RF DOPPLER SENSOR FOR ASSESSING BEEHIVE HEALTH

Herbert M. Aumann; University of Maine; USA; herb@mainebiosensors

Abstract This sensor should be of interest to commercial beekeepers as well as the armchair beekeepers who want to unobtrusively monitor the health and productivity of remote beehives with a smartphone. The sensor is small and requires no disassembly or modifications of a hive. The sensor is based on a low-cost, low-power 24 GHz Doppler radar module that is commonly used in automobile collision avoidance systems. With some modifications, it is capable of detecting honeybees in flight at a short distance. The output of the Doppler sensor is an electronic signal the 0 to 800 Hz frequency range. Beehive health and productivity are assessed by monitoring the flying activity of bees arriving at and departing from the hive entrance and comparing it with the activity in front of other hives. To reduce the large volume of data to a single meaningful index, the activity level is quantified by the average root-mean-square (RMS) power in the Doppler spectrum. This index is collected every 2 minutes during daylight hours and transmitted to a central node by a wireless network. Data from three instrumented beehives collected during the summers of 2018 and 2019 are presented. The activity indices were found to be highly correlated with environmental effects, such as temperature and solar radiation. They were also indicators alerting the beekeeper to immediate intervention, such as hive failure, absconding, swarming, and robbing. The technique was validated by comparison with visual hive inspections.

7 Words 241

MYAPIARY-DATA-DRIVEN APIARY BUSINESS

Darren Bainbridge; MyApiary Limited; Australia; Darren.bainbridge@@dmyapiary.com

Abstract MyApiary is a productivity software for commercial beekeepers. We provide business support, helping beekeepers run successful businesses, not just keep bees. Beekeepers now need to pollinate more crops and manage the health of more beehives than ever before. Information management is a critical component for successful business operators in today's demanding farming environment. We have found there is a direct connection between good business management and bee colony health. Through partnering with the industry, MyApiary has custom-built and refined a software management platform specifically for commercial beekeepers. MyApiary's platform now facilitates behavioural change in many beekeeping operations, improving organizational communication and increasing productivity by helping beekeepers make informed data-driven decisions, enabling beekeepers to run effective, sustainable business, ensuring the future of our global food production ecosystem. Our tools bring record-keeping, forward planning, asset management, and cost monitoring into one, easy-to-use app. Our goal is to see commercial beekeeping companies reach their pinnacle of success by reducing business risk and maximizing finical returns. So, put our expertise to work in your business. We look forward to working with you and many industry participants as they become a part of the MyApiary ecosystem.

32 191 Words

TECHNOLOGIES FOR POLLINATOR SURVEILLANCE IN FIELD STUDIES AND INTELLIGENT IMAGE RECOGNITION: RFID, RANA, AND DAISY-II

Sarah E. Barlow; University of Utah, USA; and School of Natural and Environmental Sciences, Newcastle University, UK; sarah.barlow@redbutte.utah.edu; and Mark A. O'Neill; Tumbling Dice Ltd, UK; mao@tumblingdice.co.uk

Abstract Ecologists and beekeepers need technology-based solutions, or e-ecology tools, for acquiring, sharing, and understanding data on pollinators to address urgent knowledge gaps. We will present our work on developing and applying three novel technologies for studying pollinators: these are 1) prototype long-range RFID tags for tracking bumblebees in the field; 2) an automated video monitoring system based on active motion vision, called Rana; and 3) a deep learning intelligent image recognition system based on plastic self-organizing maps, called DAISY-II. We envisage an integrated e-ecology platform that leverages these, and other, tools. Developing the next generation of e-ecology tools will require cross-

disciplinary collaborations between ecologists, engineers, informaticians and beekeepers, and significant investment from academia and industry.

39 Words 117

TOOLS FOR TRANSFORMING DATA INTO KNOWLEDGE

Jerry Bromenshenk; Bee Alert Technology, Inc.; Andrew Dudley; Golden Software; USA; beeresearch@aol.com and andrew@goldensoftware.com

Abstract Regardless of the size of a beekeeping operation, there are times when it is useful to visualize spatial data. Suppose that I have two hives in my backyard; I suddenly discover an infestation of mites, and I would like to reference regional or national maps of varroa outbreaks? If I had 10,000 colonies across multiple states, I might ask whether there are tools to chart where my hives are at, how they are doing, and where, if any, are there problem spots. Also, I might want to overlay my apiary locations over vegetation and habitat maps, or maybe pollen maps. Routinely used in industry, business, university settings, geo-spatial analytic tools are available to anyone to run on home computers. The best programs are intuitive to use and powerful. In this video presentation, I interview Andrew Dudley, Product Manager, and Training Lead for Golden Software. I have been using their 2-D and 3-D modeling and visualization software for nearly 40 years ago. One of the founder partners has ties to the University of Montana. Think of them as a geo-spatial counterpart to the MS Office Suite of Programs, such as MS Word, Excel, Powerpoint, One Note, Outlook, Teams, and OneDrive, where Golden has Surfer, Grapher, Strater, Voxler, MapViewer, and Didger. They offer powerful analytic tools and publication-quality, high-resolution plots. They are not the only company offering visualization tools, but their pricing is comparable to others' annual costs and I have always found their technical support to be readily available and helpful.

31 Words 250

RAPID DIAGNOSIS AND MAPPING OF EMERGENT HONEY BEE HEALTH ISSUES VIA AN AI-POWERED SMARTPHONE APP

Jerry Bromenshenk, Robert Seccomb, Colin Henderson, David Firth, Geoffrey Pepos;Bee Alert Technology, Inc.; USA; beehealthguru@gmail.com

Abstract Bee Health Guru app provides a way to improve honey bee colony health by letting bees communicate their health status to their keeper. The bees become the guru, indicating colony health via their sounds. Our app: (1) Allows beekeepers to record colonies with a smartphone; and (2) Uses Artificial intelligence (AI) algorithms to diagnose each colony's health. These algorithms are not static but can learn based on new training data. Currently, we are tuning the app for accuracy. Our first step consisted of years of audio recordings from research projects. These provided the proof-of-concept, demonstrating accuracies ranging from 86-98% for eight critical colony health variables. Starting in August 2019, our second step recruited beekeepers worldwide to download the application, inspect colonies, and upload the app's diagnoses along with their recordings. Within two weeks of the app's release, we had 653 participants and 400 data uploads, which yielded geo-referenced data maps. These maps showed locations reporting healthy colonies and those reporting colonies with pest or disease problems. Our smartphone application automatically creates a copy of all recordings, beekeeper observations and combines them into a comprehensive, transformative AI colony health diagnosis system featuring real-time monitoring and mapping. All electronic records are stored in a secure, cloud-based destination with safeguards to protect data privacy, confidentiality, and security. We recently added a report-back to the beekeeper feature based on user feedback, automated the mapping, and began producing training videos to use the app effectively.

3 240 words

RFIDS FOR ASSET (HIVE) IDENTIFICATION, LOCATION, TRACKING, AND INVENTORY

Jerry Bromenshenk, Robert Seccomb; Bee Alert Technology, Inc.; USA; beeresearch@aol.com

Abstract Working with Ron Gilbert's team at the USA Pacific Northwest National Laboratory, in 1999, we put the first true RFID tags on bees. Small passive tags using nanoblock microchip technology are now employed for inventory control in the medical industry, warehouses, and stores such as Wal-Mart. These tags, produced by Alien Technology, a world leader in volume production of Radio-Frequency Identification (RFID) products, were developed by Gilbert's team. This same team placed the first RFID tag on a bee for us. Combinations of passive and active RFID tags connected to wireless, cellular, and satellite communications can economically provide theft-protection and hive recovery and also enable nearly effortless inventory, location, tracking, and management options to the commercial bee industry. In our presentation, we cover currently available options, not only for theft protection but also for data-driven bee management. We conclude with this advice to beekeepers: " The infra-structure for intercepting loads of stolen hives is already in place and being used by other industries. It is time to put in place a well-designed, state, and nation-wide service. If you buy only for theft protection, the odds are that it will not be working when a theft does occur. Instead, build a system to meet your daily needs, make it useful for many purposes, and use it to improve your management by providing data-based information. Theft protection is a bonus. Please contact us for help designing an integrated RFID and communications system that meets your unique business needs.

43 Words 246

HIVE MONITORING SYSTEMS AND HOW THEY HELP BEEKEEPERS SAVE HIVES AND MONEY

Rafael Cabrera; Solutionbee LLC: USA; rafael.cabrera@solutionbee.com

Abstract Hive monitoring systems have advanced greatly in the last few years. Their features have matured, and the equipment has become even more reliable and durable. Saving money on equipment starts by selecting equipment that will last a long time in the beeyard. Apiaries are exposed to months and years of rain, dust, and temperature swings that can overwhelm poorly designed equipment. Features such as buttonless controls, wireless configurations, and water-tight enclosures ensure that your investments last trouble-free for years. Replacing batteries can also be a time-consuming effort. Furthermore, batteries that deplete in the middle of a nectar flow, or in the winter are annoying to replace. Look for designs that only sip power sparingly and whose batteries last for at least three years, if not longer. Some excellent designs will last well over five years or more on a single battery. If designed well, hive monitoring equipment will last more than a decade out in the field in the harshest conditions. Weight is one of the most important characteristics of a hive that is the source of a tremendous amount of useful information. There are several critical points throughout the year when tracking weight is extremely important. In conclusion, investing in weight and internal temperature hive monitoring saves hives and improves beekeeping costs and time management. Equipment purchase costs are quickly recovered by hive starvation avoidance and improved honey yield as well as valuable time savings.

Acknowledgements Thanks to Anya McGuirk, James Wilkes, and Sullivan Wilkes for their contribution to this submission.

15 Words 236

THE INSIGNIA PROJECT:

ENVIRONMENTAL MONITORING OF PESTICIDE USE THROUGH HONEY BEES.

Norman L. Carreck and the INSIGNIA Consortium; Carreck Consultancy Ltd and University of Sussex; UK; norman.carreck@btinternet.com
*The INSIGNIA Consortium consists of 16 partner institutions from 12 European countries: https://www.insignia-bee.eu/

Abstract Honey bee colonies are excellent bio-samplers of biological material such as nectar, pollen, and plant pathogens, as well as non-biological material such as pesticides or airborne contamination. All material collected is concentrated in the hive, and the honey bee colony can provide four main matrices for environmental monitoring: bees, honey, pollen, and wax. INSIGNIA aims to design and test a scientifically proven citizen science environmental monitoring protocol for the detection of pesticides via honey bees. It is a pilot project funded by the EU and is being carried out by a consortium of scientists from twelve countries. Pollen collected in pollen traps is being sampled every two weeks to record forage on a single day. In contrast, wax acts as a passive sampler, building up an archive of pesticides, so

alternative in-hive passive samplers are being tested to replicate wax as a "pesticide-sponge." Samples are being analyzed for the presence of pesticides and the pollen's botanical origin using a DNA fingerprinting approach. Data on pollen and pesticides will be then be combined to model the exposure risks to honey bees and wild bees. The system was tested in four countries in 2019, and this has been expanded to nine countries for 2020.

Acknowledgments The pilot project "Environmental monitoring of pesticide use through honey bees" (ref: Multi Call PP-1-1-2018; Grant Agreement SANTE/E4/S12.788418) with the acronym INSIGNIA has received funding from the European Union.

40 Words 204

BEEXML: STANDARDIZING THE WORLD'S BEE DATA

Joseph Cazier; Appalachian State University; Dick Rogers; Bayer Crop Science; Ed Hassler; Appalachian State University; Agnes Gambill; Appalachian State University; USA; cazierja@appstate.edu

Abstract This presentation explores the role that data science and machine learning can play in helping bees and illustrates the need for data sharing. We then summarize efforts by Apimondia Working Group #15 to enable data sharing through data standardization, data policy recommendations and data harmonization efforts. A new journal, BeeXML: Journal for Bee Data Standardization is introduced as a vehicle for data standardization. We conclude with ways you can help these efforts.

25 Words 73

NECTAR TECHNOLOGIES: UPDATE AND CASE STUDY

Maximilian Cherney; Nectar Technologies; Canada; max@nectar.buzz

Abstract Nectar Technologies is a sensor-based precision beekeeping company for the commercial beekeeping and pollination industries. Nectar's mission is to secure the world's pollinated food supply. Using in-hive sensors and external solar-powered data aggregators, Nectar provides real-time insights to help commercial beekeepers raise healthier honey bee colonies and provides growers analytics to optimize their pollination supply chain. We start by giving an update on precision beekeeping. We address some of the challenges that Nectar and other industry members face in advancing beehive monitoring in commercial beekeeping, including the effort required by beekeepers who test new technologies. We propose a few solutions to help advance the integration of monitoring as rapidly and as effectively as possible. We then introduce Nectar's scientific board of advisors, including pollination economists, honey bee researchers, and artificial intelligence researchers. We also introduce Nectar's hive population model, which can classify if a beehive is over 15 frames of bees or under seven frames of bees with 77% accuracy. Finally, we discuss the application of our new hive population model within a Blueberry pollination contract. This model was applied to the Blueberry pollination setting in June of 2020. Nectar monitored 40 hives in Quebec that were contracted to have at least 12 frames of bees and accurately classified 83% of the hives compared to the provincial inspector. This sensor-based model shows promise in improving pollination contracts for both the beekeeper and the farmer.

Acknowledgements Nectar CEO Marc-André Roberge and CSO Evan Henry for the assistance in the development of the presentation.

18 Words 232

WINTER BEEHIVE STORAGE

Kyle and Shannon Christensen; Utah, USA; moroni770@icloud.com

Abstract Three seasons ago, our local beekeeper community approached us about wintering beehives in our vacant commercial poultry barns. They asked for a barn that could maintain 40 degrees in total darkness, control the Co2, and provide backup safety measures at an affordable price from Thanksgiving time to February. With 20 years of experience ventilating these barns through the harshest Utah climate, we knew we could help. Much of the equipment needed was already in place. By re-purposing what we

had, we could pass the savings on to the beekeeper. Our 15-minute presentation focuses on four main areas: Barn prep, ventilation, temp and humidity control, and safety backups. The program describes how the barns are set up. Then we walk you through the process of what we had to do extra to achieve the four requests from the beekeepers. Along the way, we offer tips on how to size and place equipment, manage problems, and other issues to prepare better the listener to store their hives or be more aware of what topics to discuss with a potential vendor. Ventilation is the heart of winter storage success. We demonstrate a crash course on setting up a negative pressure vent system. Also, we share thoughts on managing the 24-hour swing. We wish you the best success in caring for your bees.

49 Words 219

COLONY MONITORING USING THERMAL IMAGING

Scott Debnam; University of Montana; USA: Scott.Debnam@umontana.edu

Abstract Honey bee colonies are superorganisms that display parental care behaviors at the colony level. This behavior includes feeding and protecting the brood, as well as temperature and humidity regulation. It is the responsibility of the youngest adult bees to provide parental care. This subset of the colony has been identified as nurse bees. Within this subset of bees, there are further labor divisions such that there are members of the nurse bees who are specifically engaged in maintaining brood temperatures. These specialized nurse bees are known as heater bees. When conducting their heating behaviors, they are indistinguishable from the other nurse bees in the colony. I utilized thermal imaging to identify the heater bees in research observation hives. The thermal camera provided detailed information about thoracic temperatures that allowed for easy identification and quantification of the heater bees and their behavior. I then utilized thermal imaging to quantify brood temperatures by the developmental stage. Thermal imaging technology allowed me to determine brood nest temperatures down to the per-cell level. Analysis of the thermal images revealed that brood care is conducted at the per-cell level. This individual level of parental care results in a wide range of temperatures within the brood nest, all regulated by the particular brood's needs in each cell.

5 Words 212

BEEHEROX

Huw Evans; BeeHero; huw@beehero.io

Abstract Innovative beehive monitoring technology establishes itself as the most necessary instrument for beekeeping, bee research, and Precision Agriculture. BeeHero's subsidiary: BeeHero X, presents three further potential applications of this technology. Two of those applications are based on bioacoustics and the experience gained over the last decade monitoring the beehive sounds. One such project has led to the development of an Asian hornet (*Vespa velutina*) recognition system. The system developed has been tested and proven in Italy and Belgium, which has given the impetus for BeeHero's initiative to apply this methodology to detect the newly reported Asian Giant Hornet (*Vespa mandarinia*) in the US. The second bioacoustics application is remote sensing of pollinators' abundance and richness. In-field sensors are placed in the crop to detect the presence of pollinators distinguishing among the different species (richness) as well as logging the abundance of each species. The applications of this tool range from precise modeling of pollination right through to conservation. The research behind providing precession pollination as a service has resulted in the development of tools and methods that are not commonplace in apiculture due to their complexity and cost. Over three growing seasons, we have deployed hive monitoring technology during almond pollination in California. We have been able to precisely monitor the changes in bee activity related to the application of fungicides, varying climatic factors, and insights into the apparently non-linear nature of the strong colonies' productivity compared to weaker.

23 Words 239

TECHNICAL INNOVATIONS IN BEEKEEPING

Huw Evans; BeeHero; Italy and USA; huw@beehero.io

Abstract Beekeeping can be considered both an art and a science; therefore, it benefits from technology, as technology applies science to solve problems and extend our abilities. Historically, the evolution of beekeeping technology has been characterized by long periods of steady state, punctuated by significant developments that dramatically changed the craft's nature. The late 1800s heralded the dawn of honey

production on a commercial scale thanks to three key technological innovations; the movable frame, smoker, and centrifugal honey extractor. Today beekeeping technology is experiencing another sharp disruption as electronics and information technology help our understanding and abilities as beekeepers. Over the last few years, the market has seen a surge in gadgets that offer a myriad of services. Beekeepers that benefit from these innovations tend to fall into three distinct groups; while there is an overlap in application, the value extracted from the information is tailored to each. Hobby beekeepers can track nectar flows, compare colony development and receive automated alerts for broodless colonies, the need to add/remove a honey super, when to feed, even when the queen goes on her mating flight. Technology has enabled commercial beekeepers to increase efficiency within their operation, improve management practices, and increase production. Growers can now better track the pollination of their crops. Scientists can collect unprecedented volumes of highly granular bee and environmental data simultaneously and precisely coupled with reliable data management. The question is not if but when will these new technologies become the mainstay of modern apiculture.

2 Words 245

BEE HEALTH GURU NSF I-CORPS NATIONAL TEAM

David Firth; University of Montana; USA; david.firth@mso.umt.edu

Abstract The Bee Health Guru smartphone app listens to bees and identifies colony health problems. This technology received an NSF I-Corps award. I-Corps uses experiential education to help researchers gain valuable insight into entrepreneurship, business startup, industry requirements, and challenges. It makes you talk to potential customers, without talking about your technology, to test hypotheses about what customers want and need. We thought that Bee Health Guru would be perfect for backyard beekeepers to see if their bees were healthy. We quickly learned that most preferred to check on their bees' health themselves. The only market for a bee health detector for this group was newbie beekeepers, a small, constantly changing market. We had also thought that our health monitor would be great for commercial beekeepers, allowing them to reduce costs by having fewer employees. Instead, we found that many commercial operations want to keep all their employees, who are hard to train, and they need those employees to take care of the bees. In an unexpected development, we found that the best customer for our bee health monitoring technology was a new type of beekeeper – professionals who place bees at hotels and other corporate locations so that those companies can say how they are helping the environment and being "socially responsible." These beekeepers found a lot of value in a technology that can monitor bees and their health remotely and allow the professional beekeeper to only go to the location (hotel, airport, etc.) when they need to.

45 Word 248

ANCGIS - AN OPEN SOURCE, MOBILE, AND WEB GEOGRAPHIC INFORMATION SYSTEM FOR RESOURCES MONITORING

Sylvain Galopin; University Gustave Eiffel IGN; France; sylvain.eloi.galopin@gmail.com

ABSTRACT The apiaries placed in large cultivation areas are confronted with recurrent problems of summer food shortages, which unfortunately increase year by year due to global warming. Based on this observation, it is necessary to determine as precisely as possible the honey potential around the apiaries. The easiest answer for a beekeeper is to place automatic scales under their hives. But that only gives an annual vision that is strongly subject to the climate of the year and the colonies' strength. This first approach may be supplemented by pollen analyzes to have another picture, but this still does not allow us to have a global and precise vision of the potential that a vegetation survey can give us. This is why the AncGIS application has been created. AncGIS is the acronym of "Apinutriculture Geographic Information System". Apinutriculture means the Cultivation of nutrients (plants) for apis (bees). AncGIS is both a desktop and mobile application and aims to allow a detailed analysis of the honey resources around an apiary. The objective is to facilitate the analysis of the territory by beekeepers to give them the keys to improve their potential.

35 Words 217

FLIGHT AND CLUSTER HOURS MODEL

Manuel Gutierrez, Appalachian State University;Dick Rogers, Bayer Crop Science, and Appalachian State University;Joseph Cazier, Ed Hassler; Appalachian State University; USA; dick.rogers@Bayer.com

ABSTRACT Honey bee colony development and behaviors are strongly influenced by conditions, including temperature, light quality, day length, wind, and rain. These factors even allow colonies to synchronize to the change in seasons. This makes honey bee colonies highly adaptable and able to survive in regions with very different climates. However, the species still does better if managed by beekeepers. The trick for beekeepers is to know how to adjust management to take weather and climate into consideration. To develop a tool to visualize the climate impact on honey bees, a series of algorithms for calculating flight and cluster hours (FCH) were developed. The calculations use published and observed threshold temperatures for these behaviors and readily available local, regional, and/or site-specific weather data. Tableau® was used to build a prototype interactive tool for the visualization of flight and cluster hours over time. Preliminary results show that the influence of elevation and local conditions on honey bee flight and clustering behaviors can be detected. We envision useful applications for precision pollination, determining forage utilization, monitoring conditions for cleansing flights, and investigating climate-change from the perspective of the honey bee. Initially, the focus of this research is on North Carolina. However, it should be possible to scale up to the entire US and beyond to produce heat maps and provide data for research. In this presentation, we present an open-source tool that was developed to help apiarists make climate-smart decisions that will improve the survival and productivity of honey bee colonies globally.

27 Words 249

SWARM MONITORING

Theo Hartmann; BroodMinder People's Drone; USA; theo@broodminder.com

Abstract The presentation shows how relatively simple instrumentation (temperature and weight) can help to detect colony swarming and to distinguish between swarms initiated by mated queens and after swarms initiated by virgins. Functionality has been implemented in the T2SM temperature measuring device for brood nest temperature spike recognition, capturing high-resolution data before, during, and after the swarm event and automated beekeeper notification when an event occurs. This instrumentation, combined with hive weight measurement, made it possible to show the timing between swarm departure and the brood nest temperature spike. In most cases, the spike occurs at or after the swarming bees' departure. The common assumption that the temperature spike is caused by the swarming bees warming up their flight muscles may not be correct. The data show that the general chaos more likely causes the spike in the hive during a swarm event and the bees which are staying behind are simply overwhelmed and unable to regulate the brood nest temperature until the swarm is over. It has further been discovered that swarms return to the hive surprisingly often. It is believed that this is a result of virgins going on mating flights, and a rather large number of bees are escorting the virgins and return to the hive when she returns. The firmware upgrade required for swarm detection is available free of charge to current BroodMinder T2 owners.

Acknowledgement Firmware upgrade was implemented following the logic published here: https://www.sciencedirect.com/science/article/abs/pii/S1537511016300964

22 Words 231

ACCURACY OF INFRA-RED (IR) IMAGING TO ASSESS COLONY POPULATION SIZE

Colin B. Henderson, Robert Seccomb, Scott Debnam, Jerry Bromenshenk;Bee Alert Technology, Inc.; USA; beehealthguru@gmail.com

Abstract Since 2010, we have been exploring the use of non-invasive, IR evaluations of colony population size, using high-end research and robust, NIST certified(accuracy), IR cameras. In 2015, using professional grade FLIR IR cameras, we inspected 1500 colonies in California, with 500 colonies in southern, central, and northern regions of the state. We imaged all of the colonies at night. We compared the IR images to visual inspections conducted by commercial beekeepers and our own Bee Alert team. Our objective was to determine if a one-to-one equivalency between IR imaging and visual inspection was possible. Our initial data analysis showed that IR imaging, compared to visual inspection, significantly

overestimated the population size of colonies with a frame count below ten and underestimated the strength of colonies with ten or more frame of bees. A one-to-one equivalency was not possible. However, when we considered temperature profiles by colony relative strength and region, we found that grading by relative colony strength was quick and reliable. Our ability to segregate moderately weak (< 6 frames of bees) from very weak colonies was the only difficulty. We also found that by accessing the certified radiometric pixels of high- resolution cameras, it is probable that we can reach the necessary IR to visual inspection equivalency for rapid, effective colony grading. Our overall objective is to algorithms readily available to work on any IR camera, all across major brands of IR cameras, allowing beekeepers to choose the best camera for their purposes.

Acknowledgements Funded by Project *Apis m.*

44 Words 245

AMERICAN HONEY PRODUCERS PERSPECTIVE

Chris Hiatt, Hiatt Honey; Matt Halbegwachs, Sweet River Honey; USA; hiattch@sbcglobal.net, matt@ahpanet.com

Abstract During this final session of the 4th International Bee and Hive Monitoring Conference, two members of the American Honey Producers (AHPA) provide insights about their interests and needs and then field questions from Conference Panelists. Chris Hiatt is the current Vice President of AHPA. He is co-owner of Hiatt Honey and runs 20,000 hives between California, Washington, and North Dakota. Matt Halbegwashs, Executive Board member of AHPA, owns Sweet River Honey. He runs 10,000 colonies between Texas, North Dakota, and California. With new technologies, there may be disconnects between researchers, innovators, and their potential customers. A common mistake made by innovators is that they first develop solutions, then look for problems. As David Firth's NSF I-Corps presentation revealed, talking to customers yielded surprising results. In the USA and Canada, the largest potential market for colony monitoring systems is the commercial or professional beekeepers. The largest businesses mostly reside in the western states and provinces. They often have thousands, or tens of thousands of colonies spread over large areas, even regions. If one wants to gain valuable insights, the obvious first step is to talk to long-established, large-scale beekeepers, who are leaders of their industry – J.J. Bromenshenk.

50 Words 196

BEEHERO - POLLINATE & PROSPER

Itai Kanot; BeeHero; USA and Israel; itai@beehero.io

Abstract As agriculture evolves into this data-driven age; modern growers know more about their businesses than ever -- except the essential beekeeping and pollination process -- until now. Started in 2017 in Israel, BeeHero is the first and only company built by commercial beekeepers for commercial beekeepers to bring efficiency and innovation to beekeepers and their essential profession. We understand their need for precision, transparency, and protection from volatility, so we are bringing innovation and technology to their craft with a product that accommodates and celebrates their imperative dedication to quality. Designed to reflect their tenacity, we built our hardware to simply and seamlessly improve upon standard operations and pollination duties using data and AI. In the process, we have also created the world's largest honey bee database, together with our network of beekeepers. We are launching our system's third generation: smaller, easier to install, even longer battery life (about three years), higher accuracy, and more. The best part about our system is that our unique model allows us to provide our platform to commercial beekeepers at no cost! We help beekeepers improve their hives year-round for in-time for almond pollination when we get them the best contracts available. We pay by the frame, so they always get the actual value of their hives with up to $340/hive. And we guarantee on-time payments, regardless of when farmers pay. Let us grow together!

13 Words 227

APIMAYE INSULATED BEEHIVES

Korhan Kaftanoglu; Kaftan LLC; Osman Kaftanoglu; Arizona State University; Emre Yildirim; Yildirim Plastik AS; Turkey

Abstract APIMAYE insulated beehives are designed to increase the honey bee colonies' productivity, reduce bee mortality, and fulfill the beekeepers and queen breeders' needs. The project was supported by the Turkish Scientific and Technical Research Council (TUBITAK). Apimaye hives are sold worldwide and received the gold medal at the APIMONDIA International Congress in 2015. APIMAYE insulted beehives are made from food-grade polyethylene and insulated with polyurethane (R-Value of 6.9). The insulation reduces honey consumption during the winter. Therefore the colony can survive harsher and longer winters. Insulation also leads to better build up in the spring. The frames and supers can be used interchangeably with the wooden hives. Apimaye product range includes ten-frame hives, seven-frame hives (nucs), 4-compartment queen-rearing hives, and upgrade kits for wooden hives. All hives are fully assembled. The ten-frame hives' standard features include a built-in pollen trap, pollen tray, and bottom tray, queen excluder, division boards for brood chamber and supers that enable two queen system in one hive, entrance reducer/mouse guard, top feeders for liquid or dry feeding, and insulated top cover. All hives have handles and latches for easy lifting and transportation. Seven-frame hives are designed for queen rearing and honey production. User friendly and break-resistant plastic Pro Frames accept beeswax or plastic foundations for liquid or comb honey production. All the hive monitoring programs and technologies can easily be implemented in the Apimaye hive components. Sensors and chips can be implanted in the hive body or frames for hive monitoring and theft protection.

41 Words 235

Honey Bee Colony State Detection by Temperature Data

Armands Kviesis, Vitalijs Komasilovs, Olvija Komasilova, Aleksejs Zacepins; Latvia University of Life Sciences and Technologies, Latvia; armands.kviesis@llu.lv

Abstract Bees, as the main pollinators, are one of the important insects in the world. Therefore, it is important to preserve them from danger and help the beekeepers manage their colonies. During the bee colony's annual life cycle, different bee states can be observed or distinguished, like brood rearing, swarming, colony death, or other abnormalities. It is of high importance to detect such states in an early stage, so the beekeeper could act accordingly in order to manage, save, or improve the life of his colonies. Since bees are excellent at thermoregulation, it is possible to recognize a majority of the bee states by looking at temperature data. Nowadays, information technologies have developed rapidly, providing various methods and techniques for different problem-solving. Our study focuses on a combination of Artificial Intelligence methods like Fuzzy logic and Artificial Neural Networks in order to automatically detect and identify bee colony states and other abnormalities by using only in-hive temperature data. Performance evaluation of the proposed methods proved their stability and robustness and can be considered a core part of a Decision Support System for beekeepers. This scientific research, publication, and presentation is supported by the Horizon 2020 Project SAMS" Smart Apiculture Management Systems." SAMS proposes implementing Precision Beekeeping by allowing active monitoring and remote sensing of bee colonies and beekeeping by developing appropriate ICT solutions supporting the management of bee health and bee productivity and a role model for effective international cooperation.

Acknowledgments Scientific research, publication and presentation are supported by the Horizon 2020 Project SAMS" Smart Apiculture Management Systems." This project receives funding from the Horizon 2020 European Union Research and Innovation Framework under Grant Agreement Nr° 780755 – SAMS.

16 Words 239

DEMO OF BEESCANNING - MONITORS VARROA

Björn Lagerman; BeeScanning Global AB; Sweden, björn@beescanning.com

Abstract The BeeScanning app analyzes images taken with a smartphone's camera. It is based on our findings that there is a correlation between the actual varroa infestation level, as measured by alcohol washing or other chemical treatments, and the varroa that is optically detectable. Please find more at https://beescanning.com. Diagnosing varroa is for free. Deformed wing virus, brood disorders, queen and colony strength will soon be offered as a subscription. Images are taken of living bees on the comb. The app forms a basis for a decision on treatment and selection in breeding programs and population modeling research in colonies. New features include brood diseases and bee behaviours based on evolving technology using AI video and sound analyses. In our database, there are 100,000 + images and videos (increasing by 1000 images per day from users all over the world) and more than 25,000 manually annotated regions in 15 classes. These can be viewed at http://tagger.beescanning.com. Analyzed images are stored and used for further training of the AI. During the season 2020, users have detected 300,000 varroa in their pictures. Varroa: Mean average precision: 83% Recall 67%, meaning it is accurate enough as a powerful tool. Metadata such as time, geo-position, breed - is collected to monitor events, nutritional status, health, and to make prognoses. The Swarm is the sequel to BeeScanning, a research center for projects using Beescanning technology and finding new paths sustainably using land. The motto is healthy bees in healthy landscapes. Please visit theswarm.one

BeeScanning is funded by the European Innovation Program, the Swedish Board of Agriculture, The Swedish Agency of Innovations, via Kickstarter, and 15 national and international awards.

4 Words 248

NONINVASIVE BEEHIVE MONITORING THROUGH ACOUSTIC DATA

Yuwei Liao; SAS Institute Inc.; USA; Yuwei.liao@sas.com

Abstract Honey bees are critical pollinators of food crops, and it is likely that their demise would be disastrous for human beings. Thus, maintaining healthy bee colonies is vitally important. Beekeepers usually monitor the status of beehives by performing manual examinations in order to check whether the queen bee is missing or to look for any other potential problems. However, manual hive inspections are not only time-consuming but also disruptive to the colony. With the advances in sensor technology and decreasing cost of sensors in recent years, noninvasive beehive monitoring is growing more and more popular. Research in computational bioacoustics has discovered connections between the sounds in the hive and different behaviors of bees. This presentation shares our progress in developing a noninvasive beehive monitoring system using acoustic data. Along the way, we illustrate the usefulness of the digital signal processing tools and machine learning algorithms available in SAS® Event Stream Processing and SAS® Viya® software to noninvasively monitor the real-time condition of a beehive and detect important queen bee and worker bee piping sounds. The technical aspects of the acoustic monitoring system described here are part of a larger effort at SAS to monitor the four beehives at the Cary, North Carolina, headquarters with many different sensors.

10 Words 207

MONITORING COLONY STATUS WITH A TEMPERATURE SENSOR GRID

Frank Linton, Colony Monitoring Website; fnlinton@gmail.com

Abstract Honey bees optimize their nest environment for carrying out major activities such as overwintering, brood rearing, and nectar processing. We designed, constructed, and installed a temperature sensor grid consisting of 36 temperature sensors (in 4 rows of 9 sensors) to observe these activities in detail. Our sensor grid yielded unexpected results regarding in-hive temperatures during overwintering, unexpected results regarding springtime brood volume, and it tracked the transition from overwintering to brood rearing.

Acknowledgments Anna Stumme, Brett Padula, Gregory Behrmann, and Gail Ifshin.

17 Words 72

THE 4TH INTERNATIONAL BEE & HIVE MONITORING CONFERENCE: CONFERENCE OVERVIEW

Frank Linton, Colony Monitoring Website; fnlinton@gmail.com

Abstract The 4th International Bee & Hive Monitoring Conference will provide Zoom attendees worldwide with the latest colony monitoring developments, ranging from products on the market today to research that may result in products in the future. The monitoring technologies presented take advantage of low-cost sensors, powerful batteries, communications technology, cloud storage, information processing algorithms, and interactive visualizations. From the analyses these technologies present, beekeepers may obtain overviews of the health and productivity of their colonies, evaluate the results of past actions, and make plans for effectively managing their colonies on the next visit to the apiary.

Acknowledgements Jerry Bromenshenk, co-organizer.

1 Words 96

A GAME OF DRONES, USING UAVS TO FIND WHERE HONEY BEES MATE

Julia Mahood; Master Beekeeper; USA; julia@mapmydca.com

Abstract Honey bees mate only in flight, up to sixty meters high, a practice that has made studying this area of reproduction a challenge. In the spring and summer months, drones leave the hive and fly to discrete places called drone congregation areas (DCAs) where thousands of drones from different colonies meet and fly around looking for queens with which to mate. Mysteriously, new drones find the same DCAs year after year, even though no old drones survive the winter. In the past, looking for DCAs has been done by surveying an area with a weather balloon filled with helium, dangling queen pheromone below as lure. This method is expensive and limiting in scope. Using the other kind of drone, an Unmanned Aerial Vehicle (UAV), a single user can easily survey areas of varying terrain. Mapmydca.com is a citizen science project designed to collect locations of DCAs in hopes that this data will be useful for future research on this honey bee behavior. The site features information about honey bee drones and DCAs and information about looking for DCAs using UAVs. When a user finds a DCA, they can post the location on a world map along with information about the DCA, including an option for a link to a video.

37 Words 208

Monitoring Hives with SAS® Event Stream Processing

Anya McGuirk; SAS Institute Inc.; Anya.McGuirk@sas.com; USA

Abstract SAS Institute Inc., a leader in advanced analytics software, is currently monitoring beehives at its world headquarters in Cary, North Carolina. The goal of the project is to demonstrate the real-time analytics and alerting capabilities of SAS using SAS® Event Stream Processing software, a foundation product of the Internet of Things Division at SAS. The system monitors hive weight, internal temperature and humidity, acoustics, and bee activity using computer vision. The monitoring system includes sensors from various hive monitoring companies, including BroodMinder and Solutionbee. The streaming analytical capabilities of SAS Event Stream Processing are critically important. A robust principal component analysis (RPCA) model trained offline on video recorded at the hive entrance is used to score streaming video with the software. Its connected component and tracking plug-ins are then used to track and count the number of arriving and departing bees, with all analyses done at the hive. RPCA is also used to decompose 10-minute spectrograms estimated at the edge into a spectrogram that characterizes the hum of the hive (the low-rank matrix) and another that captures the extraneous sounds (external and internal). The low-rank matrix is used to monitor the general hum of the hive over time. A 21-hour acoustic recording of a queenless split revealed a worker making piping sounds at the same frequency as a virgin queen calling to her competitor queens within 30 minutes. The piping subsided after approximately five hours. Was the worker calling to see whether a queen was present? The work continues.

30 249 Words

GOT SENSOR, NOW WHAT? EXTRACTING INFORMATION FROM CONTINUOUS DATA

William Meikle; Carl Hayden Bee Research Center, USDA-ARS: ARS; William.meikle@usda.gov

Abstract Using sensors to monitor bee colony health, like monitoring the environment or even human health, is becoming feasible for most researchers as cost and size of sensors decrease while their precision and capacity increase. Monitoring bee colony temperature has been done for a long time (I have a USDA publication on that from 1914). Our approach to extracting information from continuous temperature data has been to detrend the data by subtracting the 24-hour running average from the raw data, and then modeling the residuals using sine curves. This breaks the data into a between-day part (the running average) and the within-day part (the residuals), and each part can be evaluated separately. We showed that effects of sublethal pesticide exposure on thermoregulation in the field were reflected in clusters of caged bees in the laboratory. We extended this approach to the analysis of continuous CO2 data. We have found that sensor data can detect effects on colony collective behavior and health in situations that periodic hive inspections or standard analyses of individual bees do not.

Acknowledgements: Many thanks to Milagra Weiss, Eli Beren and Meg Glodowske

28 Words 175

SNIFFING OUT AMERICAN FOULBROOD: VOLATILE BIOMARKERS FOR NON-INVASIVE DIAGNOSIS

Jessica Moran; Cooperative Research Centre for Honey Bee Products (CRC-HBP), Australia; Honey Bee Health Research Group at School of Molecular Sciences, University of Western Australia; jessica.moran@research.uwa.edu.au

Abstract American foulbrood (AFB) is the costliest honey bee disease in Australia. Caused by the bacterium, *Paenibacillus larvae*, AFB kills honey bee larvae and converts the cadaver to a foul-smelling, spore-laden, glue-like mass. Early detection and intervention are critical to prevent the disease from spreading to nearby hives and apiaries. Although various diagnostic methods have been developed, AFB remains a significant problem for beekeepers. Diagnosis is often slow, generally requiring beekeepers to open hives and visually identify AFB symptoms. In this project, we investigated the volatile compounds associated with AFB's notoriously foul smell to determine if specific compounds could be used as a method for quick and non-invasive diagnosis. We used gas chromatography-mass spectrometry (GC-MS) to identify numerous compounds that are significantly elevated in - or exclusive to - AFB-diseased brood compared to healthy brood. We further investigated the specificity of the compounds for AFB compared to brood that had died of temperature shock or other brood diseases. These biomarker compounds can be used to diagnose AFB-diseased brood with an accuracy of over 97%. In a follow-up field experiment, we demonstrated that these volatile biomarkers could be detected non-invasively in beehive air. We are now developing sensor surfaces for the biomarkers to create a portable, electronic, diagnostic "beehive breathalyzer" device. This work aims to develop a practical and cost-effective tool that will de-risk high-density beekeeping through improved biosecurity.

Acknowledgements Contributing authors of this work are Jessica Moran, *Tiffane Bates, Maike Bollen, Gavin Flematti, Julia Grassl;* This research is supported by a CRC for Honey Bee Products Ph.D. Scholarship and UWA Alexander Juett Fellowship Ph.D. Top-Up Scholarship in Agriculture, with assistance from the Western Australian Department of Primary Industries and Regional Development and the Metabolomics Australia, Centre for Microscopy, Characterization, and Analysis, University of Western Australia .

29 Words 233

WHAT ARE YOU MISSING? ADVANCES IN HIVE MONITORING

Rich Morris; BroodMinder, USA; Rich@BroodMinder.com

Abstract In this talk, we look at how hive monitoring can impact visual hive inspections. By utilizing Dick Roger's Healthy Colony Checklist as a guide, we walk through a variety of hive events and how they manifest in hive temperature, humidity, and weight measurements. Examples include brood rearing, queen loss, swarming, and overwintering.

Acknowledgments Thanks go to the entire BroodMinder and Mellisphera development teams.

21 Words 52

IOT APPLICATIONS FOR HONEY BEE COLONY CONDITION – WHAT'S THE BUZZ ALL ABOUT?

Fiona Edwards Murphy; ApisProtect; Ireland; enquiries@apisprotect.com

Abstract Contributing $174 billion worth of pollination to the agri-food industry annually, honey bees play an essential role in global food production. ApisProtect is an Irish agtech company established to help reduce honey bee losses worldwide. ApisProtect uses a unique combination of sensors to monitor honey bees in the hive and collects temperature, humidity, sound, and movement data from a single sensor unit. This technology's key value is the processed data – a high-level overview of each apiary with a breakdown of which hives are doing well, which ones are likely to experience problems, and which hives currently need immediate attention providing a 24/7 early warning system to help reduce honey bee losses. These sensors will help beekeepers identify a wide variety of problems earlier than they can using traditional inspections. ApisProtect is now available in the US for commercial beekeepers; please email enquries@apisprotect.com to find out more.

11 Words 146

O'KEEFE ELECTRONICS WIFI HIVE SCALE

Patrick O'Keefe Jr.; O'Keefe Electronics; USA; info@wifihivescale.com

Abstract Bees need our help more than ever. Today's electronic technology can provide the beekeeper with insights into the colony's behavior to give the needed guidance. This information is useful in managing the hive as well as preventing catastrophic events. The *WIFI Hive Scale* provides profound knowledge about the condition of the colony. The beekeeper can determine the strength of the hive the first day the scale is installed. The information can be used to monitor nectar runs, know when to add supers, when to feed, know when to harvest the honey, and help with decisions such as how much to leave for winter feeding. This presentation focuses on the catastrophic events that are encountered in the hive. Clear trends in the data provide information to prevent swarms, stop robbing, identify dearth conditions and act, pinpoint queen loss, and determine early warning signs of disease. Actual graphical data examples of catastrophic events from live colonies are illustrated and discussed where the *WiFi Hive Scale* has been deployed. This presentation shows how these events can be preempted and mitigated. The *WiFi Hive Scale* was designed to provide many years of operation in the difficult and challenging physical environment that hives find themselves in with rain, sleet, intense cold and heat, salt spray, and even hurricanes.

19 Words 213

BEAVER PLASTICS' EPS (EXPANDED POLYSTYRENE) MOLDED LANGSTROTH HONEY BEE BROOD BOX

Paul O'Neil and Stuart Shim; Canada and USA; paul.oneill@beaverplastics.com

Abstract Beaver Plastics' eps (expanded polystyrene) molded Langstroth honey bee brood box has many advantages over conventional wood. Beekeepers report greater yields and better overwintering survival rates. Benefits of Beaver Plastics Langstroth honey bee brood boxes include: (1) Excellent insulation/thermal properties compared to wood, (2) Will not expand or shrink due to moisture, (3) Lightweight, yet strong; (4) Discourages mold growth, (5) Provides years of service with proper care, (6) Readily accepted by honey bees, (7) No nails to spring loose, or metal components, (8) No assembly required; (9) Uniform dimensions; and (9) Embedded RFID (Radio Frequency Identification) technology.

The current and future versions of Beaver's box include an embedded RFID (Radio Frequency ID) tag, developed with input from the California Department of Agriculture and Natural Resources and USDA. This enhancement allows positive and unique identification of each box, aiding in inventory and management control and tracking using mobile, fixed, and drone-mounted RFID readers. Reading distances of 15-18 feet using a mobile reader are typical due to the lack of signal interference by metal box components. Since the electricity to activate the RFID signal is provided by the reader, no external power sources are needed. Future developments may include embedding temperature-sensing RFID tags to help monitor real-time colony health and side-by-side nuc (nucleus colony) boxes, depending on demand.

42 Word 207

OPEN SOURCE PRECISION-BEEKEEPING PLATFORM FOR BEEKEEPERS AND RESEARCHERS

Lorenzo Pons;Mellisphera; France; lorenzo@mellisphera.com

Abstract Bees and beekeepers face strong challenges with respect to keeping healthy honey bee colonies. The reasons are multiple and well documented. Some problems can be addressed and solved; others will stay a long time. Many initiatives are addressing this endeavor—research institutions, corporations, policymakers, start-ups, beekeepers, and citizen scientists. Their numbers are growing as the world realizes the urgency to help pollinators. Technology offers promising levers to address the question. Unfortunately, part of these efforts are redundant. How many hive scale initiatives? How many inner temperatures or apiary digital logbooks? Stakes are high, and we are losing time and resources by remaking the same things. In most cases, what is needed is mostly identical: a database with apiary, hives, devices, and locations, dataViz, weather services, and other metadata. At Mellisphera, we want to address the question from a different perspective by building an open-source platform—a foundation for anyone willing to work on technology for bees. More people need to start working directly on what matters the most: research and solution assessment, making greater progress in problem understanding, not in IT architecture. And we want to help researchers as much as we want to help beekeepers. We are giving data-analytics and user-experience the same priority. The reason being that the most effective way to make progress is by getting rapid feedback from users. We apply design thinking and lean startup techniques to build an open platform that links researchers with users as much as it connects users with researchers.

33 Words 251

OREGON STATE UNIVERSITY *VARROA* RESEARCH UPDATES

Ramesh Sagili; Oregon State University; USA;
Ramesh.sagili@oregonstate.edu

Abstract Oxalic Acid Vaporization Study: Over the past couple of years, there has been increased interest among backyard and commercial beekeepers regarding using oxalic acid in vapor form during the brood-rearing season. Toxicity to brood (eggs, larvae, and pupae) is a concern when using oxalic acid in a brood's presence in a colony. To evaluate the toxicity of oxalic acid vapor to brood, we conducted a short study in 2019. We used 30 colonies of similar size with an equal number of frames of bees and brood and similar mite levels. Out of the total 30 colonies, ten received OA treatment, ten colonies served as controls (no OA), and the remaining ten colonies received formic acid (Formic Pro). Formic pro was used as a positive control (two pads of Formic Pro). Each oxalic acid treatment colony received a single dose of 2 gm oxalic acid vapor as per label recommendation. In each experimental colony, we marked 50 eggs, 50 young larvae, and 50 old larvae using acetate sheets before the application of treatments (oxalic acid vapor and formic acid). Mortality of eggs and larvae was recorded 24 hours, 48 hours, and one week after the oxalic acid vapor and formic acid treatments. We did not observe any significant differences in brood (eggs and larvae) mortality between colonies receiving oxalic acid and control treatments. However, the brood mortality was significantly higher in the formic acid treatment group when compared to oxalic acid and control groups.

46 Words 243

SAMS – SMART APICULTURE MANAGEMENT SERVICES

Stefanie Schaedlich* and Florian Scholl; Coordinator* of the SAMS project; Germany;
Stefanie.schaedlich@giz.de

Abstract SAMS is an abbreviation for International Partnership on Innovation in Smart Apiculture Management Services. SAMS is a multi-national, interdisciplinary project, with the goal to promote beekeeping in tropical regions by applying the Internet of Things (IoT) systems and Information and Communication Technology (ICT). The three-year project enhances international cooperation on ICT technology and sustainable agriculture between the SAMS partners from Ethiopia, Indonesia, Latvia, Austria, and Germany since January 2018. The SAMS project aims to develop and offer an open-source remote monitoring technology that supports beekeepers in managing and monitoring the health and level of productivity of bee colonies. Therefore, beehives are equipped with sensors to measure different variables representing the status of bee colonies. The logged data is transferred to a central, online SAMS Data Warehouse. The data monitoring is beneficial for two stakeholder groups: First, beekeepers receive additional information on their bee colonies' status from wherever they are and can use it for their decisions in beekeeping. Second, researchers can access the worldwide monitored data about bee colonies for studies and scientific recommendations on apiculture. Small-scale beekeeping businesses provide perfect innovation labs for demonstrating and disseminating cheap and easy-to-use open-source ICT applications. The integrated Decision Support System (DSS) constitutes a remunerative incentive for the beekeepers to use such ICT applications to ensure bee productivity. The DSS provides recommendations for managing monitored beehives based on the analysis of the logged beehive data.

Acknowledgement This project has received funding from the European Union´s Horizon 2020 research and innovation programme under Grant Agreement N 780755.

34 Words 239

Open source monitoring platform BEEP development in B-GOOD project

Marten Schoonman; BEEP Foundation, Netherlands; marten@beep.nl

Abstract BEEP is based in The Netherlands and provides open source tools to beekeepers to help them keep honey bee colonies healthy. The BEEP platform consists of a responsive web application and a digital hive monitoring system. The BEEP app is a digital colony management logbook in which one can register inspections and access sensor data from the BEEP base or another (hive monitoring) device via API interfacing. Its main strength is the standardized data categorization with over 600 items that the beekeeper or bee researcher can select from to organize their data collection. The BEEP base measures weight, temperature, and sound of the bee colony. More sensors can be added, and the app code and base designs and firmware are open source available. The custom PCB is designed to be as energy efficient as possible and uses LoRa data connectivity. The BEEP platform is further developed into a decision-making support tool for honeybee health in the B-GOOD research project.

Acknowledgments BEEP team members, research project teams including B-GOOD, partners, funders, the BEEP community of techno beekeepers, B-GOOD project.

14 Words 159

BPRACTICES - CORRELATING GOOD BEEKEEPING PRACTICES WITH DATA

Andrew Scott; Ed Hassler, Joseph Cazier, Jame Wilkes; Appalachian State University; USA; Giovanni Formato; Istituto Zooprofilattico Sperimentale; Italy; scottaj4@appstate.edu

Abstract The environment and habitat of almost all species around the world are being affected by climate changes, and pollinators are definitely not an exception. As part of the United Nation's 17 Sustainable Development Goals, the Istituto Zooprofilattico Sperimentale del Lazio e della Toscana (Veterinary Beekeeping Laboratory Office) affiliated with the Food and Agricultural Organizations took on this global best beekeeping practices project. The first part of this project culminated in a list of 234 beekeeping practices proven to help with key hive metrics like survival and honey flow. In the next section of the BPractices project, we searched to prove a handful of practices legitimacy using data from apiculture integrated software systems. During this iteration of the project, we have found significance in four of the seven original hypothesized practices. Recordkeeping, fall, spring, and winter inspections have all been proven as significant factors in the hives overwinter survival rates through this study. Further analysis of the queen acceptance, treatments, and yard address variables would be needed to prove these. The final phase of this project will be transferring the information we have gleaned from the database

analysis to an economic metric for the impact of following these practices. This will be conducted by officials qualified for this analysis at the United Nations. Preparing the data and understanding what the differences are between the groups that survived and those that died is critical to the forward progress of this project in the coming months.

Words 243

DECIMETER RESOLUTION LIDAR FOR MAPPING FORAGER BEES

Robert Seccomb; Bee Alert Technology, Inc.; USA; bobseccomb@gmail.com

Abstract When people ask me what I do for work, and I casually say, "Well, sometimes I make honey bees go look for land mines. For almost 20 years, the Montana team has been conditioning bees to find nearly anything with an odor: bombs, drugs, cadavers, etc. If the bees can smell it, they probably can be directed to search for it. But, if you have got bees looking for land mines, how do you look for the bees? Twenty years ago, few people knew about LIDAR (Light Detection and Ranging). Back then, it was being used for atmospheric research. Now it is being used in automated cars and landscape mapping. The principle is simple enough; a pulse of light is shot out, hits a target, and gets reflected. Measure the time between the pulse and the reflection, and you can work out the distance to the target. Our target happens to be a bee buzzing in the field. Or, more accurately, a lot of bees trained to locate explosives. If that laser is set up to scan back and forth across the field, you can start mapping where every bee is and how often bees visit a specific spot. If those TNT seeking bees are lingering over one spot, you have got explosive residue there. And probably a land mine.

36 Words 222

LANDSCAPE-SCALE FLOW/DEARTH MONITORING: A ROBUST METHOD FOR MESSY DATA

Douglas Sponsler; University of Würzburg Germany; douglas.sponsler@uniwueraburg.de

Abstract Colony weight monitoring is a powerful approach for studying the ecology and social physiology of bees. Its implementation, though, is fraught with a host of inherent theoretical and methodological challenges, including issues of experimental design, data processing, and quality control, statistical modeling, and biological interpretation. In this paper, I present a study in which weight monitoring data from 36 honey bee colonies distributed across 12 apiaries were used to characterize the temporal patterns of floral resource availability in a complex urban landscape of Philadelphia, PA. To address issues of data quality and site-specific artifacts, I developed a robust analytical workflow using normalized, first-order-differenced data fit with generalized additive models. The results of this analysis reveal three strong nectar flow periods in mid-spring, late spring, and late summer, respective. A strong nectar dearth occurred in August, during which all colonies in our study lost weight. In conjunction with other emerging techniques, such as waggle dance mapping and pollen metabarcoding, colony weight monitoring harnesses the sampling power of foraging honey bees to provide a unique perspective on the ecology of landscapes.

38 Words 179

VERIFLI: INFRARED IMAGE ANALYSIS FOR COLONY SIZE INSPECTION

Ellie Symes; The Bee Corp; USA; ellie.symes@thebeecorp.com

Abstract The Bee Corp (TBC) received a Small Business Innovation Research (SBIR) Phase I Grant from the National Science Foundation (NSF) to research and develop a beehive grading solution for commercial pollination in 2018. TBC's Phase I research proved the viability of infrared (IR) image analysis to determine hive population from a commercial and a technical feasibility perspective. Modeling hive population from IR images included image processing and segmenting, statistical modeling, feature engineering, model optimization, and performance testing. To build these models, ambient, biological, and thermodynamic factors were included to account for heat effects on the IR image not caused by the bees. TBC then built an image recognition model to find the hive in each image in order to extract thermal values for analysis automatically. During Phase I, TBC proved the technology is viable, and IR data can be used to calculate colony size accurately. TBC also demonstrated market demand and commercial viability for the solution. Through these pilot tests, TBC determined necessary improvements for its NSF SBIR

Phase II grant for full commercial scalability and viability. Halfway through this second grant, The Bee Corp will present an update on its research.

Acknowledgments: Growers and beekeepers who helped build this technology, our advisors and board members, the National Science Foundation, gBETA, THRIVE, and its other partners and supporters for making this opportunity possible

8 Words 193

PRACTICAL HIVE MONITORING FOR THE SERIOUS BEEKEEPER

Etienne Tardif; Serious Hobbyist and Asker of Questions; Yukon Territories; yukonhoneybees@gmail.com

Abstract One challenge that new beekeepers have is learning and understanding that all beekeeping is local. Most beekeeping is done in locations where some knowledge or history is already in place through Beekeeping Association/Groups or an established network of experienced, knowledgeable beekeepers. In my talk, I will describe what a serious beekeeper/club can do where there is no prior knowledge/experience or critical gaps exist. In the next 15 minutes, I will describe the approach I took to fill some of these gaps quickly. Hive monitoring is most effective if multiple data points are captured simultaneously. My approach has been to capture critical internal hive metrics (temperatures, weight), local weather data, forage, and environmental information, disease and pest trends (microscopy, mite counts), and most importantly, colony progression observations collected through routine inspections. The information can be collected individually or as part of a club/group activity over a couple of years.

The information collected can then be used to improve/test hive management approaches (i.e., feeding, hive configuration), to understand critical environmental queues (seasonal changes, nectar flows/dearths), to understand critical bee stressors (i.e., nutritional gaps, weather impacts, forage types, diseases & pests), concerning bee biological processes (i.e., brood-rearing cycles, queen health).

20 Words 200

EYESONHIVES - CAN COMPUTER VISION MONITORING SEE MORE THAN BEES?

Kelton Temby; Keltroniz, Inc.; USA; ktemby@keltronix.com

Abstract Understanding a beehive's health and pollination strength is more complex than simply counting bees. Beekeepers can get a much more meaningful picture by observing bee behavior at the hive entrance, even without disturbing the hive. From the California almond fields, to outback Australia, to within the Arctic Circle, this talk introduces Eyesonhives and reviews common patterns of bee activity from around the world. You will see how computer vision sees a beehive and can detect what is obviously recognizable to a beekeeper in the apiary including swarming, orientation and pollination. You will also see how computer vision can constantly monitor the colony and uncover insights impractical for a beekeeper.

We empower commercial beekeepers to blend network edge computer vision as well as actual beekeeping experience. Eyesonhives gives rich and meaningful understanding of beehive behavior as well as the benefit of simple, scalable and standardized beehive activity data. Bonus: The Eyesonhives App will be officially released during the conference and includes a free augmented reality experience to visualize a beehive! The feature supports educators and backyard beekeepers via fun, safe science education, literally in the living room.

Acknowledgements: Anonymized Eyesonhives customer data from UC Davis, Lapland University, La Trobe University and backyard beekeepers.

6 Words 183

THE VARROA COUNTER – AN APP TO SUPPORT BEEKEEPERS AND RESEARCHERS IN THEIR FIGHT AGAINST THE VARROA MITE

Werner Toplak; Toplab – Toplak Laboratory; Austria; dr.toplak@toplab.at

Abstract In this presentation, the Varroa Counter is introduced. This app aims to support beekeepers and researchers by gathering Varroa mite counting data and estimating critical infestations in beehives. However, there are several ways to treat a varroa mite diagnosis, if therapy is essential, and when it

should be conducted. Currently, these are mainly manually counting tasks, which are time-consuming and constraining. Therefore, the app's purpose is to make the first steps in the automation of counting dead mites located in hive trays, respective on so-called hive diapers. The user takes a photo of the diaper with his mobile device, starts the estimation process, and has the necessary information quickly. By knowing the natural death rate of mites in a beehive within a certain period and using a population model to consider the exponential growth of Varroa mites, a final estimation of the number of living mites in a bee colony is given. When the mite population reaches a critical limit of 1,000 individuals, the day is also estimated and can be stored as a calendar event. Feedback and photos for Quality Assurance and further development are very welcome. The Computer Vision & Artificial Intelligence (AI) approach can be linked to other hive monitoring systems in the future. We hope to continue our endeavor to realize our vision: "What a fever thermometer is for humans the Varroa Counter is for bee colonies."

Acknowledgments The project "Varroa Counter" was supported by Austrian Wirtschaftsservice (AWS) and the EcoDesign Company. Special thanks to Prof. Wolfgang Wimmer for his ideas and expertise.

9 Words 231

VIRUSES, BACTERIA, FUNGI, AND CHEMICALS AFFECTING YOUR BEES

David Wick; BVS, Inc.; USA; mrwick@montana.com

Abstract Honey bees (*Apis mellifera*) are threatened by multiple threats to their health. Research on many topics related to these threats is vital to beekeepers, as confirmed by the number of researchers presenting their work and data at yearly bee conventions. The challenge is to get this information quickly to beekeepers. In 2007, BVS, Inc. set out to detect and track viruses in commercial apiaries with funding from Apis m., some state associations, government agencies, and individuals. Viruses occur in bees and interact with different factors such as mites, viruses, and pesticides. *Nosema ceranae* is another problem threatening bees that we added, along with mite testing. Pesticides are a threat and worsen pest and disease impacts, with more detail coming out from exposure research for multiple chemicals. The health of the bee is becoming more and more a concern for the beekeepers. The challenge is, how does the beekeeper track all the threats? BVS, Inc started with the Integrated Virus Detection System, licensed from the Army at ECBC, to test viruses. We recently added a LC-MS/MS proteomic test to track the bee gut bacteria and other microbes in and with the bees. Then we adjust the setup to include chemical testing - all from one sample of bees mailed to the lab. We have been conducting this research and providing the data or results back to the beekeepers for years. We have a story to tell about how all this data fits together.

47 Word 242

VISUALIZING HONEY BEE HIVE WEIGHT SENSOR DATA

Josh Williams, Appalachian State University; Dick Rogers, Bayer and Appalachian State University; Joseph Cazier, Ed Hassler, Appalachian State University; dick.rogers@bayer.com

Abstract Sensors in honey bee hives are powerful tools for collecting hive weight data. However, so much data is collected that it is overwhelming, the variability in weights clouds much of the information, and being gross weights, the results are not comparable between hives. Also, any management activities performed will alter the weight readings. The purpose of this project was to build a tool that processes hive scale sensor data to create meaningful and actionable visualizations. Hive scale weight data was obtained from Solutionbee and Broodminder scales operated by the former Bayer Bee Care Center and collaborators. Scale data was formatted and combined with hive management records. Net weight changes caused by bee activity are the weight differences between inspections. Net weight changes caused by human contact with the hives are the differences in weights just before inspection and just after inspection. This process tares the weights at each interval and removes noise from the weight data. Plots of data related to bees made it easier to spot bee-mediated events, e.g., nectar flows, swarming, consumption of stores. Plots of cumulative weight change from bees over time show productivity and may be a good trigger for when to feed. Human impact on weight was easy to visualize and correlated perfectly with management notes indicating addition and removal of weights. The scale data tool handles every step, from data import to visualization. The next steps will be to fully automate the whole process and further mine the visualizations for new insights.

24 Words 249

AUTOMATING CATCH BOX MONITORING

Andrew Wootton; Victorian Apiarists' Association, Australia; andrew.wootton@gmail.com

Abstract Detecting bees moving into a swarm catch box is critical when these are used for biosecurity surveillance and valuable for normal swarm trapping. Rather than relying on human observation, this process can be automated. An ultrasonic sensor was connected to an Arduino microprocessor to monitor the space across an empty hive. Measurements were taken hourly and reported via LoRa radio or cell phone network to the Internet. On fulfilling changed distance criteria, an alert via SMS is triggered to a receiving mobile phone. The system was tested by shaking a colony in front of a monitoring hive. As the bees moved in and clustered, the distance reported fell from 40cm to 23cm. A swarm catch box in Port Melbourne was fitted with a working prototype using LoRa radio. The device was successfully connected to a public gateway located on a city building at a 3.2 km distance and commenced reporting. However, intermittent connection issues were experienced due to the hive location being surrounded by trees. Consequently, communication via the cell phone network was preferred in this location. The sensor appears robust under field conditions and will provide alerts when triggered. Components are readily available and can be assembled for less than $100. Expansion of the project for deployment in additional locations requiring biosecurity surveillance is being considered.

12 Words 215

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