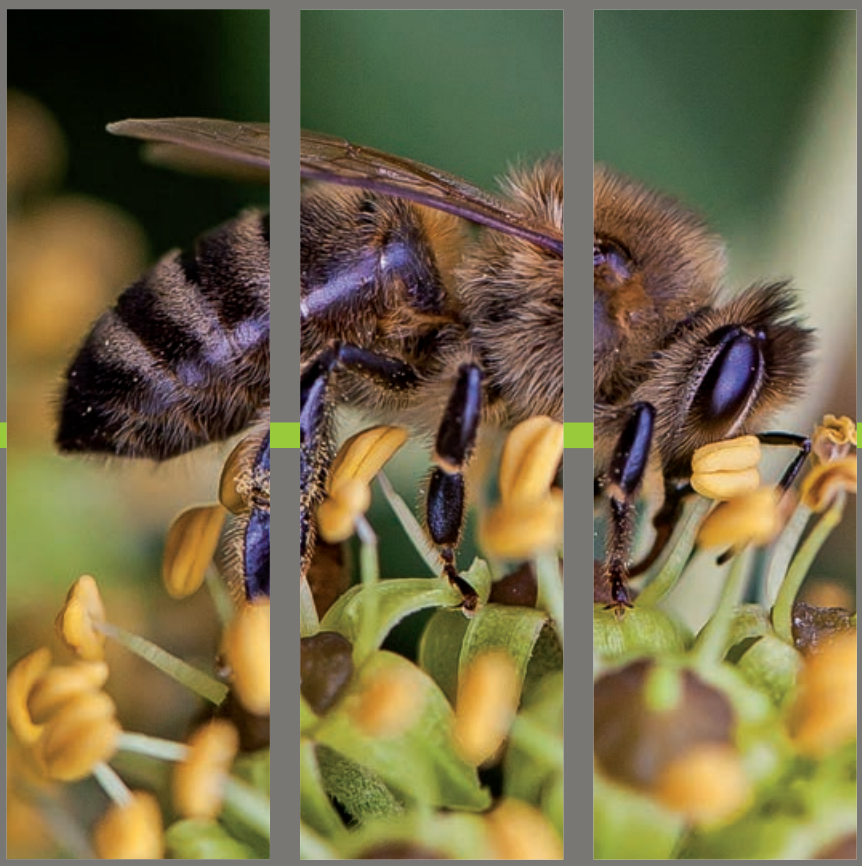

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Expert Forum Bees and Agriculture

Researching synergies, developing solutions

Research Strategy of the German Agricultural Research Alliance

Imprint

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Researching synergies, developing solutions
Research strategy of the German Agricultural Research Alliance

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Contents

Brief overview

Large parts of the society are occupied by the relationship between bees and agriculture. The DAFA Expert Forum Bees and Agriculture has therefore created a strategy to provide scientific recommendations to actors in politics, research funding and economics concerning ways in which the conditions can be improved for honeybees and wild bees and the interactions between bees, beekeeping and agriculture. This should contribute towards maintaining biodiversity, improving yields through optimised pollination performance, and to resilience of the agricultural systems and agricultural ecosystems.

The recommendations include amongst others the results of two workshops with around 150 participants from agriculture, beekeeping, nature protection, administration, science and politics. During these events, the current and target situations were compared, and paths and research requirements were discussed for synergistic cooperation between bees and agriculture. This led to the formation of the scientific steering group of the expert forum Bees and Agriculture.

Fields of research

The strategy expresses three central fields of research. Here, the vitality of the wild and honeybees is top priority because they can only fulfil their role in the agricultural ecosystem and apiculture if they are healthy and productive. The second area of research is dedicated to the question of how the landscape structure and the types of use and agriculture influence the abundance, diversity and vitality of the bees. The third research area concerns the interactions between agriculture, landscape and bees. These together give rise to the following primary research tasks:

1 Promoting vitality (health, performance, bee fitness)

- Develop new methods for the recording and treatment of diseases in the field and in the laboratory
- Create concepts for the promotion of wild bee habitats and food sources for wild and honeybees
- Further develop analytical methods for evaluating the effect of plant protectants on honeybees and wild bees, taking into consideration the application techniques

2 Developing agricultural landscapes and cropping systems of the future

- Create practically-oriented improvements in the feeding and living conditions for bees (nesting habitats, food plants)
- Design bee-friendly crop production systems using innovative technologies
- Raise the economic threshold for the use of plant protectants through technical and agro-ecological innovations
- Regenerate agricultural landscapes in model regions to be bee promoting, and investigate the effect of measures at the landscape level

3 Understanding the interactions between agricultural practices and bees and other pollinators, achieving synergies

- Develop the level of knowledge concerning the interactions between agriculture, landscape and bees, and in doing so improve the preconditions for synergies (Fig. 1)
- Develop training concepts for government veterinarians, plant protectant advisors, farmers and beekeepers on the topic area “bees and agriculture”
- Harmonise the official veterinary practices for fighting bee epidemics throughout the country
- Develop and validate the indicators for goal-oriented remuneration approaches for the promotion of pollinator insects in agri-environmental programmes

Research structures and communication

Basic and applied research should be designed synergistically and incorporate laboratory, semi-field and field trials. The latter should at the same time be designed at the landscape, farmland and regional level, and also include the establishment of model regions. Research projects should enable the existing structures and experts to network with each another and with those working in the field, and in this way, continuously integrate the scientific and the practically-oriented knowledge.

Suitable and sufficiently flexible forms of financing should be found for projects with time-demanding topics and/or large project groups. The design and testing of sustainability on a landscape scale, its scientific evaluation and the transfer of findings are new challenges for the scientific community and should be supported through new forms of research funding.

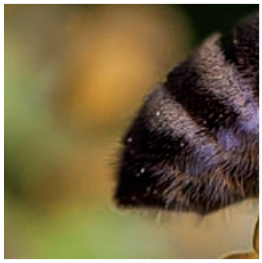
Currently, new findings concerning bee health currently must be disseminated to many different institutions, organisations and individuals. Therefore, a central platform for data, knowledge and communication management should be created.

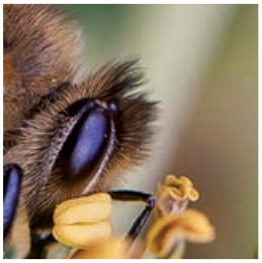
Political leadership

Competition in the market economy implies that farmers can generally not afford to align their production systems “economically sub-optimally” by providing unpaid services for the common good. In this respect, politics is facing the challenge of developing the agricultural and regulatory frameworks in such a way that bee-promoting activities are in the business interest of the farmers, or at least do not represent a competitive disadvantage. To this end, suitable measures must be developed, which are legally controllable with justifiable effort, regionally manageable and crop-specific and minimise possible conflicts of aims with those of other agricultural policies.

Further information on the Expert Forum Bees and Agriculture can be found in German on the DAFA website:
www.dafa.de/foren/fachforum-bienen-und-landwirtschaft/

1 Problem description and aim of the strategy





Given the area of conflict between bees and agriculture, DAFA is targeting a very topical issue, which is represented by the very different ways in which the two sides are assessed. On the one hand, society's appreciation of intensive agriculture has decreased in recent years with the increasing criticism of agricultural practices. On the other hand, bees are receiving more attention than ever before thanks to the controversy regarding the threat to bee populations. During the in part emotional debates, the interests of agriculture, beekeeping and nature conservation are presented as conflictive, despite there being common fundamental interests.

The aim of the DAFA Expert Forum Bees and Agriculture is therefore to create a scientific basis to enable the actors in politics, research funding and economics to bring about **improved conditions for bees and synergistic interactions between bees and agriculture**, taking into consideration the entire agricultural landscape. This should contribute to maintaining biodiversity and improving the conditions for honeybees and wild bees, as well as for apiculture. At the same time, optimisation of pollinator capacity can increase the resilience of the agricultural ecosystems and production systems and lead to an overall improvement in yields. In the following, the term "bees" is used to refer to both honeybees and the multitude of wild bee species (including solitary bee and bumblebee species) to the same extent.

As the basis for the strategy presented here, the complex ecological, agronomic and social relationships were subjected to multidisciplinary analysis and the weak points and knowledge gaps were identified. Building on this, fields of research are identified within the strategy, which range from basic research to application- and realisation-oriented questions.

The overriding aim of the strategy, however, stretches far beyond proposals for research funding. The long term goal is to achieve substantial impacts for diversity-promoting and sustainable agriculture, as well as sustainable regeneration of the entire agricultural landscape. This can only succeed if all the actors are brought on-board. The strategy, therefore, specifically addresses farmers, professional and hobby beekeepers, nature conservationist, NGOs, citizens and the public in general, specialist advisors and scientists. Recommendations to political decision-makers complete the strategy, with the aim of improving the framework conditions for the synergistic cooperation between bees and agriculture. It is evident that measures to promote bees and biodiversity in the agricultural landscape also have positive effects for other pollinating insects.

2 Fields of research



2.1 Key goals

Only vigorous honeybees and wild bees can fulfil their roles in the ecosystem. Therefore, the health aspect is top priority in the research strategy. Landscape structures and the type of land use and its management also influence the abundance, diversity and vitality of the bees. The use of plant protectants in particular can have a considerable influence on the vitally and health at the level of the individual bee, the colony or even at the population level, depending on the active substance and exposure (type, duration and degree of exposure). Monitoring the influence of plant protectants, risk minimisation during the use of plant protection products and their interactions with other stress factors are, therefore, also very important. In the medium-term, the development of management forms not requiring the use of plant protectants are extremely desirable and to be aspired to in both conventional and organic agriculture. This is the second main area of the fields of research. As the third research aspect, we consider the interactions between agriculture, landscape and bees. These together give rise to the following research targets:

1 Promoting vitality (health, performance, bee fitness)

The focus here is to increase vitality and health. This means fighting diseases to improve the performance of the pollinators and apiculture production. The environmental requirements for honeybees and wild bees are considered together, i.e. bees should be better protected and cared for, particularly habitats for wild bees should be created and improved, the decline in species should be halted, and populations and their distribution should be promoted. Whether and to what extent the honeybee is suitable as a representative organism for other bees must be determined. For this purpose, the differences in ecological and toxicological sensitivity and exposure to plant protectants must be assessed for a variety of wild bee species, and realistic scenarios and effects must be examined at the level of individuals and populations. An important component of the research design is the development of new indicators for recording population densities, as well as their functionality and vitality, in order to improve the measurement of the influencing factors.

2 Developing agricultural landscapes and agriculture systems of the future

Agriculture in general, grassland farming, horticulture, fruit, vine and special crop cultivation, as well as new cultivation systems and forms of landscape management should be developed with the aim of creating improved foraging and living conditions for bees. In this way, the strategy contributes to a fundamental reconceptualisation of agricultural ecosystems, thereby guaranteeing sustainable, environmentally responsible and diversity maintaining food production through the preservation of economically acceptable framework conditions for agriculture. The proposed solutions should include interfaces for **agricultural, ecological and beekeeping research** and follow a practical approach.

3 Understanding the interactions between agricultural practices and bees and other pollinators, achieving synergies

Besides knowledge of the core elements of the strategy, i.e. bees and landscape, information about the interactions between agriculture, landscape and bees are prerequisites for achieving synergies (Fig.1).

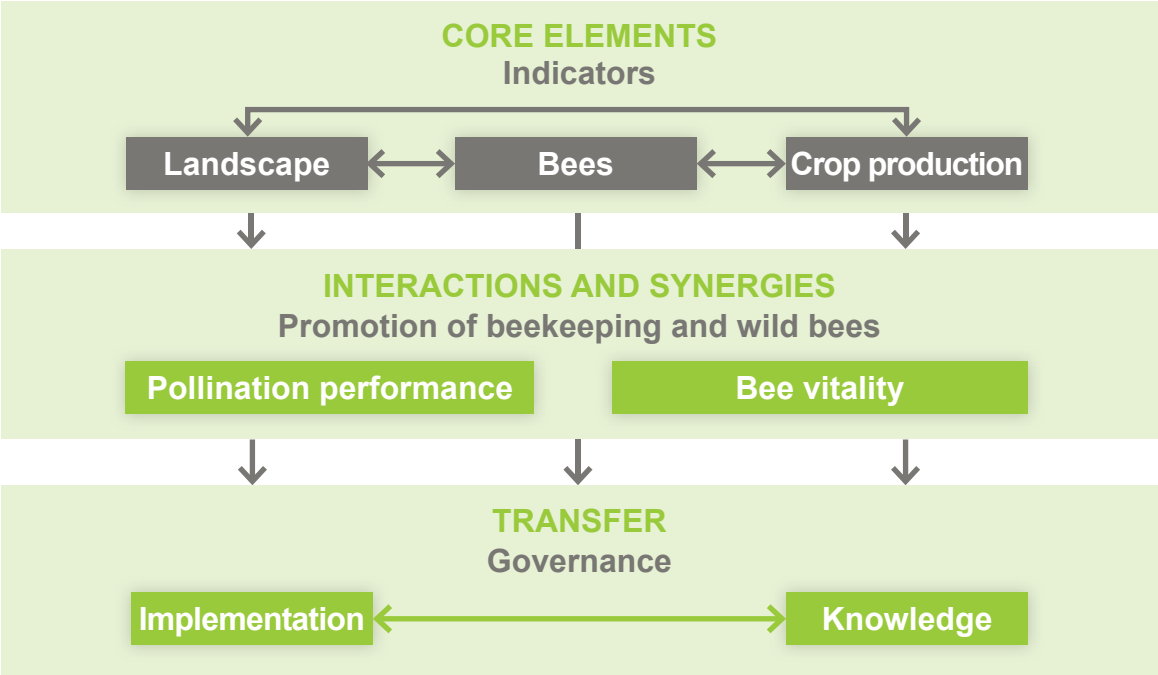


Figure 1: Elements and structure of the DAFA Strategy Bees and Agriculture.

2.2 Promoting vitality (health, performance, bee fitness)

We recommend that a holistic health management system for honeybees be designed at the federal state level – if possible with agreement among the federal states – based on the health management systems of the veterinary authorities and bee institutes, and involving apiculture associations and other officials. Where possible, disease transmission between honey bees and wild bees should be considered and appropriate preventative measures developed.

2.2.1 Indicators — identification and development

To measure the success of the work on promoting bees, in addition to recording the population, it is especially important to assess the vitality and fitness of the individual bees, at the colony level (for social species), through to the population level.

The known, classical vitality parameters that have been compiled up to now for honeybees do not represent the state of science and technology. There is an urgent need for refined indicators both for honeybees and wild bees. While for honeybees, some parameters can be recorded with relatively high reliability, the scaling and measurement accuracy are, however, insufficient, and continuous measurement series are only possible to a very limited extent. There are no such evaluation methods available for wild bees. Based on the new indicators, improved evaluation of vitality would be possible, and also improved success monitoring. There are promising new technological developments which can be used for collecting data concerning bee vitality.

2.2.2 Parasites and diseases

Parasites and diseases reduce the vitality, productivity and fitness of honeybees and wild bees. For this reason, improvement in the prevention of diseases and transmissions must

continue. Likewise, improvement in control and preventative measures must be enhanced. Meanwhile, the special interactions between the different types of bees are still largely unresearched. Thanks to previous workshops of the expert forum, the steering group of the DAFA Expert Forum Bees and Agriculture has identified the following important areas:

- Research into parasite and disease (viruses, fungi and bacteria) transmission pathways between and within different origins / breeding lines of honeybees (also with spatial consideration: urban and rural and the two-way influence)
- Examination of diseases and transmission pathways within wild bee populations and options for increasing resilience
- Faster and more reliable diagnostic procedures in the field and in the laboratory (e. g. for viruses and *Nosema* spp.) for early recognition and characterisation of vitality. This should incorporate validated biomarkers, the development of new point-of-care test systems for screening and simple field diagnostics for vitality and pathogens, and could be connected well with citizen science monitoring projects through digitalisation
- Science-based establishment of treatment thresholds for bees
- Development of healing and control measures for diseases, e. g. through the development of new, approvable active substances and the characterisation of new molecular targets in honeybees and pathogens, investigations into the use of new nucleic-acid-based therapies
- Breeding of more resistant and vital honeybees
- Research into the influence of commercially released wild bees (e. g. mason bees and bumblebees) and local wild bee populations

2.2.3 Plant protectants and other abiotic and biotic stress factors

Beside parasites and diseases, the vitality of bees is also compromised by plant protectants, the lack of foraging opportunities, extreme weather conditions, and, as far as honeybees are concerned, through inappropriate husbandry. The direct effects of these stress factors are generally known. The effects of long-term and low-threshold influences, especially in mutual combination and particularly the interactions with plant protectants are complex, however, and therefore remain largely unresearched, especially in wild bees. For this reason, the following topics need to be addressed urgently:

- Research into the sublethal effects of multifactoral stressors (pathogens, food, plant protectants, varroacides, biocides) on bee vitality
- Evaluation of the sublethal, chronic and acute toxic effects of active substances in plant protectants on larvae and imagos
- Research into the medium- and long-term sublethal effects on bee colonies and wild

bee populations of short-term acute stress factors, especially insecticides

- Examination of the additive or synergistic effects of active substances and preparations in tank mixtures or short interval applications on the health of honey bees and wild bees. Here, their specific lifestyle, all the developmental stages and their functional aspects, such as homing instinct and pairing behaviour should be considered.

These investigations are very involved due to the number of possible stressor combinations (e.g. plant protectants, veterinary drugs, feed, residues of environmentally harmful substances, husbandry conditions). For this reason, it seems sensible to split the examinations into groups and coordinate them well.

Method-based analyses are also required to complement them, as it is unclear how well the investigation results from individual bees can be applied to bee colonies or wild bee populations. By implementing digital measurement systems and new technological procedures, it is also possible to precisely record sublethal and lethal effects on adult bees and bee larvae, taking into consideration short-, medium and long-term effects. To use the research funding wisely, these method-based analyses should be funded in a targeted manner right from the start of a programme.

2.2.4 Habitat requirements

The causes of the threat to numerous wild bee species are primarily the loss of suitable habitats (nesting places and materials, specific food plants), and the direct and indirect effects of insecticides and herbicides on the bee populations. Changing agricultural production systems aiming at more intensive forms of use, the expansion of settlement areas, transport pathways and industrial facilities have led to a significant loss in suitable habitats.

The state of the knowledge regarding resource use by honeybees and wild bees and the effects of stock development and vitality is currently very incomplete. Furthermore, both, recording the genetic diversity in wild bee populations and if necessary, measures to increase diversity are required. Knowledge is lacking in:

- Species-specific nectar and pollen quality of cultivated and wild plants for honeybees and wild bees
- Competition for food between honeybees and wild bees at different food sources, species-specific preferences and configurations of agricultural landscapes
- Effects of the landscape composition on the vitality of honeybees and wild bees (habitats, nesting places and food resources, foraging patterns, genetic exchange, stressors, management)

2.3 Developing agricultural landscapes and culture systems of the future

Multifaceted interaction exists between bees and agriculture, which can be further developed for greater mutual benefit. For bees, the priority here is

1. an improved supply of diverse pollen and nectar plants, and
2. the creation of suitable habitat structures for building nests and overwintering.

Suitable measures for improving the situation for bees can be integrated into plant cultivation, for example through expansion of crop rotations, mixed crop cultivation, integrated or organic forms of farming without herbicides or insecticides, and the integration of non-productive field areas, like self-greening fallows. Parallel to these, measures for the creation of new habitat structures are required to stop the decline in bee diversity in agricultural areas. A landscape-based research approach is urgently required to achieve the spatial complementarity of different habitat elements, and the configuration of the landscape for optimisation of the networking and provision of ecological services. From the farming point of view, the pollination activities of the bees are priority, which can be improved through spatially and temporally coordinated direct or indirect management of the pollinator population. For this reason, the following topics need to be addressed urgently:

- Use of the crop cultivation potential for improvement of the resource supply for honeybees and wild bees.
- Spatial assessment of gaps in the current pollinator diversity compared to their potential diversity in an environment
- Spatial prioritisation and objectives of agri-environmental measures
- Examination of pollinator dependency, diversity-function relationships and variety differences for annual and perennial cultivated plants
- Landscape experiments concerning pollinator limitation, yield quantity and quality, and resilience to extreme climatic events in selected agricultural regions in Germany
- Meta-analysis of the effectivity of existing agri-environmental programmes in temporal and spatial (landscape, climatic zone) contexts
- Development and testing of new measures in selected German agricultural regions, including the involvement of farmers, authorities, beekeepers, nature conservation organisations.

2.3.1 Plant cultivation

Crop rotations

The food supply for bees from agricultural crops is available essentially in spring (blooming of fruit trees and oilseed rape). Depending on the region, other late-flowering nectar and/or pollinator plants are also available (e.g. sunflowers, fava beans, asparagus). Further crops that are attractive to bees but are less common for economic or arable farming reasons (e.g. false flax, linseed, buckwheat), soya beans, other large and small grained legumes, renewable resources (e.g. cup plant) and medicinal and herbal plants could broaden the spectrum. Essential for this would be

1. breeding improvement for yield performance and stability with the same or increased attractiveness to bees,
2. breeding adaptation of classical bee-attractive cultures to improve nectar and pollen production, and
3. development and promotion of diverse and abundantly flowering crop rotations.

For this, incentives for improving the economic viability of these crops must be put in place, taking into consideration other ecosystem activities. Further research is necessary relating to how these incentives can be designed, whether markets can be expanded for the mentioned crops, whether compensation can be offered, or whether the provision of environmental services can be remunerated directly.

Mixed cultures

Mixed cultures such as undersow crops, maize-bean mixes, legume mixes, wild plant mixes for energy production and wild flower strips which were created in the framework of agri-environmental programmes can improve the nectar and pollen supply for bees, promote natural pest control and increase soil fertility. Quantification of the benefits of using mixed cultures is necessary to convince farms to try a new approach to offer incentives for change and to highlight the economic significance to beekeepers. This quantification also provides the basis for further development of crop cultivation, economic viability of mixed cultures and their positive effects on the bees and other ecosystem activities.

Grassland – improvement in land use and extensification

Permanent grassland is an important habitat for many animal and plant species. Extensively managed permanent grassland in particular has generally a high species diversity and a broad temporal distribution of flowering plant species. This means they represent a good source of food for bees. However, up to now, the focus of management of permanent grassland has not been on bees. This means it is necessary to find out how permanent grassland can be cut in the most insect-friendly way possible, taking into consideration the practical aspects (e. g. delayed, cutting partial fields once or twice and removing the cuttings) without causing overall deterioration of the habitat for other animal groups and plant species. Furthermore, how the diversity of permanent grassland can be increased, for example through sowing of appropriate seed mixtures and restoration of near-natural site conditions, must be investigated. For this, it is necessary to assume a cross-regional approach and assess individual measures during practical application to avoid a conflict of aims. To increase the acceptance and result-oriented implementation of the suggested measures, they should be promoted as agri-environmental measures in permanent grassland and the research should be undertaken together with farmers to develop instructions for applications for various situations.

Integrated plant protection

Many insects use plants, including crops and weeds as a basic food resource and as nesting places. Some insect species damage the plants by doing so. To protect the crops, plant protectants are used, which primarily decimate the pest insects and weeds. New studies show the significance of species diversity among antagonists for biological pest control, and indicate alternative ways of protecting the crops. In this way, an important contribution can be made to a sustainable and species diversity-preserving agricultural use.

At present, according to the principles of integrated plant protection, plant protectants should only be applied if economic thresholds are exceeded. Basically, the economic losses caused by pest organisms (loss of yield, harvesting difficulties, subsequent weed growth, etc.) should exceed the costs incurred by plant protectant application. Here, the definition of the economic threshold should be revised. For the concept of integrated plant protection does not yet consider sufficiently a reduced use of plant protectants beyond economic thresholds and hence the prevention of negative effects on the ecosystem. For this new orientation, the following questions must be addressed:

- Which innovative methods are available for recording infestations of pest insects and what are the possibilities for partial field treatments?
- Which weeds have positive effects on bees and starting at which weed density?
- During which time periods, in which cultures, and how can flowering weeds be tolerated or actively encouraged?
- Can possible yield losses after discontinuing the use of plant protection measures be countered by optimum pollinator performance and the promotion of natural pest control?
- How can approaches for bee-friendly plant protection (e. g. digitalisation, autonomous mobility, seed dressing, precision plant protection, small robots, drop-leg technology) find wider use in agriculture?
- How can economic thresholds for different pest organisms be realigned, taking into consideration positive environmental effects and economic constraints?

There is an urgent need for action concerning the continuous alignment of the testing and approval procedures for plant protectants with the current state of the art in science and technology, and their continuous further development regarding both honeybees and wild bees. A lot of catching up remains to be done concerning wild bees and sublethal effects. This includes the development of methods that will permit reliable measurements of bee welfare and their abundance at the population and landscape levels. In the biocide area, in which as yet no criteria for testing the safety to bees as an approval requirement exist, there appears to be a particularly urgent need for new regulation. Furthermore, the testing and approval procedure for plant protectants and biocides should be presented transparently and publicly communicated.

Adapted soil management

With reduced disruption of the upper soil layers, nesting opportunities for ground nesting wild bees can possibly be created through low soil disturbance, gentle tillage processes or direct seeding. These processes are of little significance in organic farming, and on conventional farms, they are generally connected to the use of glyphosate. Therefore, it is necessary to

1. investigate whether and to what extent ground nesting bees are harmed by the use of glyphosate and other herbicides or other mechanical tillage measures,

2. investigate in which cultures or time periods other alternatives are practical, and

3. develop alternative tillage methods for promoting ground nesting wild bees.

To ensure that gentle or alternative tillage procedures will be applied in practice, economic data must be collected simultaneously, which clearly demonstrate the possible costs or savings of these methods compared to other tillage processes.

Organic farming

Many of the points mentioned above are also applicable to organic farming. However, organic farming has additional positive effects on honeybees and wild bees. This is due to, among other things, the effects of expanded crop rotations, perennial forage cultivation with legumes, and increased effort in reducing the use of plant protectants and the use of preventive measures for plant invigoration not based on chemical-synthetic methods. Nevertheless, an urgent need for action particularly exists for further developing biological plant protectants, testing and approval procedures for plant protectants for the organisms in question, such as viruses, bacteria and fungi, concerning both honeybees and wild bees, as there are few suitable methods and guidelines available for these organisms.

As stated in ”Organic Faming – Looking-Forwards Strategy”, the Federal Ministry of Food and Agriculture (BMEL) is aiming to raise the proportion of organic farming in Germany to 20 % of the agricultural land. It can be expected that this will result in further positive stimuli for honeybees and wild bees and the diversity of the agricultural landscape. There is also a need for further research in organic agriculture with regard to how pollinators and other functionally relevant species groups can be encouraged even more through appropriate management measures.

2.3.2 Landscape structures

Creation of field copses

Copses with a high proportion of pollen and nectar supplying species (e. g. wild fruit, berry bushes, maples, limes, roses) can supplement the food supply for many bee species above all in areas dominated by large agricultural fields, which offer bees little food. Copses also have beneficial effects on other ecosystem activities in the agricultural landscape, in that they fix carbon, reduce wind and soil erosion, and offer a habitat to a multitude of animal and plant species, e. g. wild bees nest in dead wood, pithy stems and abandoned mouse nests.

Apart from the species composition of the copses and the suitability of the species, the optimal dimensioning and distribution must be examined through to linear short-rotation plantations and agroforestry system.

Field enrichment (transformation)

There is currently restricted availability of suitable nesting places for wild bees. Although the majority of wild bee species are ground nesters, very little is known about the creation of suitable species-specific nesting sites in the ground. Above all, large-scale agricultural landscapes must be specifically further developed and augmented with structure-providing landscape elements (e. g. flowering strips, hedges and copses).

The optimum composition, dimensioning, distribution and interlinking of field margins, edge and island habitats, as well as the field size must be investigated for the respective regional landscape type, taking into consideration the flight radius of honeybees and wild bees. Subsequently, one must determine which support programmes and regulatory measures are most suitable to be applied to these habitat structures.

Spatially optimised configurations of suitable nesting sites for wild bees should be researched and established to promote pollinator species depending on a variety of nest materials. Furthermore, investigations should be carried out to determine what measures should be specifically used to promote rare or valuable wild bee species, or promote or establish stable populations of the wild bee species important for pollination.

Furthermore, the effectiveness of transitional landscape structures as agri-environmental measures, e. g. flowering strips, must be examined. Measures with demonstrably higher effectivity should be established politically on a larger scale in the long term.

Specific redesignation of field areas
Areas of fields that are unprofitable or awkward to farm can be extensively cultivated, or converted to fallow land with spontaneous vegetation, flowering strips, copses or nesting sites so that a mosaic of forage and nesting opportunities can be created. Here, research can develop recommendations how European and national support schemes can be adapted to provide incentives for such redesignation without causing major operational disadvantages.

Flowering plants in public and private green areas
Only a limited number of crops flower in summer and autumn, for example *Phacelia*, which is sown as a catch crop. Here, flowering plants in public and private green areas (e.g. road verges, gardens, sports fields and recreational areas) are very important in the agricultural landscape, as they supplement the food supply for bees.

In addition to recommendations for a spatial network targeted at municipalities and administrative districts, the temporal availability and optimum species composition of the flowering plants in public and private green areas must be examined.

2.4 Agriculture and bees: Effects, interactions and achieving synergies

Bees are influenced by a wide range of agricultural factors. The effects and possible interactions of these factors with and among the bees, as well as with the targeted synergies can only be explored and uncovered using systematic observations, independent of the seasonal cycle. For this, the habitat demands of other species groups must be taken into consideration. This means the examinations are complicated and take longer than research projects involving single aspects that can be considered in isolation. The research should form the starting point for further works investigating the synergies of bees and agriculture,

1. what nutritional value and what exploitation significance do crop, wild and ornamental plants have for bees and in which seasons do forage gaps exist for the individual species,

2. between which bee species and under what conditions does competition for resources occur and how can this competition be prevented,

3. what influence does the dimensioning, material, design and distribution of nesting boxes have for wild bees, and

4. what is the significance of diseases and their spread for wild bees.

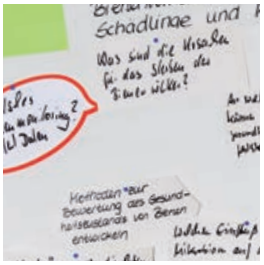
2.4.1 Optimising pollination performance

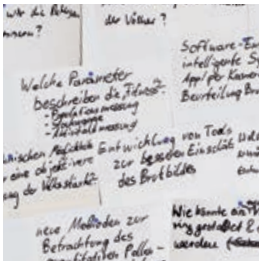
In Germany, around 80 % of the crop plant and domestic wild plant species are reliant on insect pollination. Based on numbers, the honeybee is a particularly important bee species for pollination (economic value for Germany of more than 2 billion Euro per year) due to its social organisation and it being held by numerous beekeepers, the majority of which are hobby beekeepers. After seeing the number of managed bee colonies fall for many years, the good news is that this trend has recently reversed: 2018 saw an increase of 6 % compared to the previous year, with around 800,000 colonies registered with the Deutscher Imkerbund e. V. (German Beekeeper Association).

While numbers for the pollination performance of wild bees are lacking, reliable pollination is only guaranteed when a variety of bee species is present in the region. Of the approx. 580 wild bee species present in Germany, more than half (62 %) are on the Red List. The long-term trend shows that while 233 species are in decline, only 5 have increased in numbers.

In addition to increased pollinator abundance the species diversity is also significant. At the same time, a comprehensive understanding of the basic mechanisms is also lacking. There is also a need for research concerning the long-term effect of insect pollination on crop cultivation (including increase in yield, yield quality, robustness, resilience).

3 Research structures and knowledge transfer to practice





3.1 Research priorities

The focuses in basic research and above all in applied research (Chapter 3.2) must be viewed as a whole complex. Only a holistic and, where appropriate, interdisciplinary examination of the focuses within a specific research field is constructive. From the research fields mentioned above, the following were selected:

1. Improvement in the vitality of honeybees and wild bees

- Optimisation of field diagnoses, documentation of regional abundance
- Recording and improvement of bee colony vitality
- New methods and digital techniques for recording bee health, for the diagnosis of effects, for knowledge compilation and dissemination
- Fighting bee pathogens with alternative methods
- New methods for recording wild bee diseases
- Expansion of testing methods regarding the effect of plant protectants on honeybees and wild bees (acute and chronic toxicity, sublethal effects, contamination of food for the larvae)

2. Creation of habitats for wild bees and improvement in the basic food resources for bees

- Creation and optimisation of wild bee habitats (nesting places, food plants)
- Optimisation of the cropping system taking into consideration bee-friendly technologies, new observations of culture-specific economic thresholds fighting pests and weeds
- Change and optimisation of agricultural practice and technical innovations, taking into consideration ecology and economy
- Bee-promoting redesign of agricultural landscapes in model regions for checking the effect of measures at the landscape level (see Chapter 3.3)

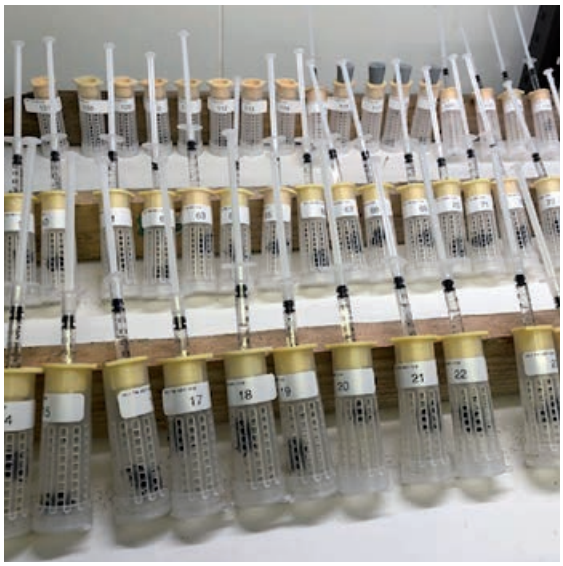
3. Improvement in the cooperation between stakeholders through research into optimisation of formats for communication and information exchange

- Development of training concepts for government veterinarians, plant protectant advisors, farmers and beekeepers, and advisors of farmers and beekeepers on the topic area “Bees and Agriculture”
- Nationwide harmonisation of official veterinary practices for fighting bee epidemics

4. Development and validation of goal-oriented remuneration approaches for the promotion of pollinating insects in future agri-environmental programmes

- Development of suitable indicators for evaluating environmental performance (see Chapter 3.4)

The drafted research approaches presented here can, in part, build on the already existing research methods and results; their implementation to improve the synergies of bees and agriculture is already possible. This application and practice-oriented research involving the public can immediately lead to visible results through the use of new media, digital technologies, and networking with, for example, monitoring projects. Further basic research is required for the remaining questions. The research structures and research focuses are given below.



3.2 Basic and applied research

Basic and applied research should be designed synergistically, and cover laboratory, semi-field and field trials, experiments at the landscape level, agricultural areas and regions, as well as the establishment of model regions. As the research topics are very diverse, differently planned research levels, from small research collaborations to large networks, can be productive. Therefore, funding recipients should substantiate the selection of their method with the aid of the expected contribution to the improvement in bee living conditions and a synergistic interaction between bees and agriculture. In particular, the already established structures and expertise should be promoted, expanded and adapted by the research projects. The research should be complemented by results controls, for example wild bee monitoring at the landscape level. Additionally, modern diagnostic and therapy measures will have a decisive influence on the ongoing screening and treatment possibilities, as will have the results control in the field.

3.3 Other research approaches and implementation possibilities, including in model regions

There are a multitude of relevant parameters that can be adjusted to increase the numbers of honeybees and wild bees, their species diversity and pollinating performance. However, it is not easy to find the perfect combination of influencing parameters for a particular site. In an extreme case, a well-intentioned bee protection measure – for example the offer of forage at the wrong time of year – may even have a counter-productive effect on the bee populations. Therefore, the aim must be to set a specific mix of measures in place that are correct for the respective site conditions. In doing so, special attention must not be paid only to the agriculturally used areas, but all the elements of the agricultural landscape, the managed landscape and the accompanying public and private areas must also be considered.

Regional concentration of implementation-oriented research and development projects in selected model regions is one possible means of presenting a standardised comprehensive overview of all the elements of an agricultural landscape. Compared to the implementation-oriented concepts at a national level, model regions provide information that can lead to deeper understanding of ecosystem and socio-economic interactions but are less universally applicable to the entire country. Therefore, activities in model regions must be complemented by additional analyses in specific crops and regions in order for the gathered information to be of use nationwide. Model regions could be selected with the aid of a nationwide competition. For this, applicant regions could form partnerships with research institutes, while using already existing networks. Relevant, ongoing projects of other authorities and competent ministerial departments, e. g. environment and conservation in addition to agriculture, should be incorporated to enhance synergies. While the size of the applicant regions should be handled flexibly, it is recommended for the purpose of organisation that suitable existing administrative units, such as districts, be used. Established administrative structures are required for demonstrating which measures have already been performed and for planning future projects. Based on the model regions, nationwide monitoring (see next section) should be designed and used in such a way that the results of the model regions can be scaled and generally applied to other regions.

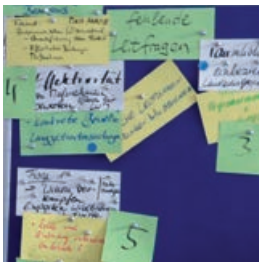
3.4 Monitoring, evaluation and indicator development

Irrespective of the design approach, the evaluation of the realisation measures must always be performed by monitoring of the bees and their vitality, distribution and pollination performance. This offers the opportunity to address the effects of changing environmental conditions, climate change and invasive species. A broad, area-wide programme, Deutsches Bienen-Monitoring (DeBiMo, German Bee Monitoring) was already established for honeybees in 2004. The DeBiMo in its current form collects primarily health-relevant parameters, such as disease pathogens, development, and colony losses, as well as plant protectant residues in pollen. Further expansion of the environmental monitoring of bee colonies is conceivable. Furthermore, in 2019, a national monitoring of biodiversity in the agricultural landscape (MonViA) was established, including honeybees and

wild bees. Thus, additional parameters could be recorded in collaboration with DeBiMo. The monitoring data for wild bees should also be collated on a federal digital platform. To do this, activities including the development and further development of indicators for honeybees and wild bees should be aligned in such a way that the monitoring data and future new indicators can be compiled for optimum knowledge gain. This also offers the possibility of involving people interested in bees and nature in citizen science projects in order to, for example, register the distribution of species and possible habitats.

Existing knowledge should be compiled in the whole process and new collective activities led by science, agriculture and society should be initiated to quickly and comprehensively expand the knowledge base.

4 Communication, data and knowledge management



Communication, data and knowledge management aims

- to process and disseminate the currently available knowledge, particularly concerning pollinator management, in a manner tailored to farmers and beekeepers, and specifically within the areas of agriculture, landscaping, horticulture, and public green spaces (see Chapter 4.1),
- to make the existing wealth of experience and expanding knowledge base available on a universal, publicly accessible platform,
- to awake interest in honeybees and wild bees in a large number of people, to encourage local activities by beekeepers, farmers and conservation activists, and position the topic in educational institutions,
- to communicate to people that consumer behaviour is a decisive factor in agricultural orientation,
- to analyse target group motivation – so that information can be communicated faster and more convincingly to the different target groups and
- to provide grounds for political decisions and policy management.

4.1 Structure and operation of an interdisciplinary centre of data and information

The available knowledge concerning the effects of different measures should be prepared in a structured manner in a basis project. This knowledge platform should then later also be able to incorporate new scientific knowledge and practical experience (see Chapter 4.3) and derive guidance from the data for bee-promoting designs of agricultural landscapes.

The setup and maintenance of standardised databases and the creation of a central platform as a long-term task should be in the public domain. Using this platform, the communication boundaries at the states level and other administrative units will be overcome, which are caused by, among other things, heterogeneity of the administrative structures (veterinary authorities, plant protection consultation).

4.2 Improvement in the training of farmers, beekeepers, veterinarians and agricultural consultants

Both the academic and non-academic training can help improve the situation of the bees in the agricultural landscape on two levels. In return, scientifically inclined agricultural actors are more likely to be prepared to take part in research projects and be motivated to initiate application-related implementation projects. In view of the academic education, the continuous decline in bee experts, who offer the necessary organisational and methodological knowledge for working on apiculture questions, must be counteracted.

In both apicultural and agricultural training, there should be mutual reference to the topic areas, in order to improve communication between all the parties involved. Agricultural consultant training should include transdisciplinary networking functions and considerable emphasis placed on the value of species diversity for the promotion of ecosystem activities. The monitoring and improvement of training materials for beekeepers and farmers are recommended.

For beekeepers in particular, concepts for further training in the prevention of bee diseases and avoidance of practices harmful to bee health should be developed, and the consultation concerning bee health should be optimised so that concepts for diagnoses and action can be better implemented.

An especially important aspect is the professionalisation of the competent (official) veterinarians for bee health. For this, additional obligatory training units must be introduced into the basic study stage of veterinary medicine. Accordingly, obligatory further / additional training courses in bee health should be organised and coordinated through the official veterinary training institutions and academies. A nationwide harmonisation of monitoring and prevention measures is recommended, as well as an increase in transparency during official decision-

making concerning epidemics or quarantine cases. A network of actors should be encouraged so that agriculture, beekeeping, science and veterinary authorities mutually develop coherent training and information concepts.

4.3 Processing and presentation of the available knowledge: Information and training designed for specialist and target groups

To make available the information and data collected by the scientific community in the past, present and future, submitting processed data in permanent repositories for easy access should be planned to occur during the lifetime of a research project and financed by project funds. This also applies, in particular, to projects with negative results or those which for other reasons will not be published in specialist journals. The funding organisations must organise appropriate funding periods and conditions for this. The funding of scientific meta-analysis and synthesis projects of already existing knowledge should be taken into consideration.

5 Conceptual / higher level recommendations for political decision-makers

5.1 Governance

The application-oriented concepts, outlined in Chapters 2 to 4, aim to already achieve the greatest possible improvement for honeybees and wild bees and hence pollination with benefit for agriculture and rural landscape within the existing political framework.

The processing of research questions is essential to elucidate in the medium-term demonstratively improved and aligned measures.

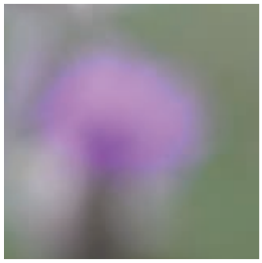
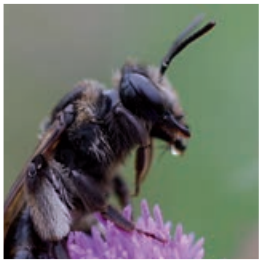
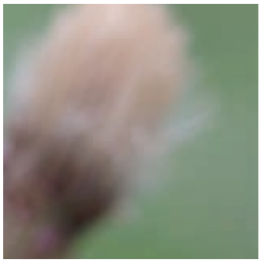
A change in the agricultural political framework conditions could considerably increase the potential for bee protection and pollination performance. Farmers compete with each other in the market economy and can, therefore, generally not afford to align their production system "economically suboptimally". Politics, therefore, faces the challenge of developing the agricultural political framework in such a way that bee-promoting actions are viewed not as deviations from the normal economic optimum, but rather to be within the economic interests, or at least to not present a competitive disadvantage compared with those of their colleagues.

To apply this general guideline to concrete political actions is by no means easy and also requires scientific support. Here, it must be analysed which political options should be seriously considered, and these linked to the resulting consequences. In doing so, two issues should be handled individually:

- **Political options for bee-friendly crop cultivation:**
  The prominent question here is, which measures can politicians use to influence the farmers' actions in such a way that sustainably bee-friendly production systems are developed. The measures must the legally controllable with justifiable effort and crop-specifically developed, and they should trigger beneficial side-effects as far as possible on other agricultural policies.

- **Political options for bee-friendly agricultural landscapes:**
  This concerns controlling the collaboration between farmers and other land users at a regional level, which is necessary for establishing interlinked systems of biotopes and sustainable bee-friendly landscape structures. When considering policy design, the question arises, which authority could regulate the necessary collaboration and how could agricultural and environmental policies be used.

6 Outlook

For decades, wild bee numbers (numbers of species, population sizes of species) have been in decline; many species are severely under threat. Despite the increase in local beekeepers and bee colonies in recent years, sustainable keeping of honeybees is a challenge involving considerable effort on the part of the beekeeper. The causes for the constantly reoccurring loss of bee colonies – varroosis, seasonal food limitations, intensive agriculture and the (improper) use of plant protectants and biocides, as well as incorrect management of bee colonies – contribute to differing extents to problems in apiculture; especially the particular influencing factors, which are extremely heterogeneous at a site. It is important to highlight that not only colony survival is decisive for pollination and honey production, but also the size of the colony. Causes of the threat to wild bee stocks are predominantly habitat loss (loss of nesting opportunities, nest materials, food sources) brought about by sealing and disturbance of the ground, but also through over-fertilisation and the incorrect use of plant protectants. Generalised accusations, however, are not helpful; it is more productive to highlight the causes and the precise mechanisms to be able to initiate optimal and specific counter-measures.

Although the extent of wild bee loss is not documented for all species and regions, and can only be described through long-term ecological monitoring studies, we must not wait for the results of these types of studies. It can be irrevocably assumed that a varied, multifaceted landscape also secures and promotes the biodiversity of bees, their food plants and other organisms. A change in the agricultural landscape to greater diversity, linking of habitats, and reduction in the use of fertiliser and plant protectants will lead to improved living conditions for honey and wild bees.

Scientific facts are essential to determine suitable measures, their acceptance by the stakeholders and their economically justifiable implementation and communication. Where these facts are lacking, there is a need for further research.

Landscape-ecological and agro-ecological research with spatial and regional planning measures must be accompanied by lab work, field experiments and ultimately monitoring projects. This interdisciplinary approach often requires participants with diverse scientific competences (agricultural scientists, biologists, ecologists, economists, sociologists, political scientists).

The DAFA Strategy Bees and Agriculture therefore recommends ideally the involvement of several federal ministries (Ministry of Food and Agriculture, Ministry of Environment, Ministry of Education and Research, etc.) already at the planning level and calls for proposals for the appropriate research projects. For projects with time-consuming topics and/or large project groups, the financing should extend considerably beyond the usual 3 years, to guarantee the sustainability, meaningful structuring of the work, and establishment of new measures in landscape regions, their scientific evaluation and the transfer of knowledge.

7 History of the DAFA Strategy Bees and Agriculture



In autumn 2017, a proposal was sent to the DAFA board of directors, requesting the topic “honeybees” be addressed in the scope of a DAFA Expert Forum. This proposal was accepted at the DAFA members’ general meeting in November 2017, and the recommendation was made for the establishment of a new expert forum for bees and agriculture. The staffing and topical allocation of the expert forum’s steering group took place at the start of 2018 taking into consideration fields of research and institutional criteria. During a meeting in May 2018, an initial concept was developed, which would form the basis of a strategy named Bees and Agriculture.

An important milestone on the path to the Research Strategy Bees and Agriculture was the two-day conference in Berlin on 25 and 26 September 2018. Besides scientists, research funders, economists, NGOs, organisations, practitioners and authorities were invited. During the conference, an initial, still very brief outline was discussed. Based on the multitude of expert contributions during and after the conference, the concept of a research strategy was prepared by the steering group of the bee forum. The central topics of this concept were then discussed and further developed during a second conference with similar participants on 27/28 February 2019 in Brunswick. This was followed by the planning of the strategy concept, which was published and put up for discussion in summer 2019.

After presenting the strategy to the members of DAFA and its formal approval by DAFA members in February 2020, the finished strategy will be presented to the federal and state governments at the start of 2020 to serve as a suggestion for research funding.

The German Agricultural Research Alliance (DAFA) represents the majority of publicly funded German agricultural research institutions. One of DAFA’s main goals is to develop strategies that combine the capabilities of German agricultural research institutions in order to solve grand societal challenges. Dedicated expert forums established by DAFA and participatory processes enable integrated solutions.

Link to the Expert Forum Bees and Agriculture (in German) at the DAFA web site:
https://www.dafa.de/foren/fachforum-bienen-und-landwirtschaft/

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Other Research Institutes

German Institute for Tropical and Subtropical Agriculture

German Institute of Human Nutrition Potsdam-Rehbrücke

FiBL Germany, Research Institute of Organic Agriculture

Fraunhofer Institute for Interfacial Engineering and Biotechnology

Fraunhofer Institute for Process Engineering and Packaging

Institute for Rural Development Research at the Johann Wolfgang Goethe University at Frankfurt/ Main IfLS

The Association for Technology and Structures in Agriculture

Leibniz Institute of Agricultural Development in Transition Economies IAMO

Leibniz Institute for Agricultural Engineering Potsdam-Bornim

Leibniz Institute of Vegetable and Ornamental Crops

Leibniz Institute of Freshwater Ecology and Inland Fisheries

Leibniz Institute for Farm Animal Biology

Leibniz Institute of Plant Genetics and Crop Plant Research

Leibniz Centre for Agricultural Landscape Research

Potsdam-Institute for Climate Impact Research

RLP AgroScience GmbH

ZB Med — Information Centre for Life Sciences

Federal Research Institutes

Federal Research Institute for Risk Assessment in Food Safety

German Meteorological Service, Agrometeorological Research Centre

Julius Kühn Institute, Federal Research Centre for Cultivated Plants

Friedrich Loeffler Institute, Federal Research Institute for Animal Health

Max Rubner Institute, Federal Research Institute for Nutrition and Food

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Research Institutes of the States

Bavarian State Research Center for Agriculture

Centre for Education and Knowledge Boxberg – State Agency for Pig Husbandry

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Institute of Inland Fisheries in Potsdam-Sacrow

State Agency for Rural Development, Agriculture and Land Consolidation in Brandenburg

State Agency for Agriculture and Horticulture in Saxony-Anhalt

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Centre for Agricultural Technology Augustenberg

Agricultural Centre for Cattle Husbandry, Grassland Farming, Dairy Farming, Game and Fisheries in Baden-Wuerttemberg

Chamber of Agriculture of Lower Saxony

Chamber of Agriculture of North Rhine-Westphalia

Lehr- und Versuchsanstalt Hofgut Neumühle

Saxon State Agency for Environment, Agriculture and Geology

State Institute for Education and Research in Horticulture Heidelberg

Thuringian State Institute for Agriculture and the Rural Area

DAFA thanks all persons who commented on drafts of the strategy and who contributed to the lively discussions at the meetings of the DAFA Expert Forum Bees and Agriculture.

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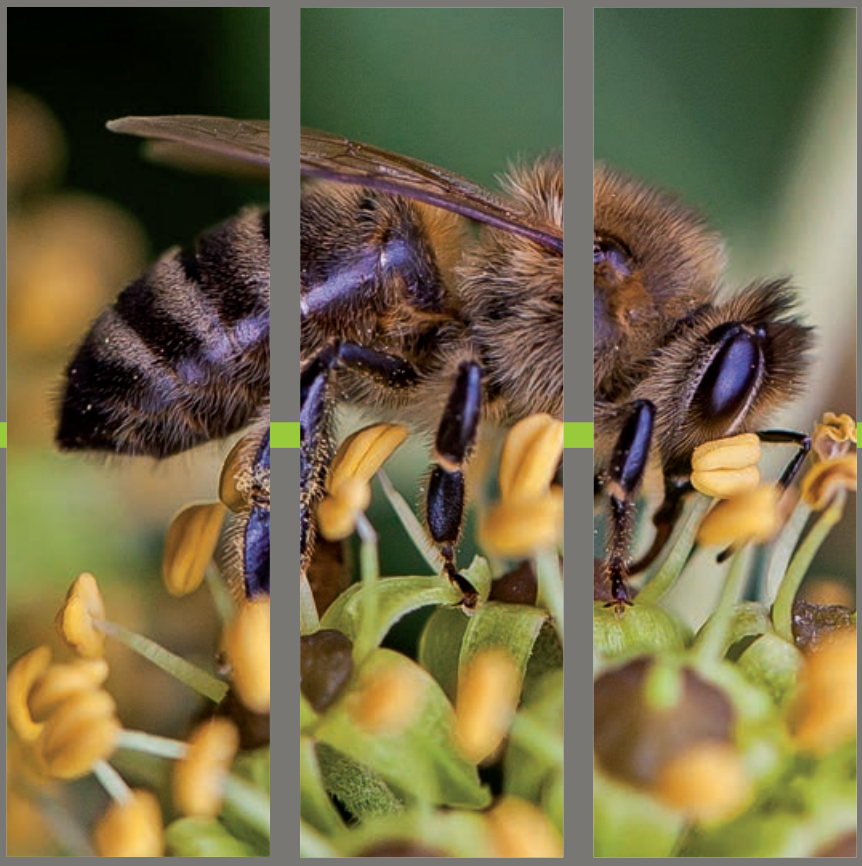

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