## SUGGESTED RESEARCH Topics

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As an on-the-ground commercial beekeeper, as well as being someone who attempts to keep current on beekeeping research, I have a perspective on what sorts of holes exist in our state of knowledge in honey bee-related science. This applies to both *basic* research in bee biology, as well as *applied* research of practical application to beekeepers. Sadly, it appears to me that there is a growing disconnect between the scientists performing research and the beekeepers who stand to benefit from such research.

I hope that the following list of suggested research topics will encourage graduate students, established bee labs, and independent researchers to address these deficiencies in our knowledge.

## Suggested *specific* research projects for RFPs by funding agencies

**(This is a short list off the top of my head)**

* For pollen sub, determine net protein utilization (NPU) relative to protein content, protein: sugar ratio, and EAA to NEAA proportions.
* Field test for measureable benefits from the feeding of Honey B Healthy® or Pro Health®.
* Field test for measureable benefits from the feeding of Nosevit® and Hive Alive ®.
* Field test for measureable benefits from the feeding of Pro DFM® or Super DFM®.
* Field test to determine the distribution of varroa mites in the colony of aged-marked cohorts of bees.
* Field test of overwintering success of colonies on honey stores contaminated with field-realistic levels of various insecticides – notable neonicotinoids.
* Field tests in apiaries across the country to determine the rate of mite immigration into colonies in late season, and whether it correlates with weight gain from robbing.
* Field tests to compare the cost/benefit ratios (as determined by colony population gain) of the feeding of the various pollen supplements on the market.
* Field/cage tests to determine the importance of particle size upon the digestibility, etc. of pollen sub components.
* Field analyses across the country in areas determined by USGS to be deficient in one or more trace elements, of royal jelly, to determine whether bees will produce trace element deficient jelly.
* Follow up on the above to determine whether supplementation of trace elements in those areas produces a measureable benefit colonies.
* Field test of wrapping hives with black or clear plastic prior to almond pollination results in cost-effective increased colony growth prior to bloom
* Field tests in almond orchards of the effects of fungicide sprays, and spray timings, upon bee foraging and nut set of sprayed blossoms.
* Test of efficacy of oxalic fogging (as opposed to dribble or vaporization).
* Field test of repeated oxalic acid dribbles vs. oxalic vaporization, testing for adverse effects, and ultimate cost: benefit.
* Compare Toomema’s dilute OA dribble method to the “standard” 5-mL method [[[1]](#endnote-2)].
* Collect data on OA residues in honey to change the label for oxalic acid to allow for application while honey supers are on.
* Create and run regional demo apiaries using BMPs across the country (managed by local clubs, with tech support and data management by USDA or PAm). Take pollen samples for pesticide testing. Purpose: to either demonstrate proof of success, or to determine weaknesses and strengths in BMPs or pesticide issues to address. Maintain a current database on the web with public access.
* Field tests of bee repellents at water sources—of huge potential benefit to urban and rural beekeepers.
* Development of bee repellents to mix with insecticides to be applied to flowering crops.
* Sterilization of combs. Tests of alternatives to radiation treatment. Since radiation facilities are not readily available, is there benefit to sterilizing the combs of deadouts with chlorine, formic or acetic acid, or phostoxin? What does it take to kill bacteria (notably AFB and EFB) and to deactivate viruses?
* Specific to the above, do formic acid vapors disinfect EFB in brood combs?
* Investigate the Möbus/Omholt hypothesis that colonies during winter initiate broodrearing in order to avoid water buildup in the workers’ rectums.
* Follow up on Amrine’s hypothesis that during formic applications, it is the workers, rather than the formic, that kills queens, and whether adding lemongrass/spearmint oils will reduce queen loss.
* Develop a bioassay to screen for the breeding stock whose worker larvae self-sacrifice in response to varroa saliva. Such a trait, if heritable, could have huge benefit in breeding mite-resistant stock.
* Fund interviews and surveys of beekeepers in other countries (notably Eastern Europe and China) for
* Methods of varroa control not currently used in the U.S.

## Suggested research by subject

### BMPs

* Create and run regional demo apiaries using BMPs across the country (managed by local clubs, with tech support and data management by USDA or PAm). Take pollen samples for pesticide testing. Purpose: to either demonstrate proof of success, or to determine weaknesses and strengths in BMPs or pesticide issues to address. Maintain a current database on the web with public access.
* Maintaining honey’s good name--methods for reducing residues in honey.
* Look for attractants or repellents at water sources—of huge potential benefit to urban and rural beekeepers.
* Sterilization of combs. Since radiation facilities are not readily available, is there benefit to sterilizing the combs of deadouts with chlorine, formic or acetic acid, or phostoxin (Eischen found this to be effective for nosema spores)? What does it take to kill bacteria and deactivate viruses?
* Top vs bottom supering; repeat Jennifer Berry’s experiment.
* Does it help with drawing foundation above an excluder to rotate combs to eliminate a honey band below the excluder?
* Quantify the benefit of top insulation and/or shade on hives during summer.

### Other management

* Find methods or attractants to provided water sources. Or repellents to nuisance sources.
* Quantifying the amount of drift or bee loss after moves.
* Test methods for reducing drift of field bees after short moves of hives in a yard, or long moves to new locations.
* Hive euthanization: test ethyl acetate to determine optimal amount, analyze for residues

### Varroa

* Develop a bioassay to screen for the breeding stock whose worker larvae self sacrifice in response to varroa saliva.
* Collect mite drift (immigration) data from around the country. I have a small citizen science project going. We need hard data as to how many mites immigrate into hives.
* Develop miticides that transfer via either bee proteins directly incorporated by varroa, or delivered via syrup added by the nurses to larval food (as by Monsanto)
* Standard methods—we need someone to test how best to harvest viable mites from colonies for *in vitro* studies—compare sugar shake, washing methods, CO2 methods, etc.
* Assist professional queen producers in establishing regional mite-resistance breeding programs, providing tech advice and ***a mite sampling service***. Selection programs to be based upon measuring r values as per Harbo [[[2]](#endnote-3)], rather than selecting for specific traits.
* Undertake additional demos of USDA, and other, resistant stocks in commercial operations (similar to Danka’s studies, or in conjunction with demo apiaries).
* Provide impartial regional comparative testing of bee stocks for varroa resistance (perhaps in conjunction with demo apiaries). Testing results could be used by breeders for marketing purposes.
* Report on varroa management status from countries that have dealt with varroa for longer than the U.S. Which methods have failed, which are most successful.
* Development, testing, and cost analysis of biotechnical varroa management methods.
* Develop new treatments—preferably phytochemical or biological.
* Identify any differences between bee and varroa odorant binding proteins, in order to develop nontoxic mite control products [[[3]](#endnote-4)].
* Determine why treatment with formic acid induces queen supersedure—the main complaint about this excellent varroacide. Is it the sudden reduction in E-β-ocimene due to the removal of young larvae? Is this the reason for the purported reduction in queen loss due to the addition of Honey-B-Healthy (lemongrass oil contains ~0.1% E-β-ocimene).
* Support Dr. Vince Ricigliano’s previous work on varroa-specific *Bacillus thuringiensis* (Bt).
* Develop better application methods for formic, thymol, and oxalic (including OA/glycerin).
* Register OA/glycerin as an approved application method.
* Continue with search for genetic markers for MAS in breeding (as by Pernal and Foster). If found, approach Monsanto for analysis of wing clippings.
* Determine whether varroa-infested larvae/pupae secrete a “remove me” olfactory signal that can be selected for by MAS
* Determine the cause of 5th-instar larval death during PMS (identify virus strain(s))
* Indoor colony storage
* Determine optimal conditions for, and construction of, indoor wintering facilities.
* Determine feasibility of storing colonies indoors at other times of the year.
* Test indoor storage options for varroa and nosema management; best feeding and disease control strategies

### QUEENS

* Work with the Calif queen producers to see why they experience sporadic failures of queen cells.
* Observe marked workers in obs hives to see whether a specific group of nurses feed the queen cells.
* Determine whether cleaner bees mark worker cells and queen cups with a pheromone to cue the queen to lay an egg there.
* Answer the question as to whether supersedure cells are typically started from queen cups (with the queen laying an egg in the cup), or rather as emergency cells from a worker larva.
* Methods for “vaccinating” queens so that they confer resistance to AFB via their vitellogenin.
* Determine cause(s) of apparent increased queen failure rate. I suspect miticide or ag chemical residues. Tarpy has a consortium leading this research, with which PAm should be collaborating.
* Determine whether we are actually experiencing increased queen *failure*, or rather *failure to successfully supersede*?
* Test the effect of temperature upon queen cells held in an incubator
* Develop a queen trap device for requeening.
* Confirm the findings on royalactin, microRNAs, and p-coumaric acid effect in queen jelly. I find the evidence to be weak.
* Analyze for differences in the jelly placed around the larvae over time, comparing that of the larvae left in the original grafting frame (destined to become workers), vs the jelly fed to sister larvae in a cell builder.
* Do jelly swapping between worker and queen cells, and between queen cells of different ages to see how it affects the resultant queens.
* Do workers move eggs or larvae? Follow up on several studies that found that they do.

### Emerging Diseases

* Follow up on James Burrit’s finding of the epidemic of *Serratia* causing systemic sepsis in wintering bees. ***Was this a localized phenomenon, or is it an emerging pandemic?***
* Support research on the evolution of DWV.

### Nosema ceranae

* Mendoza’s [[[4]](#endnote-5)] recent paper suggests that *N. ceranae* infection is not correlated with winter loss in mild temperate regions. Confirm (along with BIP data) to what extent *N ceranae* is actually a problem (as measured by risk quotient or reduced performance) in various regions of the country, especially comparing warm-winter to cold-winter effect.
* Confirm Hige’s finding that oxalic acid dribble has a beneficial effect against nosema.
* If indicated, develop alternate methods or treatments to replace fumagillin.

### Small Hive Beetle

* What’s happening in the Midwest? SHB is taking out strong colonies from the center of the broodnest.
* Determine formulas and methods for feeding pollen sub to colonies with SHB.
* Develop pheromone, UV light, or other attractant traps for SHB (following work of Peter Teal).
* Support Dr. Kirk Anderson’s work on SHB-specific *Bacillus thuringiensis* (Bt).
* Test and develop in-hive traps and baits for SHB.
* Test and confirm BMPs for SHB control.
* Set up breeding program for SHB resistance.

### Nutrition

* Develop a complete artificial diet—follow Elton Herbert Jr’s work to find diet that will support >2 generations of broodrearing. Determine the current limiting nutrient(s).
* Determine the degree of digestibility of artificial diet relative to particle size.
* Following Elton Herbert’s work, design flight cages for nutrition trials.
* Test for the benefit of supplemental feeding with abscisic acid [[[5]](#endnote-6)].
* Follow Justin Schmidt’s work on degree of digestibility of artificial diets [[[6]](#endnote-7)]
* Comparison of nuc buildup during dearth with sugar stimulations by either dry, fondant, light or heavy syrup.
* Research phagostimulants and olfactory cues of fresh beebread—how important are e-β-ocimene and quercetin?
* Understand effects of artificial feeds on microbiome—Dr. Kirk Anderson, Tucson Lab.
* Following Maes [[[7]](#endnote-8)], develop diet that can be dry fed for winter nutrition without adverse effects. ***Confirm Maes’ findings that dry-feeding pollen sub may be detrimental at times.***
* Confirm that nurses restrict jelly production rather than producing suboptimal jelly [[[8]](#endnote-9)]. If so, then jelly production could be used as a proxy for nutritional completeness of diets.
* Trace elements--perform jelly and bee body analysis from across the country, concurrent with pollen analysis, in order to confirm whether trace element deficiency is a problem [[[9]](#endnote-10)].
* Perform regional amino acid and trace element analysis of pollens (using USGS maps of trace element concentration), by species, to determine the potential nutritional effects upon colonies.
* Test the effect of diet supplementation with regionally-deficient trace elements (esp. Zn and Co) upon colony performance. Since zinc is critical to both immune function and vitellogenin production, and appears to be a limiting element in bee diets [[[10]](#endnote-11)], it deserves far more study.
* Find and test inexpensive vegetable sources for appropriate enzymes, p-coumaric acid, 24-MeChol, other phytonutrients.
* Confirm Wessler’s [[[11]](#endnote-12)] findings on the effect of neonics on ACh in jelly.
* Develop an artificial protein diet for caged bees (that doesn’t cause increased mortality)

### Probiotics

So many to test for cost/benefit ratio, as well as beneficial vs. adverse effects.

* Confirm benefits of Baikal EM1 (a generic Eastern European product) [[[12]](#endnote-13)].

### Bacterial diseases

* Dealing with the withdrawal of antibiotics.
* Phages against AFB and EFB (fund Sandra Hope)
* There are a number of food-grade alternatives to oxytet and tylosin—we should support trials of them against AFB and EFB.

### Almonds

* Test all common almond pesticide and adjuvant products in colonies to look for adverse effects. Use a quick test of simply spraying each comb of test nucs with the product at the application rate per ft2 (per acre rate/40,000) and record any signs of adverse effects over the ensuing brood cycle. This would quickly exonerate any safe treatments, and point out any with adverse effects upon bees.
* Determine any effects upon field colonies in orchards following various pesticide applications, methods, and timing of application by using hive monitors with entrance counters and acoustic sensors. This data would be of great interest to both beekeepers and growers.
* Determine best colony placement—track bees with lidar or otherwise to determine effect of drop size, location, etc.
* Develop a scanner that counts minute-by-minute incoming pollen loads

### Labs

* Set up the ARS lab in California—it is the major agricultural state, and most important state to the bee industry! ***Now in progress at U.C. Davis!***
* Get bee industry support for ARS labs—some current labs and lab leaders have little industry support, and a poor record for practical output

### Data Access

* Make published and unpublished ARS data publicly accessible—this is a valuable resource which gets lost (I recently wanted to analyze data from Harris and Eischen)
* Make all publicly-funded data available, such as that from the Stationary Hive Project

## Citations

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12. Shumkova, R., Zhelyazkova, I. & S. Lazarov (2019). Application of stimulating products in autumn feeding and

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