EIP-AGRI Focus Group

Bee health and sustainable beekeeping

MINIPAPER 03: Taking into account the well-being of bees in production: Developing husbandry staying as close as possible to the natural living conditions of bees while being productive.

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1. Introduction – motivation

The overall objective of this minipaper is to develop a reflection on beekeeping practices that allow a breeding that takes into account the well-being of bees by remaining as close as possible to the natural living conditions of bees while being productive for beekeepers.

This minipaper is needed because of:

- society's growing general demand for ethical consideration of animal welfare in animal production systems and specific attention to the care of bees in the current critical situation for their survival,
- amateur beekeepers who do not depend on their hives for production and income and can therefore adopt extensive beekeeping practices,
- professional beekeepers willing to consider changes in their practices and production in a context where all solutions are good to take to save the lives of bees, threatened from year to year.

The objective of this minipaper is to introduce the well-being of bees into the reflection on beekeeping. To do this, the "bee first" point of view is taken into account here, while trying to meet the needs of the different actors, i.e. without forgetting that beekeeping is based on an interrelation between the beekeeper, the bees and the environment and must meet the production needs of beekeepers, market conditions, ecosystem requirements and the health of bees. A real challenge is therefore to be met here because each actor has different interests to defend. The point of view developed in this minipaper attempts to avoid a polarization on "a truth" - which would oppose good and bad approaches to beekeeping - but is interested in presenting the bases of certain "apicentric" beekeeping approaches (also called "Darwinian beekeeping" or "natural beekeeping") in order to put them at the centre of a reflection still too often conducted on beekeeping practices applicable in the work of beekeepers and recognized for their utility to the well-being of bees.

2. Dissertation

Organic beekeeping follows the general principles of organic production in accordance with European Regulation 834/2007 or 889/200; it requires mandatory certification in beekeeping by an independent body with annual inspection of the colonies. Inspired by Darwin's theory of the evolution of living systems based on natural selection, Darwinian beekeeping is based on the implementation of practices that tend to minimize differences between the conditions of man-managed honeybee colonies and the evolutionary adaptation environment that has shaped the biology of wild honeybee colonies. However, there is no official definition or official practices to follow for Darwinian beekeeping, only private associations (e. g.

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Naturland, **Demeter**, **Nature&Progrès**) and recommended practices. These two approaches are based on the same assumption that conventional beekeeping practices tend to modify the environment of the colony's livestock (in order to increase productivity) to such an extent that these changes make the bees' living conditions unsuitable for their survival (because they are subject to pests, pathogens, lack of floral resources, environmental toxicity, etc.).

Tab.1 below lists the stress factors cited in the literature for their impact on the well-being on bees (the reference articles are listed at the end of the paper) and with which bees are confronted. Tab.1 ranks them according to their scale (see also minipaper 4), whether they are external factors (which depend on other activities less controllable by the beekeepers themselves) or internal factors on which beekeeping management methods can provide opportunities for intervention.

Stress factors	**Scales**	**Problems/Causes**	**Risks for the well-being of bees**	**Responsible actors**	**Possibilities of intervention**	**Solutions in terms of Darwinian beekeeping practices**	**Solutions in terms of organic beekeeping practices**
External	**Global**	**Climate change**	- Mismatch between honeybee colony development and plant phenology - Global climate and local microclimate changes - Plant phenology change - Drought, floods - Threats by invasive species	Human societies	+		
		Trade globalisation	- Dissemination of non-endemic parasites with which bees have not co-evolved and against which they do not have the means of defence (*Varroa, Vespa*)	Human societies			
	Regional	**Environmental quality and resources/Land use** - Monofloral resources - Intensive industrial agriculture - Electromagnetic radiation	-Reduction in the lifespan of bees -Reduction of plant biodiversity -Change in the distribution and diversity of wild pollinators in natural habitats	Human societies Agricultural systems Companies Farmers Beekeepers	++		-During flowering period, honey plants (grasslands, forests, wastelands, wetlands, green manure or organic crops) must represent more than 50% of food sources within a radius of 3 km
		Physicochemical exposure - High concentration of pesticides with synergistic effects in agriculture, forestry and gardening - Dust and small sized particles (nanoparticles)	- Effects on bee health (mortality, microbiome, neurological activity), lack of natural development means of resistance			- Hives have to be far from pollution sources (heavy industry, chemicals industry, coal-fired power plants)	
Internal	**Regional/ Apiary**	**Diseases and biological agents** - *Varroa* - Effect of microorganisms (fungi, bacteria, virus)		Beekeepers	+++	-Monitor and control *Varroa*. -Remove colonies with high infestation rates to limit the spread of *Varroa* mites	-Organic acid varroacides, mechanical and thermal methods only -Diligent diagnosis of infestation
	Apiary	**Apiary management** - Spacing of the colonies	-Competition for foraging, reproductive problems, transmission of pathogens and parasites.	Beekeepers	+++	-Create small apiaries (depending on the local conditions) (ex: no more than 10 colonies)	-Standards limiting the number of bee colonies in apiary

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Stress factors	Scales	Problems/Causes	Risks for the well-being of bees	Responsible actors	Possibilities of intervention	Solutions in terms of Darwinian beekeeping practices	Solutions in terms of organic beekeeping practices
Internal	**Apiary**	**Beehive construction and location** - Geometry, volume and architecture - Beehive wall thickness - Timber building material	-Limitation of swarming -Energy cost of colony thermoregulation (hive insulation) and stress for bees to keep up with favourable internal hygrothermal climate -Antibacterial action of the chemical properties of the hive building material (limitation of the rate of infestation by the Varroa parasite and micro-organisms)	Beekeepers	+++	-Hive structure (geometry, building material, wall thickness) reproducing the parameters naturally chosen by wild domestic colonies in nature (natural nest). - Choose appropriate hive location (shadow, safe from disturbers and hazards from agriculture) and beehive vertical position -Provide uncontaminated water source -Use movable boards	-From natural material (wood or polystyrene only for nucleis), no chemical wood protection, no varnish, regular disinfection of hive material with heat and steam only -Interior surface of wood: not planed for safehousing beneficial organisms (chelifera), - Beehive shape ensuring that bees can properly manage the internal climate of the hive (good ventilation management)
		Brood and colony management - Drone brood removal - Brood nest disruption	- Natural selection hampering (via drones gene) - Thermoregulation and queen egg laying hampering	Beekeepers	+++		-Keeping up genetic diversity, based on swarm drive -Possibility of having a broodless period linked to swarming
		Colony genetics selection - Queen shipping and trade - Rearing of queens on selected eggs	- Reduction of queen lifetime, disruption of natural choice of patrilines by bees themselves, unadaptation to geographical locations			-Locally adapted genetics -Selections of bee colonies according to vitality traits.	-Preference for *Apis mellifera mellifera* and its ecotypes premises -Obligation to buy organic queens and swarms (max. 10% of non-organic swarms)
		Honey and pollen harvest - Compensating artificial diets	- Reduction of worker bees' quality			Limit the harvest (1 to 2 kg honey per hive)	-Leave honey in sufficient proportion for the winter provisions -Organic honey or sugar only
		Migratory beekeeping - Relocations for honey harvest	-Troubles on colony weight gain evolution, pathogen and parasite transmission			-Avoid relocation of hives only to local and regional migrations	-Any relocation of apiaries requires information with the certifying body -No migration to conventional crops for harvest or hive products downgraded
		Wax management - Wax removal and replacement	- Energetic burden to produce wax, chemical remaining in wax from unknown origin			Avoid using wax from unknown origin	-Frequent removal of old combs (progressive renewal of body waxes over 3 to 5 years) with organic wax -Recycling of virgin wax only -Wax processing with heat only, no solvents

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3. Conclusions/Key messages

Taking the well-being of bees into account in beekeeping practices is not only about choosing the most effective treatment against parasites or infectious diseases. For an organism such as a bee colony to be strong and robust, its natural methods of propagation, habitation, feeding and life management must be respected. But for economic reasons and to make a living from beekeeping, it is inevitable to control some of these elements. Some beekeeping approaches manage to keep the impact of stress to a low level, which is positive for the well-being of bees, but also leads to lower profitability and, consequently, customers willing to pay fair (i.e. higher) prices for bee products. Such "natural beekeeping" practices (whether non-certified or certified like in organic beekeeping) emphasizing the well-being of bees are being integrated within the practices of many "in-between" small-scale and professional beekeepers who tend to keep their colonies as close as possible to their natural living conditions. However, such practices would require, on the one hand, quantitative data on the impact of these practices on production levels in order to convince more beekeepers to apply them on their farms and, on the other hand, traceability on production practices for consumers to make informed choices. Apicultural research is starting to embrace a "natural beekeeping" perspective and more and more results are available on the effects of such practices on the bee's well-being. But there is, in particular, a need to assess quantitatively with scientific studies the impact of each stress factor on the bees well-being in order for beekeepers to make informed practical choices regarding for example the limitation of treatments, winter honey supplies, improvements to the beehive model, etc (see next section). Actually, there is no evidence that such beekeeping practices are able to deliver the expected anticipated positive results by applying particular measures (as given above) on the short run. From the holistic point of view it can be assumed however that in combination with organic agricultural practices (such as abandoning the use of pesticides, enhancement of biodiversity by using farmer seeds), bees and other pollinators will obtain advantages for stress relief, which is crucial for their well-being and survival on the long run.

4. Research needs

In general, further research is needed to **assess quantitatively the impact on the well-being of bees of each human solution or practice** for rearing that differs from the natural way of life of the colony. In addition to this global question, the effects of organic and Darwinian beekeeping compared to conventional practices on the well-being of bees are subjects that question beekeepers and require scientific results to guide practices efficiently towards better bee health.

To return to the list of identified stress factors and the main control solutions implemented (Tab.1), here is a list of practical research questions ranked in order of research priority (the issues raised in each category of stressors are not ranked in order of importance):

Stress factors	What are the quantitative impact on well-being of bees
1. Environmental quality and resources/Land use	• electromagnetic radiation/5G technology • quality of the sources of nectar • flower biodiversity (including using farmer seeds) • pesticides • veterinary products • presence of underground watercourse/water vein
2. Beehive construction and apiary management	• spacing of the colonies • natural wax comb production • beehive components to fight against vespa • beehive structure (materials incl. roof, shape, entrance hole position and size, thickness) and practices around the beehive (orientation, shading) to limit the thermoregulation workload in the actual context of climate change (with heat waves) • beehive location (e.g. underground watercourse, radiation) including the effect of shadow, orientation regarding the sun regarding bee's thermoregulation efforts • inner beehive macrobiote analysis (ex: chelifera scorpion) • effectiveness of hyperthermia • migratory beekeeping (transhumance)
3. Honey and pollen harvest	• artificial and supplementary feeding to balance out the lack of resources or the important harvest
4. Brood and colony management	• using swarming process for reproduction • man-made choice of genetics instead of autochtonuous bee species related to pest tolerance

5. Ideas for innovations

Innovations should be directed towards:

- Facilitating the acquisition of data of quantitative measurements related to bee health and implement them in practical tools to be integrated in the practices of beekeepers in order to assist them with a sort of decision-making tools (see Minipaper 7). Some examples of useful data to be recorded are: varroa load, biotic factors influencing the health status (see health status index), abiotic factors (temperature, humidity) influencing the thermoregulation workload, etc.
  In addition to data collection, such innovations should provide:
  -interpretation tools for beekeepers because otherwise, these data remain gadget information that is of little practical use (e.g. temperature and humidity data should be interpreted according to the condition of the colonies, the thermoregulatory workload; the number of varroas should be interpreted according to the level of infestation, etc.).
  -advise for beekeepers on how to implement their choices and practices in the more adaptive way to promote the well-being of bees.

- Developing biotechnological methods, including biocontrol methods (through the use of insects, mites, weeds and plant diseases for predation, parasitism or other natural mechanisms) that are not yet developed in beekeeping as is already the case in other agricultural sectors (orchards, wines, etc.) and that are an important element of integrated pest management programmes (See Minipaper 2).
  In beekeeping, biocontrol could work to develop interactions based on natural interactions observed between bees and microorganisms or insects' parasites of varroa (such as chelifera scorpion) by playing on the inner environment of the hive to be attractive to such hosts.

Further research needs coming from practice, ideas for EIP AGRI operational groups and other proposals for innovation can be found at the final report of the focus group, available at the FG webpage
https://ec.europa.eu/eip/agriculture/en/focus-groups/bee-health-and-sustainable-beekeeping

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