United States	05/08/2016	2841-2854	No	Peer reviewed
3	Transcriptional signatures of parasitization	Virginia	Insect Biochemistry and Molecular Bio	Vol. 87	Elsevier Limited	United Kingdom	01/08/2017	1-13	No	Peer re

	and markers of colony decline in Varroa - infested honey bees (Apis mellifera) 10.1016/j.ibmb.2017.06.002	Zanni , David A. Galbraith , Desiderato Annoscia , Christina M. Grozinger , Francesco Nazzi	logy							viewed
4	Elucidating the mechanisms underlying the beneficial health effects of dietary pollen on honey bees (Apis mellifera) infested by Varroa mite ectoparasites 10.1038/s41598-017-06488-2	Desiderato Annoscia , Virginia Zanni , David Galbraith , Anna Quirici , Christina Grozinger , Renzo Borto lomeazzi , Francesco Nazzi	Scientific Reports	Vol. 7/Issue 1	Nature Publishing Group	United Kingdom	01/12/2017	1-13		Peer re viewed
5	A Toolbox for Quantitative Gene Expres sion in Varroa destructor: RNA Degrada tion in Field Samples and Systematic Ana lysis of Reference Gene Stability 10.1371/journal.pone.0155640	Ewan M. Campbell , Catriona H. McIntosh , Alan S. Bow man	PLoS One	Vol. 11/Issue 5	Public Library of Sci ence	United States	16/05/2016	e0155640	Yes	Peer re viewed
6	The neonicotinoid insecticide Clothianidin adversely affects immune signaling in a hu man cell line 10.1038/s41598-017-13171-z	Gennaro Di Prisco , Marco Iannaccone , Flora Ianni ello , Rosalba Ferrara , Emilio Caprio , Francesco Pennacchio , Rosanna Cap parelli	Scientific Reports	Vol. 7/Issue 1	Nature Publishing Group	United Kingdom	01/12/2017	online	Yes	Peer re viewed
7	Honey Bee Antiviral Immune Barriers as Affected by Multiple Stress Factors: A Novel Paradigm to Interpret Colony Health Decline and Collapse 10.3390/v10040159	Francesco Nazzi 1, Francesco Pennacchio	Scientific Reports	7	Nature Publishing Group		30/03/2018	online	Yes	Peer re viewed
8	The reduced brood nursing by mite-in fested honey bees depends on their acceler	V.Zannia, L.De#irmenci	Journal of Insect Physiology	109	Elsevier Limited		01/08/2018	47-54		Peer re viewed

	ated behavioral maturation 10.1016/j.jinsphys.2018.06.006	b, D.Annosciaa, R.Scheinerb, F.Nazzia								
9	Honey Bee Antiviral Immune Barriers as Affected by Multiple Stress Factors: A Novel Paradigm to Interpret Colony Health Decline and Collapse 10.3390/v10040159	Francesco Nazzi , Francesco Pennacchio	Viruses	Vol. 10/Issue 4	MDPI	Switzerland	01/04/2018	159	Yes	Peer re viewed
10	Breeding Success or Genetic Diversity in Honey Bees? 10.1016/j.jtherbio.2018.04.012	Daniel Bauer, Jakob Wegener, Kaspar Bienefeld	Journal of Thermal Biology	Volume 74	Elsevier Limited		01/05/2018	311-316	No	Peer re viewed
11	Haemolymph removal by the parasite Varroa destructor can trigger the proliferation of the Deformed Wing Virus in mite infested bees (Apis mellifera), contributing to enhanced pathogen virulence 10.1111/jbg.12347	Desiderato Annoscia, Sam Brown, Gennaro Di Prisco, Emanuele De Paoli, Simone Del Fabbro, Virginia Zanni, David Galbraith, Emilio Caprio, Christina M Grozinger, Francesco Pennacchio, Francesco Nazzi	Journal of Animal Breeding and Genetics	135(4)	Blackwell Publishing		17/07/2018	323-332		Peer re viewed
12	In vivo evolution of viral virulence: switching of deformed wing virus between hosts results in virulence changes and sequence shifts 10.1111/1462-2920.14481	Sebastian Gisder, Nadine Möckel, Dorothea Eisenhardt, Elke Genersch	Environmental Microbiology	20/12	Blackwell Publishing		19/11/2018	4612-4628	Yes	Peer re viewed
	Programul de ameliorare la albine Smart bees in Romania	Adrian Siceanu, Eliza Cauia, Aleksandar Uzunov, Ralph Buchler,	Romania apicola - bee journal of Romanian Beekeepers Association		Romanian Beekeepers Association	Bucharest	31/07/2017	14-21	Yes	Article

		Kaspar Biene feld								
	Insamantarea instrumentala a matcilor - o abordare utila si de perspectiva in controlul imperecherilor la albina melifera	Eliza Cauia, Adrian Siceanu	Romania apicola - bee journal of Romanian Beekeepers Association		Romanian Beekeepers Association	Bucharest	30/09/2017	4-8	Yes	Article
	Congresul Apimondia 2017, un eveniment de succes, recunoscut la nivel mondial, a adus Romaniei o pretioasa medalie de aur	Eliza Cauia, Adrian Siceanu	Romania apicola - bee journal of Romanian Beekeepers Association		Romanian Beekeepers Association	Bucharest	17/11/2017	4-8	Yes	Article
	Is the possible genetic variability of Var roa destructor associated with this of Apis mellifera?	Papoutsis L, Bouga M, Meixner M D, Kryger P, Em manouil M	Proceeding s of the 7th European Confer ence of Apidology Cluj-Napoca, Romania		European Association for Bee Research (EURBEE)		01/09/2016	59pp	Yes	Conference
	Molecular investigation of the genetic di versity of local honey bee Apis mellifera L. (Hymenoptera: Apidae) populations in Greece	Laetitia Pa poutsis, Maria Bouga, Myrto Tsiknia, Mar ina Meixner, Per Kryger, Andone Es tonba, Iratxe Montes, Rikke Ving borg and Nikolaos Em manouil	Proceedings of 17th Panhellenic Entomolo gical Congress, Athens, Greece		Hellenic Entomolo gical Society		30/09/2017	41 pp	Yes	Conference
	Honey bee conservation areas in Europe	Papoutsis L., Bouga M., Meixner M., Kryger P., Es tonba A., Montes I., Dahle B.	Proceedings of 45th Apimondia Interna tional Apicultural Congress , Istanbul, Tur key		Apimondia Federa tion		30/09/2017	41pp	Yes	Conference
	Smartbees project: Breeding for varroa mite resistance and preservation of honey bee diversity in Europe 10.1603/ICE.2016.94771	Ralph Büchler	2016 International Congress of Entomo logy		Entomological Soci ety of America		01/01/2016			Conference
	Pathogen-host interactions between de formed wing virus (DWV) and the honey bee (Apis mellifera)	Gisder S., Genersch E.	XXV International Congress of Entomo logy		International Con gress of Entomology	Orlando, USA	25/09/2016	345		Conference

	10.1603/ICE.2016.93822									
	Stress Factors and Honey bee Health.	Virginia Zanni			Università degli Studi di Udine	Via delle Scienze, 206	17/03/2017			Thesis

LIST OF DISSEMINATION ACTIVITIES								
No.	Type of activities	Main Leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
1	Interviews	LANDERINSTITUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	interview to bee keeping journal	01/02/2015	Deutsches Bienen journal	Scientific community (higher education, Research) - Civil society		Germany
2	Articles published in the popular press	UNIVERSITA DEGLI STUDI DI UDINE	Il progetto Smart bees una nuova opportunitˆ per la selezione delle api europee	01/03/2015	Udine	Civil society		Italy
3	Articles published in the popular press	UNIVERSITA DEGLI STUDI DI UDINE	Il progetto Smart bees una nuova opportunitÆ per la selezione delle api europee	01/03/2015	Udine	Civil society		Italy
4	Oral presentation to a scientific event	NORGES BIROKTERLAG FORENING	Prosjekter i Norges Birøkterlag	21/03/2015	Annual meeting for the Norwegian Bee keepers Association, Gardermoen, Norway	Civil society	100	Norway
5	Flyers	UNIVERSIDAD DEL PAIS VASCO/ EUSKAL HERRIKO UNIBERTSITATEA	Proyecto SMART BEES, un nuevo horizonte para la cría de abeja Europea	01/04/2015	Spain	Scientific community (higher education, Research) - Civil society - Medias	11500	Spain
6	Organisation of Workshops	NORGES BIROKTERLAG FORENING	Training course for performance testers,	09/05/2015	SMARTBEES workshop, Bergen, Norway	Civil society	12	Norway
7	Oral presentation to a scientific event	NORGES BIROKTERLAG FORENING	Nordic-Baltic Bee research Symposium	30/01/2015	Copenhagen, Denmark	Civil society	50	Denmark
8	Organisation of Workshops	AGRICULTURAL UNIVERSITY OF ATHENS	Performance testing	20/06/2015	Athens	Civil society	12	Greece
9	Flyers	UNIVERSIDAD DEL PAIS VASCO/ EUSKAL HER	SMARTBEES Proiektua - Horizonte berri bat erle	01/07/2015	Basque Country	Scientific community (higher education, Research) -	1000	Spain

		RIKO UNIBERT SITATEA	europearraren hazkuntzarako			Civil society - Me dias		
10	Oral presentation to a wider public	UNIVERSITA DE GLI STUDI DI UD INE	Smartbees: progetto europeo per la selezione di api re gine	26/07/2015	Artegna (Udine, Italy)	Civil society	50	Italy
11	Web sites/ Applications	CONSULTECH TECHNOLO GIEBERATUNG GMBH	ht tp://smartbees-fp7.e u/	01/11/2015	Berlin	Scientific com munity (higher edu cation, Research) - Industry - Civil so ciety - Policy makers - Medias		Europe
12	Articles published in the popular press	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Article on Smart Bees questionnaire for electronic news letter (Infobrief) for German Beekeepers	21/12/2015	Kirchhain, Ger many	Civil society		Germany
13	Oral presentation to a wider public	UNIVERSITA DE GLI STUDI DI UD INE	Smartbees: progetto europeo per la selezione di api re gine	10/12/2015	Castel San Pietro Terme (Bologna, Italy)	Civil society	40	Italy
14	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Performance testing and selection	01/06/2015	Conference of Aus trian Carnica Asso ciation, Mieming, Austria	Civil society	70	Austria
15	Organisation of Workshops	NORGES BIROK TERLAG FOREN ING	Training course for performance testers	13/06/2015	Kløfta, Norway	Civil society	25	Norway
16	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT	Performance testing and selection	29/09/2015	International meet ing of beekeepers and friends of hon eybee, Brno, Czech Republic	Civil society	70	Czech Republic

		UND VER BRAUCHERS CHUTZ						
17	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Das Europäische Projekt Smartbees: Bewahrung der Vielfalt der Bienenrassen Europas und Entwicklung von nachhaltigen Strategien zur Lösung des Varroa-Problems (Imkerberatungsdienst Hessen)	08/10/2015	Bad Soden	Civil society	50	Germany
18	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Coordinated selection and breeding efforts improve the mite resistance of honey bee populations	23/11/2015	Wageningen	Scientific community (higher education, Research)	30	Netherlands
19	Organisation of Workshops	NORGES BIROKTERLAG FORENING	Nordic cooperation on A. m. mellifera breeding	27/01/2016	Helsinki, Finland	Scientific community (higher education, Research) - Civil society	10	Finland
20	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Smartbees: Bewahrung der Vielfalt der Bienenrassen Europas und Entwicklung von nachhaltigen Strategien zur Lösung des Varroa-Problems	21/02/2016	Schlüchtern	Civil society	250	Germany
21	Organisation of Conference	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VER	Performance testing for improvement of A. m. iberiensis	03/03/2016	SMARTBEES workshop, Nisa, Portugal	Civil society	39	Portugal

		BRAUCHERS CHUTZ						
22	Oral presentation to a wider public	CONSULTECH TECHNOLO GIEBERATUNG GMBH	SMARTBEES - en unik mulighet for den nordiske bia	05/03/2016	Annual meeting for the Swedish Apis mellifera mellifera association "Nord bi"	Civil society	60	Sweden
23	Organisation of Conference	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Genetic improve ment of A. m. ruttneri	06/03/2016	Avignon	Civil society	13	Malta
24	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Preserving the biod iversity of honey bees in Europe de veloping sustainable strategies to solve the Varroa problem	07/03/2016	SMARTBEES workshop, Malta	Civil society	70	Malta
25	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Breeding for healthy bees	11/03/2016	European confer ence, Malmö	Scientific com munity (higher edu cation, Research)	300	Europe
26	Oral presentation to a scientific event	NORGES BIROK TERLAG FOREN ING	Prosjekter i Norges Birøkterlag	12/03/2016	Annual meeting for the Norwegian Bee keepers Associ ation, Gardermoen, Norway	Scientific com munity (higher edu cation, Research) - Civil society	100	Norway
27	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND	Smartbees: Biodiversität der Bienen in Europa	12/03/2016	Deutscher Imker bund Züchtertagung Triefenried, Ger many	Civil society	50	Germany

		WIRTSCHAFT UND VER BRAUCHERS CHUTZ						
28	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Regionale Selektion vitaler Völker	12/03/2016	Deutscher Imker bund Züchtertagung, Zachenberg, Ger many	Civil society	50	Germany
29	Posters	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Characterization of local honey bees in Greece based on ge netic and morpho metric studies: A case study in Amor gos island (Cyclades, Aegean islands)	23/03/2016	Braunschweig	Scientific com munity (higher edu cation, Research)	200	Germany
30	Oral presentation to a scientific event	NORGES BIROK TERLAG FOREN ING	The national breed ing programme for honey bees in Nor way	09/04/2016	BBKA spring con vention, Birming ham, UK	Scientific com munity (higher edu cation, Research) - Civil society	90	UK
31	Organisation of Conference	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Performance testing protocol	30/04/2016	SMARTBEES workshop, Vilnius, Lithuania	Civil society	47	Lithuanian
32	Posters	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	SMARTBEES Verbesserung der Attraktivität lokaler Bienenpopulationen (Apis mellifera L.)	23/06/2016	Braunschweig, Ger many	Scientific com munity (higher edu cation, Research)	120	Germany

33	Organisation of Workshops	NORGES BIROK TERLAG FOREN ING	Training course for performance testers,	13/06/2016	Vretstorp, Sweden	Civil society	8	Sweden
34	Organisation of Workshops	NORGES BIROK TERLAG FOREN ING	Training course for performance testers	25/05/2016	Lyngdal, Norway	Civil society	12	Norway
35	Oral presentation to a scientific event	INSTITUTUL DE CERCETARE-DEZVOLTARE PENTRU APICUL TURA SA	Protocol of perform ance testing in SMARTBEES project	21/02/2016	National confer ence for beekeepers Romanian Beekeep ers Association - counties branches - Tulcea and	Scientific com munity (higher edu cation, Research) - Civil society	50	Romania
36	Oral presentation to a scientific event	INSTITUTUL DE CERCETARE-DEZVOLTARE PENTRU APICUL TURA SA	Some critical points in the evaluation of VSH and the results of a first study in Romania	22/04/2016	The Coloss Re search Network of Sustainable Bee Breeding Spring 2016 Workshop, Tessaloniki, Greece	Scientific com munity (higher edu cation, Research) - Civil society		Greece,Europe
37	Oral presentation to a scientific event	INSTITUTUL DE CERCETARE-DEZVOLTARE PENTRU APICUL TURA SA	Protocol of perform ance testing in SMARTBEES project	28/01/2016	National confer ence for beekeepers Romanian Beekeep ers Association - counties branch –Oradea, Roman	Scientific com munity (higher edu cation, Research) - Civil society		Romania
38	Press releases	UNIVERSITA DE GLI STUDI DI UD INE	Mite-virus alliance could be bringing down honeybees	07/03/2016	Italy	Civil society - Me dias		Italy
39	Press releases	UNIVERSITA DE GLI STUDI DI UD INE	Parasite-Pathogen Partnership	07/03/2016	Italy	Civil society - Me dias		Italy
40	Press releases	UNIVERSITA DE GLI STUDI DI UD INE	Study suggests mu tualistic symbiosis between parasitic mite and pathogenic virus responsible for bee colony loss	08/03/2016	Italy	Civil society - Me dias		Italy
41	Press releases	UNIVERSITA DE GLI STUDI DI UD INE	Due parassiti alleati contro le api	10/03/2016	Italy	Civil society - Me dias		Italy
42	Posters	AGRICULTURAL UNIVERSITY OF	«SMARTBEES» ### #########	20/10/2015	16th Panhellenic Entomological Con	Scientific com munity (higher edu		Greece

		ATHENS	########## ######µµ# ### ### ####### ########## ########## ######µ## ########		gress, Heraklio, Crete, Greece	cation, Research) - Medias		
43	Flyers	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	TESTUOJAMU# ŠEIMU# SU DARYMAS SUKURIANT DIRBTINI# SPIEC#IU#	31/05/2016	Kirchhain	Civil society		Lithuania
44	Flyers	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	TESTUOJAMU# ŠEIMU# SU DARYMAS ATID ALIJANT ŠEIMA#	31/05/2016	Kirchhain	Civil society		Lithuania
45	Flyers	AGRICULTURAL UNIVERSITY OF ATHENS	Leaflet for the SMARTBEES ques tionnaire	31/05/2015	Athens	Civil society		Greece
46	Flyers	AGRICULTURAL UNIVERSITY OF ATHENS	Leaflet for the sampling	30/04/2015	Athens	Civil society		Greece
47	Organisation of Workshops	AGRICULTURAL UNIVERSITY OF ATHENS	Training course ?Performance test ing"	20/06/2015	Athens	Scientific com munity (higher edu cation, Research) - Civil society	12	Greece
48	Organisation of Conference	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Performance testing protocol	02/05/2016	Vilnius	Civil society	47	Lithuania

49	Posters	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Characterization of local honey bees in Greece based on genetic and morphometric studies: A case study in Amorgos island (Cyclades, Aegean islands)	23/03/2016	Braunschweig	Scientific community (higher education, Research)	200	International
50	Posters	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Assessing honey bee diversity in Europe ? a comprehensive sampling across the continent	15/03/2017	Celle	Scientific community (higher education, Research)	200	International
51	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	First results from the research on Comino Island	30/05/2017	Malta	Civil society	20	Malta
52	Press releases	UNIVERSITA DEGLI STUDI DI UDINE	Mite-virus alliance could be bringing down honeybees	07/03/2016	Udine	Scientific community (higher education, Research)		International
53	Press releases	UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II.	Parasite-Pathogen Partnership	07/03/2016	Napoli	Scientific community (higher education, Research) - Civil society		International
54	Press releases	UNIVERSITA DEGLI STUDI DI UDINE	Study suggests mutualistic symbiosis between parasitic mite and pathogenic virus responsible for bee colony loss	08/03/2016	Udine	Scientific community (higher education, Research) - Civil society		International
55	Press releases	UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II.	Due parassiti alleati contro le api	10/03/2016	Napoli	Scientific community (higher education, Research) - Civil society		International

56	Films	INSTITUTUL DE CERCETARE-DEZVOLTARE PENTRU APICULTURA SA	Queen rearing in an intensive system	31/01/2017	Apimondia Congres	Scientific community (higher education, Research) - Civil society - Policy makers		Romania
57	Interviews	UNIVERSIDAD DEL PAIS VASCO/ EUSKAL HERRIKO UNIBERTSITATEA	Bertako erleak eza gutzen	28/11/2015	Teknopolis (regional TV programme)	Civil society		Spain
58	Interviews	UNIVERSIDAD DEL PAIS VASCO/ EUSKAL HERRIKO UNIBERTSITATEA	Caracterización de la abeja autóctona	29/11/2015	Teknopolis (regional TV programme)	Civil society		Spain
59	Films	INSTITUTUL DE CERCETARE-DEZVOLTARE PENTRU APICULTURA SA	Queen rearing in an intensive system	06/01/2017	Bucharest Romania	Scientific community (higher education, Research) - Medias	1000000	Europe
60	Films	NORGES BIROKTERLAG FORENING	Smartbees regional workshop presentation 6 uploaded video presentations	05/12/2018	Smartbees Website	Scientific community (higher education, Research)	1000000	Europe
61	TV clips	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	Folge 129 - Bienensterben	20/04/2015	Biotechnologie.v	Scientific community (higher education, Research)	50	Germany
62	Organisation of Workshops	NORGES BIROKTERLAG FORENING	Training course for performance testers,	01/06/2017	Kløfta	Scientific community (higher education, Research)	11	Norway
63	Organisation of Workshops	UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II.	Training course for performance testers,	13/06/2015	Kløfta	Scientific community (higher education, Research)	25	Norway
64	Organisation of Workshops	UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II.	Training course for performance testers	09/05/2015	Bergen	Scientific community (higher education, Research)	12	Norway
65	Organisation of Workshops	INSTYTUT OGRODNICTWA	SmartBees trainng course in artificial	11/07/2017	Pulawy	Scientific community (higher edu	20	Poland

			insemination of queen bees			cation, Research)		
66	Organisation of Workshops	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Bee health and breeding better bees	01/10/2017	Istanbul	Scientific community (higher education, Research)	60	International
67	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Genetische Ressourcen der Honigbiene ? Aktueller Stand und Handlungsbedarf	25/10/2017	Hohen Neuendorf	Scientific community (higher education, Research) - Policy makers	20	Germany
68	Posters	INSTYTUT OGRODNICTWA	Varroa destruction Mite Population Level Influence on The Strength and Survivability of Apis Mellifera carnica&Apis mellifera caucasica Bees in Poland	02/11/2017	Athens	Scientific community (higher education, Research)	100	International
69	Posters	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Nachhaltiges management von widerstandsfahigen bienenvolkern	03/04/2015	Kirchhain	Civil society	50	Germany
70	Posters	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Neuermittlung des bevorzugten Alters von Arbeiterinnen-Larven bei der Wirtswahl durch Varroa destructor	21/03/2018	Koblenz	Scientific community (higher education, Research)	200	Germany
71	Posters	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Hygieneverhalten gegenüber Varroa destructor und Tropilaelaps sp. In	20/03/2018	Koblenz	Scientific community (higher education, Research)	200	Germany

			gemischten Arbeiter innen-Gruppen von A. mellifera und A. cerana					
72	Posters	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Comparison of colony development, behavior, production and vitality between the endemic sub-species A. m. ruttneri and the in troduced A. m. ligustica in Malta	23/03/2018	Koblenz	Scientific com munity (higher edu cation, Research)	200	Germany
73	Posters	NORGES BIROK TERLAG FOREN ING	SMARTBEES – Sustainable manage ment of resilient bee populations	20/09/2018	Ghent	Scientific com munity (higher edu cation, Research)	500	International
74	Organisation of Workshops	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	SMARTBEES train ing on instrumental insemination	10/07/2017	Pulawy	Scientific com munity (higher edu cation, Research)	26	Poland
75	Organisation of Workshops	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	3rd Seminar for SMARTBEES co ordinators - Breed ing Values estima tion and selection of honey bees	07/07/2017	Pulawy	Scientific com munity (higher edu cation, Research)	26	Poland
76	Organisation of Conference	INSTYTUT OGRODNICTWA	A.m.mellifera Au gustowska line and Kampinoska line) - Polish National Her itage	15/01/2017	Plaska	Scientific com munity (higher edu cation, Research)	50	Poland
77	Organisation of Conference	INSTYTUT OGRODNICTWA	Conference for queen breeders in Poland	18/11/2017	Pulawy	Scientific com munity (higher edu cation, Research)	55	Poland
78	Organisation of Conference	AGENCE NA TIONALE DE SE CURITE SANITAIRE DE L'ALIMENTATIO N, DE L'ENVIRONNEME NT ET DU TRAV	Honey bee perform ance testing	01/04/2016	Avignon	Scientific com munity (higher edu cation, Research) - Civil society	31	France

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79	Organisation of Conference	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Performance testing of honey bee colonies	01/06/2015	Sisak	Scientific community (higher education, Research)	15	Croatia, Bosnia and Herzegovina, Italy, Slovenia
80	Organisation of Conference	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Performance testing of honey bee colonies	01/05/2015	Pulawy	Scientific community (higher education, Research)	29	Poland, Lithuania
81	Organisation of Conference	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Performance testing of honey bee colonies	02/05/2015	Belgrade	Scientific community (higher education, Research)	16	Serbia
82	Organisation of Conference	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Performance testing of honey bee colonies	12/05/2015	York	Scientific community (higher education, Research)	21	Great Britain
83	Organisation of Conference	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VER	Performance testing of honey bee colonies	02/04/2015	San Sebastian	Civil society	16	Spain, Portugal, France

		BRAUCHERS CHUTZ						
84	Organisation of Conference	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Performance testing of honey bee colonies	06/04/2016	Skopje	Scientific community (higher education, Research) - Civil society	15	Macedonia, Albania
85	Organisation of Conference	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Performance testing of honey bee colonies	09/04/2015	Nea Moudania	Civil society	10	Greece, Macedonia
86	Oral presentation to a wider public	AGRICULTURAL UNIVERSITY OF ATHENS	Presentation Bee keeping Conference	07/12/2015	Athens	Scientific community (higher education, Research)	300	Greece
87	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Breeding locally adapted bees	03/08/2017	Gormanston, Ireland	Civil society	250	International
88	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Smartbees project: Breeding for varroa mite resistance and preservation of honey bee diversity in Europe	29/09/2016	Orlando/USA	Scientific community (higher education, Research)	60	International
89	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLI	Low Varroa reproduction in European honey bees	09/09/2016	Cluj/Romania	Scientific community (higher education, Research)	120	International

		MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ						
90	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Vorteile regional an gepasster Bienen und deren Kon sequenzen für die Auslese vitaler Bien en in Europa	03/03/2015	Drubeck	Civil society	60	Germany
91	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Un nuovo orizzonte per selezionare api vitali: presentazione del progetto europeo SMARTBEES	05/02/2015	Bologna	Civil society	100	Italy
92	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Breeding Vital European Honey Bees (SMARTBEES project)	05/02/2015	Pulawy	Civil society	120	Poland
93	Oral presentation to a wider public	UNIVERSITA DE GLI STUDI DI UD INE	IL PROGETTO SMARTBEES PER LA SELEZIONE DI API AUTOCTONE TOLLERANTI	11/06/2016	Rome	Scientific com munity (higher edu cation, Research) - Civil society	100	Italy
94	Oral presentation to a wider public	UNIVERSITA DE GLI STUDI DI UD INE	Honey bee, Varroa and virus interac tions and the effect of bee nutrition	06/10/2018	Lazise sul Garda, Verona, Italy	Scientific com munity (higher edu cation, Research) - Civil society	50	Italy
95	Oral presentation to a wider public	UNIVERSITA DE GLI STUDI DI UD	Honey bee, Varroa and virus interac	30/10/2018	Bucharest Romania	Scientific com munity (higher edu	40	Romania

		INE	tions and the effect of bee nutrition			cation, Research) - Civil society		
96	Articles published in the popular press	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	"SmartBees" soll die Bienen retten	09/03/2015	Märkische Allgemeine Zeitung	Medias	1000000	Germany
97	Articles published in the popular press	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	Neurupin: Suche nach robusten Bienen	25/04/2016	Märkische Allgemeine Zeitung	Civil society - Medias	1000000	Germany
98	Articles published in the popular press	AGRICULTURAL UNIVERSITY OF ATHENS	Announcement and information for SMARBEES	09/03/2015	Beekeeping journal "Melissokomiko Vima"	Civil society - Medias	1000000	Greece
99	Interviews	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	Superbienen in der Testwabe	16/07/2015	Die Zeit	Civil society - Medias	1000000	Germany
100	Interviews	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	6 Millionen Euro für Kampf gegen Bienensterben	13/10/2014	Focus	Civil society - Medias	1000000	Germany
101	Interviews	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	GreenSeven-Report 2015 - Bienenalarm	21/06/2015	Pro7 - TV	Civil society - Medias	1000000	Germany
102	Media briefings	UNIVERSIDAD DEL PAIS VASCO/EUSKAL HERRIKO UNIBERTSITATEA	En la elite de la apicultura europea	02/04/2015	Bilbao	Civil society - Medias	1000000	Spain
103	Media briefings	NORGES BIROKTERLAG FORENING	Testvertkurs i Søylands biegard på Store Milde	01/05/2015	Bergen	Civil society - Medias	1000000	Norway
104	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	Pathogen-host interaction of deformed wing virus (DWV) and the honey bee (Apis mellifera)	09/08/2015	International Congress on Invertebrate Pathology and Microbial Control and the 48th Annual Meeting o	Scientific community (higher education, Research)	100	International
105	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENEN	Varroa und DWV	27/11/2015	Heidenheim, Germany	Scientific community (higher edu	100	Germany

		KUNDE HOHEN NEUENDORF EV				cation, Research)		
106	Oral presentation to a wider public	LANDERINSTITUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Neue Ansätze für die Resistenzzucht bei der Honigbiene	28/02/2016	Niedersächsische Züchtertagung	Scientific community (higher education, Research)	70	Germany
107	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Milben-Mehrfachmessungen, Basis für die Züchtung Varroa-resistenter Honigbienen	03/03/2016	AG-Tagung der deutschen Bienen institute	Scientific community (higher education, Research)	250	Germany
108	Oral presentation to a wider public	LANDERINSTITUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	SmartBees - Sustainable breeding strategies for the honeybee	13/03/2016	4th European Bee come Congress	Scientific community (higher education, Research)	300	Sweden
109	Oral presentation to a wider public	LANDERINSTITUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Das EU-Projekt SmartBees - Was haben die europäischen Imker davon?	15/04/2016	Neuruppin	Scientific community (higher education, Research) - Civil society - Medias	40	Germany
110	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Performance testing of honey bees	11/06/2016	Banska Bystrica, Slovakia	Civil society	40	Slovakia
111	Oral presentation to a wider public	LANDERINSTITUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Zusammenhang zwischen Varroa-Parasitierung und DWV-Infektionen	02/07/2016	Klötze	Scientific community (higher education, Research) - Civil society	40	Germany
112	Oral presentation to a scientific event	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Genetic improvement of European honey bee (Apis mellifera L.) populations	08/09/2016	Cluj/Romania	Scientific community (higher education, Research)	100	International

113	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	Pathogen-host interactions between deformed wing virus (DWV) and the honey bee (Apis mellifera).	29/09/2016	XXV International Congress of Entomology Orlando, Florida USA	Scientific community (higher education, Research)	100	International
114	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	Varroa und DWV - Was gibt es Neues?	16/10/2016	Schönwalde, Germany	Scientific community (higher education, Research) - Civil society	150	Germany
115	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Activities for genetic improvement of A. m. mellifera within the SMARTBEES project	22/10/2016	Duurzame Bij Netherlands	Civil society	80	International
116	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Data validation for essential statistical analysis. Smartbees seminar for breeding coordinators	09/11/2016	Malta	Scientific community (higher education, Research)	30	International
117	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Breeding programs and performance testing of honey bee colonies	09/11/2016	Bologna	Civil society	60	Italy
118	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHENNEUENDORF EV	Sustainable Breeding Strategies for the honey bee	24/01/2017	First International Honey Bee Breeding Seminar	Scientific community (higher education, Research)	30	Iran
119	Flyers	HESSISCHES MINISTERIUM FÜR UMWELT, KLI	Establishment of test colony from artificial swarm	01/05/2015	Kirchhain	Civil society	50	International

		MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ						
120	Flyers	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Establishment of test colony from nucleus	01/05/2015	Kirchhain	Civil society	50	International
121	Oral presentation to a scientific event	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Breeding Vital European Honey Bees (SMARTBEES project)	01/03/2015	Kirchhain	Scientific com munity (higher edu cation, Research)	30	Germany
122	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	The SmartBees Project	04/03/2015	Indian Agricultural Research Institute (ICAR), New Del hi, India	Scientific com munity (higher edu cation, Research) - Civil society	30	India
123	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	The SmartBees Project	09/03/2015	National History Museum of Nepal, Kathmandu, Nepal	Scientific com munity (higher edu cation, Research)	30	Nepal
124	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	SmartBees - europäisches Projekt zur Förderung der Bienenzucht	21/03/2015	Züchtertagung des Deutschen Imker bundes, Drübeck, Germany	Civil society	150	Germany
125	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Neue Strategien bei der Krankheitsres istenz - Züchtung der Honigbiene	09/04/2015	Frühjahrstagung der Schweizer Ver einigung für Tir produktion	Scientific com munity (higher edu cation, Research)	100	Switzerland
126	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN	Status and Prospects of Apis cerana	17/09/2015	APIMONDIA, Daejeon, Korea	Scientific com munity (higher edu cation, Research)	200	International

		NEUENDORF EV						
127	Oral presentation to a scientific event	UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II.	The SmartBees Project	10/03/2016	EU Scientific Workshop on Bee Health and Pollination, Parma	Scientific community (higher education, Research) - Policy makers	40	Italy
128	Oral presentation to a scientific event	AGRICULTURAL UNIVERSITY OF ATHENS	Is the possible genetic variability of Varroa destructor associated with this of Apis mellifera?	09/09/2016	Cluj/Romania	Scientific community (higher education, Research)	50	International
129	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Proteomic analysis of hygienic behaviour in Apis mellifera carnica	09/09/2016	Cluj/Romania	Scientific community (higher education, Research)	100	International
130	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Neue Konzepte bei der Krankheitsresistenzzüchtung der Honigbiene	22/09/2016	14. Kongress des Landesverbands Berlin-Brandenburg des Deutschen Vereins zur Förderung des mathemati	Scientific community (higher education, Research)	40	Germany
131	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Neue Zuchtstrategien für die Honigbiene	24/09/2016	37. Tagung des Internationalen Bundes der Sklenarbienenzüchter	Scientific community (higher education, Research)	50	Germany
132	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Aktuelle und zukünftige Methoden der Resistenzzüchtung bei der Honigbiene	18/02/2017	2. Tagung der Ukrainischen Bienenzüchter	Scientific community (higher education, Research)	50	Ukraine
133	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Performance testing and selection of local honey bee populations in Europe	23/02/2017	Lukovica, Slovenia	Scientific community (higher education, Research)	80	Slovenia
134	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN	Varroa und DWV	04/03/2017	Celle,Germany	Scientific community (higher education, Research)	120	Germany

		NEUENDORF EV						
135	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Erste Ergebnisse einer Simulationsstudie über die Langzeiteffekte ausgewählter Zuchtprogramme bei der Honigbiene	15/03/2017	64. Jahrestagung der Arbeitsgemeinschaft der Institute für Bienenforschung; Celle	Scientific community (higher education, Research)	250	Germany
136	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Die Gefährlichkeit von DWV	26/03/2017	Schönwalde, Germany	Scientific community (higher education, Research) - Civil society	120	Germany
137	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Warum ist der Erhalt der Biodiversität so wichtig für die Honigbiene?	31/03/2017	Züchtertagung des Deutschen Imkerbundes	Scientific community (higher education, Research) - Civil society	100	Germany
138	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Varroa und DWV	02/04/2017	Biberach, Germany	Scientific community (higher education, Research) - Civil society	180	Germany
139	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Estimating regional Varroa threshold levels across Europe	06/04/2017	Avignon, France	Scientific community (higher education, Research)	40	International
140	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Sustainable breeding strategies for the honey bee	14/06/2017	Convention International Agro-Forestal	Scientific community (higher education, Research) - Civil society	100	Cuba
141	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	The Basic Concept of Honey Bee Breeding Programs	28/07/2017	Pulawy, Poland	Scientific community (higher education, Research) - Civil society	20	International

142	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Was hat die Imkerschaft von dem Projekt SmartBees?	28/07/2017	Kreisimkerversammlung Passau	Scientific community (higher education, Research) - Civil society	100	Germany
143	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Zuchtwerte und was zu tun ist, damit sie realistisch sind	26/08/2017	ACA Tagung	Scientific community (higher education, Research)	200	Austra
144	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	BeeBreed Arbeit im Jahreslauf	26/08/2017	ACA Tagung	Scientific community (higher education, Research)	200	Austria
145	Oral presentation to a scientific event	AGRICULTURAL UNIVERSITY OF ATHENS	Molecular investigation of the genetic diversity of local honey bee Apis mellifera L. (Hymenoptera: Apidae) populations in Greece	01/09/2017	Athens	Scientific community (higher education, Research)	300	Greece
146	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Vergleich von Infinitesimalmodell und Finite-Locus-Modellen in maternale Effekte berücksichtigenden Simulationsstudien zum Selektionserfolg bei Honigbienen	21/09/2017	Vortragstagung der DGfZ und GfT, Stuttgart	Scientific community (higher education, Research)	30	Germany
147	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Strategien zur Verbesserung der Zuchtwertschätzung für die Honigbiene	21/09/2017	Vortragstagung der DGfZ und GfT, Stuttgart	Scientific community (higher education, Research)	30	Germany
148	Oral presentation to a scientific event	AGRICULTURAL UNIVERSITY OF ATHENS	Honey bee conservation areas in Europe.	30/09/2017	Istanbul	Scientific community (higher education, Research)	200	Turkey
149	Oral presentation to a scientific event	AGRICULTURAL UNIVERSITY OF ATHENS	Round Table “ Conservation of local bees and genetic pollution"	30/09/2017	Istanbul	Scientific community (higher education, Research)	70	Turkey
150	Oral presentation to	NORGES BIROK	Initiating breeding	02/10/2017	Istanbul	Scientific com	200	International

	a scientific event	TERLAG FOREN ING	programs for genetic improvement and preservation of European honey bee populations			munity (higher edu cation, Research) - Civil society		
151	Oral presentation to a wider public	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Genetik der Ein-Drohn-Besamung	04/11/2017	Arbeitstagung der Züchter des D.I.B.	Scientific com munity (higher edu cation, Research)	250	Germany
152	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Neue Möglichkeiten in BeeBreed bei künstlicher Bes amung	04/11/2017	Arbeitstagung der Züchter des D.I.B.	Scientific com munity (higher edu cation, Research) - Civil society	250	Germany
153	Oral presentation to a wider public	HESSISCHES MIN ISTERIUM FÜR UMWELT, KLI MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Balancing Conflict ing Needs - A case study in the Conser vation of the Endem ic honeybee Apis mellifera ruttneri	18/11/2017	Malta	Scientific com munity (higher edu cation, Research)	80	Malta
154	Oral presentation to a scientific event	NORGES BIROK TERLAG FOREN ING	The SmartBees Pro gress	25/01/2018	Nordic-Baltic Bee Research Symposi um, Riga, Latvia	Scientific com munity (higher edu cation, Research)	80	International
155	Oral presentation to a scientific event	AGENCE NA TIONALE DE SE CURITE SANITAIRE DE L'ALIMENTATIO N, DE L'ENVIRONNEME NT ET DU TRAV AIL	Europe-wide di versity of deformed wing virus variants	08/02/2018	Warsaw (COLOSS)	Scientific com munity (higher edu cation, Research)	15	International
156	Oral presentation to a wider public	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Varroa, DWV und Bienenverluste	02/03/2018	Falkenhagen, Ger many	Civil society	80	Germany
157	Oral presentation to a wider public	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Zucht langfristig gedacht – Welche Antworten können Computersimula tionen geben?	03/03/2018	Züchtertagung der GdeB	Scientific com munity (higher edu cation, Research)	100	Germany

158	Oral presentation to a wider public	UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II.	SmartBees: Ergebnisse aus dem Länderinstitut für Bienenkunde Hohen Neuendorf.	17/03/2018	Zell am Hamersbach	Scientific community (higher education, Research)	70	Germany
159	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Das Infinitesimalmodell und Finite-Locus-Modelle in Simulationsstudien zur langfristigen Selektion bei Honigbienen	21/03/2018	AG-Tagung der deutschen Bieneninstitute	Scientific community (higher education, Research)	200	Germany
160	Oral presentation to a scientific event	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	The EU project Smartbees initiates sustainable breeding for endangered honeybee subspecies.	22/05/2018	Shanghai (China)	Scientific community (higher education, Research)	100	International
161	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Local breeding programs in practice	26/05/2018	Copenhagen	Civil society	30	Denmark
162	Oral presentation to a scientific event	NORGES BIROKTERLAG FORENING	Varroa Resistance Traits - New Findings on the biological Background	26/05/2018	Copenhagen	Scientific community (higher education, Research)	30	Denmark
163	Oral presentation to a scientific event	NORGES BIROKTERLAG FORENING	Smartbees - project overview	27/05/2018	Smartbees regional workshop, copenhagen	Scientific community (higher education, Research)	15	International
164	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Local breeding programs in practice	09/06/2018	Athens	Civil society	25	Greece
165	Oral presentation to	LANDERINSTI	Simulation studies	09/06/2018	Athens	Civil society	25	Greece

	a wider public	TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	for breeding of en dangered honeybee subspecies					
166	Oral presentation to a wider public	AGRICULTURAL UNIVERSITY OF ATHENS	Round Table “ Con servation of local bees and genetic pol lution"	09/06/2018	Athens	Civil society	25	Greece
167	Oral presentation to a wider public	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Conserving genetic diversity in the hon eybee	29/06/2018	Rome	Scientific com munity (higher edu cation, Research) - Policy makers	150	Italy
168	Oral presentation to a scientific event	NORGES BIROK TERLAG FOREN ING	SMARTBEES ? Sustainable manage ment of resilient bee populations - main results	13/07/2018	SICAMM confer ence, Mustiala, Fin land	Scientific com munity (higher edu cation, Research)	70	International
169	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Sustainable breeding strategies using BLUP in the honey bee.	27/08/2018	Antalya, Turkey	Scientific com munity (higher edu cation, Research)	100	Turkey
170	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Simulationsstudien zur Bedeutung der sicheren Anpaarung in der Honigbienen zucht	12/09/2018	Vortragstagung der DGfZ und GfT, Bonn	Scientific com munity (higher edu cation, Research)	50	Germany
171	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Genetic models for long-term simula tion studies in hon eybee breeding	18/09/2018	Ghent (Belgium); EurBee-conference	Scientific com munity (higher edu cation, Research)	50	International
172	Oral presentation to a wider public	AGENCE NA TIONALE DE SE CURITE SANITAIRE DE L'ALIMENTATIO N, DE L'ENVIRONNEME NT ET DU TRAV AIL	Europe-wide di versity of deformed wing virus variants	19/09/2018	Ghent (Belgium); EurBee-conference	Scientific com munity (higher edu cation, Research)	60	International
173	Oral presentation to a wider public	UNIVERSITA DE GLI STUDI DI NA POLI FEDERICO II.	Nachhaltige Bienen haltung durch Zucht und Erhalt der genet ischen Vielfalt bei	22/09/2018	Goldbrunnhof (Österreich)	Scientific com munity (higher edu cation, Research)	150	Austria

			der Carnica.					
174	Oral presentation to a wider public	HESSISCHES MINISTERIUM FÜR UMWELT, KLIMASCHUTZ, LAND WIRTSCHAFT UND VERBRAUCHERSCHUTZ	Local breeding programs in practice: Including Integrated Pest Management and Disease Threshold	25/09/2018	York	Scientific community (higher education, Research)	30	Great Britain
175	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Varroa Resistance Traits - New Findings on the biological Background	25/09/2018	York	Scientific community (higher education, Research)	20	Great Britain
176	Oral presentation to a wider public	AGENCE NATIONALE DE SECURITE SANITAIRE DE L'ALIMENTATION, DE L'ENVIRONNEMENT ET DU TRAVAIL	Europe-wide diversity of deformed wing virus variants	02/10/2018	Sophia-Antipolis (LRUE annual workshop)	Scientific community (higher education, Research)	30	France
177	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Varroa resistance traits – Actual status and future tends	06/10/2018	Lazise (Italy)	Scientific community (higher education, Research)	40	Italy
178	Oral presentation to a wider public	AGENCE NATIONALE DE SECURITE SANITAIRE DE L'ALIMENTATION, DE L'ENVIRONNEMENT ET DU TRAVAIL	Diversité des virus des ailes déformées (Deformed wing virus) en Europe	12/10/2018	Nantes (Journées vétérinaire apicoles)	Scientific community (higher education, Research)	40	France
179	Oral presentation to a wider public	LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV	Sustainable breeding and conservation strategies for native honeybees	13/10/2018	Bucharest Romania	Scientific community (higher education, Research)	50	Romania
180	Oral presentation to a scientific event	HESSISCHES MINISTERIUM FÜR UMWELT, KLI	Local breeding programs in practice: Including Integrated	20/10/2018	SMARTBEES conference, Görlitz	Scientific community (higher education, Research)	220	Germany, Poland

		MASCHUTZ, LAND WIRTSCHAFT UND VER BRAUCHERS CHUTZ	Pest Management and Disease Threshold					
181	Oral presentation to a scientific event	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Ein Überblick über das Smartbees-Pro jekt und Ergebnisse bezüglich des Ein satzes neuer, nach haltiger Zucht strategien.	20/10/2018	SMARTBEES con ference, Görlitz	Scientific com munity (higher edu cation, Research)	200	Germany, Poland
182	Oral presentation to a wider public	LANDERINSTI TUT FUR BIENEN KUNDE HOHEN NEUENDORF EV	Overview of Smart bees project & Cur rent strategies for sustainable breeding and conservation of endangered honey bee subspecies	06/10/2018	Lazise (Italy)	Scientific com munity (higher edu cation, Research)	40	Italy

Section B (Confidential or public: confidential information marked clearly)

LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS,UTILITY MODELS, ETC.					
Type of IP Rights	Confidential	Foreseen embargo date dd/ mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant(s) (as on the applica tion)
Others	No		Romanian Office for Author ship rights - ht tp://www.orda.ro/	DVD - Queen rearing in in tensive system	Institutul de Cercetare Dezvol tare pentru Apicultura
Others	No		DOI 10.5682/9786062806491	BOOK-Manual de in samantare instrumentala la al bine (Apis mellifera)(The Handbook for instrumental in semina-tion in honeybees ?A. mellifera)	Institutul de Cercetare Dezvol tare pentru Apicul-tura

OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND								
Type of Exploitable Foreground	Description of Exploitable Foreground	Confidential	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable for commercial use or any other use	Patents or other IPR exploitation (licences)	Owner and Other Beneficiary(s) involved
General advancement of knowledge	INGREDIENT FOR SUPPLEMENTARY NUTRITION	No		SUPPLEMENTARY FOOD FOR HONEY-BEES	BEEKEEPING	NOT YET SPECIFIABLE	no	DIPARTIMENTO DI SCIENZE AGROALIMENTARI, AMBIENTALI E ANIMALI, UNIVERSITÀ DEGLI STUDI DI UDINE
General advancement of knowledge	MARKER OF HEALTH	No		DIAGNOSTIC KIT	VETERINARIAN OR BEEKEEPING	NOT YET SPECIFIABLE	no	DIPARTIMENTO DI SCIENZE AGROALIMENTARI, AMBIENTALI E ANIMALI, UNIVERSITÀ DEGLI STUDI DI UDINE

ADDITIONAL TEMPLATE B2: OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND	
Description of Exploitable Foreground	Explain of the Exploitable Foreground
INGREDIENT FOR SUPPLEMENTARY NUTRITION	Exploitable product: SUPPLEMENTARY FOOD FOR HONEYBEES, Sector of application: BEEKEEPING Our studies on the mitigation of the detrimental effects of parasitic infestation on bees, by means of pollen, and, in particular, the chemical work already started, could lead to the identification of some active principles that could be exploited as possible ingredients of supplementary food to be provided to bees when the infestation level is higher.
MARKER OF HEALTH	Exploitable product: DIAGNOSTIC KIT, Sectors of application: VETERINARIAN OR BEEKEEPING Our studies on the transcriptional signatures of parasitic infestations in bees allowed us to identify a number of genes that are affected in case of such a biotic stress. The proteic products of the genes that more reliably react to parasitic infestations could be used as markers of stress of bee colonies and exploited as monitoring tools to guide control interventions.

4.3 Report on societal implications

B. Ethics

1. Did your project undergo an Ethics Review (and/or Screening)?	No
If Yes: have you described the progress of compliance with the relevant Ethics Review/ Screening Requirements in the frame of the periodic/final reports?	

2. Please indicate whether your project involved any of the following issues :

RESEARCH ON HUMANS

Did the project involve children?	No
Did the project involve patients?	No
Did the project involve persons not able to consent?	No
Did the project involve adult healthy volun teers?	No
Did the project involve Human genetic materi al?	No
Did the project involve Human biological samples?	No
Did the project involve Human data collec tion?	No

RESEARCH ON HUMAN EMBRYO/FOETUS

Did the project involve Human Embryos?	No
Did the project involve Human Foetal Tissue / Cells?	No
Did the project involve Human Embryonic Stem Cells (hESCs)?	No
Did the project on human Embryonic Stem Cells involve cells in culture?	No
Did the project on human Embryonic Stem Cells involve the derivation of cells from Em bryos?	No

PRIVACY

Did the project involve processing of genetic information or personal data (eg. health, sexu al lifestyle, ethnicity, political opinion, reli gious or philosophical conviction)?	No
Did the project involve tracking the location or observation of people?	No

RESEARCH ON ANIMALS

Did the project involve research on animals?	Yes
Were those animals transgenic small laboratory animals?	No
Were those animals transgenic farm animals?	No
Were those animals cloned farm animals?	No
Were those animals non-human primates?	No

RESEARCH INVOLVING DEVELOPING COUNTRIES

Did the project involve the use of local resources (genetic, animal, plant etc)?	Yes
Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	Yes

DUAL USE

Research having direct military use	No
Research having potential for terrorist abuse	No

C. Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	0	1
Work package leaders	2	8
Experienced researchers (i.e. PhD holders)	10	20
PhD student	5	5
Other	14	14

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	16
Of which, indicate the number of men:	8

D. Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project ?	Yes

6. Which of the following actions did you carry out and how effective were they?	
Design and implement an equal opportunity policy	Effective
Set targets to achieve a gender balance in the workforce	Almost effective
Organise conferences and workshops on gender	Not Applicable
Actions to improve work-life balance	Not Applicable
Other:	Followed institution’s gender equality policy

7. Was there a gender dimension associated with the research content - i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in tri als, was the issue of gender considered and ad dressed?	No
If yes, please specify:	

E. Synergies with Science Education

8. Did your project involve working with stu dents and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?	Yes
If yes, please specify:	Open days for students; Internship bachelor stu dent; students participated in the research in the form of internships, or for the preparation of their bache-lor/master thesis; Involved in public en gagement EXPLORATHON (EU-funded) for 3 years;

9. Did the project generate any science educa tion material (e.g. kits, websites, explanatory booklets, DVDs)?	Yes
If yes, please specify:	Queen rearing in an intensive system; Videos presenting some main result; materials on the webpage, method sheets for performance testing, online toolkit for extension; protocol for honey bee breeding; development of three DNA geno typing kits for honeybees; Website, newsletter, DVD

F. Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

Main discipline:	4.1 Agriculture, forestry, fisheries and allied sci ences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)
Associated discipline:	1.5 Biological sciences (biology, botany, bacteri ology, microbiology, zoology, entomology, genet ics, biochemistry, biophysics, other allied sci ences, excluding clinical and veterinary sciences)
Associated discipline:	4.2 Veterinary medicine

G. Engaging with Civil society and policy makers

11a. Did your project engage with societal act ors beyond the research community? (if 'No', go to Question 14)	Yes
11b. If yes, did you engage with citizens (citizens' panels / juries) or organised civil so ciety (NGOs, patients' groups etc.)?	No
11c. In doing so, did your project involve act ors whose role is mainly to organise the dia logue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	
12. Did you engage with government / public bodies or policy makers (including interna tional organisations)	Yes, in communicating /disseminating / using the results of the project
13a. Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?	Yes - as a secondary objective (please indicate areas below - multiple answer possible)
13b. If Yes, in which fields?	
Agriculture	Yes
Audiovisual and Media	No
Budget	No
Competition	No
Consumers	No
Culture	No
Customs	No
Development Economic and Monetary Affairs	No
Education, Training, Youth	Yes
Employment and Social Affairs	No
Energy	No
Enlargement	No
Enterprise	No
Environment	Yes

External Relations	No
External Trade	No
Fisheries and Maritime Affairs	No
Food Safety	Yes
Foreign and Security Policy	No
Fraud	No
Humanitarian aid	No
Human rightsd	No
Information Society	No
Institutional affairs	No
Internal Market	No
Justice, freedom and security	No
Public Health	No
Regional Policy	No
Research and Innovation	Yes
Space	No
Taxation	No
Transport	No
13c. If Yes, at which level?	International level

H. Use and dissemination

14. How many Articles were published/accep ted for publication in peer-reviewed journals?	21
To how many of these is open access provided?	12
How many of these are published in open ac cess journals?	1
How many of these are published in open re positories?	0
To how many of these is open access not provided?	3
Please check all applicable reasons for not providing open access:	
publisher's licensing agreement would not per mit publishing in a repository	No
no suitable repository available	No
no suitable open access journal available	Yes
no funds available to publish in an open access journal	No
lack of time and resources	Yes

lack of information on open access	No
If other - please specify	
15. How many new patent applications ('priority filings') have been made? ("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).	0

16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	
Trademark	0
Registered design	0
Other	2

17. How many spin-off companies were created / are planned as a direct result of the project?	0
Indicate the approximate number of additional jobs in these companies:	1

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:	Increase in employment, In small and medium-sized enterprises

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (FTE = one person working fulltime for a year) jobs:	0Difficult to estimate / not possible to quantify

I. Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?	Yes

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?	No

22. Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?	
Press Release	Yes
Media briefing	No
TV coverage / report	Yes
Radio coverage / report	Yes
Brochures /posters / flyers	Yes
DVD /Film /Multimedia	Yes

Coverage in specialist press	Yes
Coverage in general (non-specialist) press	Yes
Coverage in national press	Yes
Coverage in international press	Yes
Website for the general public / internet	Yes
Event targeting general public (festival, con ference, exhibition, science café)	Yes

23. In which languages are the information products for the general public produced?	
Language of the coordinator	Yes
Other language(s)	Yes
English	Yes

Attachments	Logo_SMB_high.jpg, SMARTBEES publications.pdf, SMARTBEES Final Report.pdf
Grant Agreement number:	613960
Project acronym:	SmartBees
Project title:	Sustainable Management of Resilient Bee populations
Funding Scheme:	FP7-CP-TP
Project starting date:	01/11/2014
Project end date:	31/10/2018
Name of the scientific representative of the project's coordinator and organisation:	Prof. Kaspar Bienefeld LANDERINSTITUT FUR BIENENKUNDE HOHEN NEUENDORF EV
Name	
Date	28/12/2018

This declaration was visaed electronically by Ursula WIRTZ (ECAS user name nwirtzur) on 28/12/2018