

Electromagnetic Radiation

And Honey Bee Health - Part 1

The potential for harmful impacts from electromagnetic radiation to bees first came into the general public's consciousness shortly after the emergence of Colony Collapse Disorder (CCD). It was the result of reports of a study in which cordless telephone base stations that emitted 1900-MHz electromagnetic field (EMF) radiation were set in hives and found to decrease comb building and increase the duration of foraging trips. (Kimmel et. al. 2007) The study was poorly designed, had a small sample size, and there was the small issue that beekeepers do not typically place mobile phone base stations used by cordless landline phones in their hives. As a result the idea of electromagnetic radiation harming bees was quickly discredited and became the subject of jokes and ridicule. I certainly wrote it off as inconsequential. This was an unfortunate situation because I have since found that when you look at the studies on the subject with an independent mind, there just happens to be enough peer reviewed research to suggest that there may in fact be cause for concern. The collective evidence drawn from scientific studies of the adverse health and biological impacts of artificial electrical field exposure from sources such as cell phone towers, cell phones, smart meters, power lines and WiFi routers may be jeopardizing the health of our bees and more.

What is EMF and EMR?

An electromagnetic field (EMF) is produced when electric and magnetic charges radiate energy (aka radiation). Electromagnetic radiation (EMR) is a kind of energy that includes radio waves and visible light. Even solar wind generated from the sun creates an electromagnetic field as it hits the earth which means that all life on earth is in the presence of electromagnetic fields. EMF radiation in wireless communication only works because the transmission is more powerful than the natural background radiation. These man-made sources of electromagnetic radiation

greatly increase normal background exposure. Common sense suggests that biologically based scientifically sound public exposure standards be developed to protect the health and well-being of people, bees and other wildlife. Unfortunately, such standards do not exist for pollinators and wildlife, and studies suggest that even the human standards that exist are outdated and inadequate.

Electromagnetic radiation is measured in hertz (Hz) which represents the cycles per second of the wavelength. One hertz represents a single time that a analog sound wave or digital pulse repeats each second (e.g. one cycle per second). Kilohertz (kHz) measures thousands of cycles per second, Megahertz (MHz) refers to millions and Gigahertz billions of cycles per second. It is well established that EMR has the ability to seriously impact living organisms and that EMR of 900 MHz is highly bioactive causing significant changes in the physiological function of living organisms. (Aday 1975)

Radiofrequency electromagnetic fields (RF-EMF) are emitted from the wireless communication devices we use daily: radios and televisions, satellite communication systems, WiFi systems and wireless mobile phones and cell phones. RF-EMFs emit non-ionizing radiation. This differs from ionizing radiation of nuclear power plants in that while non-ionizing radiation has enough energy to excite the electrons in molecules and atoms (moving the electrons to a higher energy state) they do not knock electrons out of their orbits around atoms like ionizing radiation does.

The agency responsible for regulating the wireless communications industry is the Federal Communications Commission (FCC). Unfortunately, FCC radiofrequency (RF) safety guidelines have not been updated since their implementation in 1996. This is significant since these fields are about to get significantly stronger with the current roll-out of the fifth generation technology standard (aka 5G) for broadband cellular networks.

Today no-one, including the Federal Communications Commission (FCC) knows whether 5G is safe or not. Even wireless carriers have to admit that they are not aware of any independent studies on 5G safety. When asked during Senate hearings what research has been done on the safety of 5G technology, the answer was "none". (Blumenthal 2019)

Meanwhile, the public is consistently told that there is no need for anything to worry about concerning the rollout of this new technology that the FCC is pushing and if current plans come to fruition has the potential to result in over 800,000 new antenna installations throughout the U.S. providing fast 5G internet service to many Americans by the end of the decade.

Effects on insects

There is a growing body of evidence of harm from wireless non-ionizing radiation such as from cell phones, cell towers, WiFi, and smart meters can harm insects. A 2013 review of 113 studies that found that 70 percent of papers analyzed reported a significant impact of RF-EMF on birds and insects. This suggests an urgent need for more research and repetitions of studies given the fast pace of cellular telephone technological progress. (Cucurachi et. al. 2013)

Lab studies on insects show negative effects of EMR on reproductive success, development, and naviga-

Ross Conrad



tion abilities. However, the impact of widespread mobile telecommunication antennas on wild pollinator communities in field-realistic conditions is still largely unknown. In one trial, beetle, wasp and hoverfly abundance **decreased** with EMR, while the abundance of underground-nesting bees and bee flies **increased** with EMR. This cries out for additional research to understand the ecological impacts of EMR on wild pollinators and the subsequent effects on plant diversity, crop production, as well as human welfare. (Lázaro et. al. 2016)

In 2012 Sivani and Sudarsanam published a paper that states: “Based on current available literature, it is justified to conclude that RF-EMF radiation exposure can change neurotransmitter functions, blood-brain barrier, morphology, electrophysiology, cellular metabolism, calcium efflux, and gene and protein expression in certain types of cells even at lower intensities. The biological consequences of such changes remain unclear.” The authors further noted that short-term studies on frogs, honey bees, birds, bats and even humans are scarce and long-term studies are non-existent.

A review of the literature published just this past year came to the

Cell phones and the towers use to transmit their signals are just one of many sources of man-made electromagnetic radiation.



conclusion that there is sufficient evidence to support claims of damage caused by electromagnetic radiation. The study’s author goes on to state that “...electromagnetic radiation should be considered seriously as a complementary driver for the dramatic decline in insects, acting in synergy with agricultural intensification, pesticides, invasive species and climate change. The extent that anthropogenic electromagnetic radiation represents a significant threat to insect pollinators is unresolved and plausible.” (Balmori 2021)

Up until recently, the range of frequencies used for wireless communication has not risen above 6 GHz (2G, 3G, 4G, and WiFi). The impending deployment of the new and highly anticipated 5G technology utilizes a signal of 120 GHz. Research on insects showed that as the power density of frequencies above 6 GHz increased, the power absorbed by the invertebrates studied increased from three to 370 percent (Thielens et. al. 2018) making the importance of being able to understand the potential threat to pollinators from electromagnetic radiation all the more urgent.

Worker Bee Exposure

While lots of research documents the impacts of EMF on insects generally, some studies have looked at the impacts of electromagnetic radiation on honey bees and the majority of the papers have found potential cause for concern when honey bees are exposed to EMFs. Such exposure has been shown to cause significant cognitive impairment and behavioral changes. These include reduced locomotion activity, impaired homing and orientation abilities, fewer foraging flights and short-term memory loss. (Harst et. al. 2006; Warnke 2007; Kimmel et. al. 2007; Sharma and Kumar 2010; Shepherd et. al. 2018; Lopatina et. al. 2019; Shepherd et. al. 2019) Many of these studies, and others,



Honey bees and wild pollinators like this sweat bee pictured, are among the many insects that can be negatively affected by man-made sources of electromagnetic radiation.

document increased aggression when bees are exposed to EMR. (Mixson et. al. 2009; Halabi et. al. 2014).

Meanwhile, in 2017 researchers found that DNA damage in honey bee larvae increased significantly when exposed to modulating EMR fields. Exposure levels during the trial were much higher than what honey bees in nature could reasonably be expected to encounter but the results suggest the need for further intensive research on all stages of honey bee development. (Vilić et. al. 2017)

Cell Phone Towers

Cell phone towers have been a focus of additional research, but unfortunately the few studies that have looked at the effect from cell phone towers suffer from small sample sizes.

Some studies have concluded that the effect of cell tower electromagnetic radiation on colonies placed directly under cell-phone towers is insignificant. (Mall and Kumar 2014, Patel and Mall 2019) However, these researchers placed colonies under the transmission antennae at the base of the tower where the radiation broadcast angle approaches zero degrees resulting in little-to-no radiation exposure.

One of the more realistic studies that looked at the impact of electromagnetic radiation (EMR) on hives exposed to cell phone tower emissions was done on the Eastern honey bee *Apis cerana*. (Taye 2017) Foraging behavior was observed in colonies placed at distances of 100 meters, 200m, 300m, 500m, and 1000m from a cell phone tower. Researchers documented significantly reduced colony foraging activity in the hives closest to the radiation source. Clearly more research is needed on impacts of cell towers before firm conclusions can

be drawn on exactly how and under what circumstances cell phone towers may be harmful to bees and other pollinators.

Next month in part two of this article, we will look at the effects of RF-EMR on queens and share some ideas on what we as beekeepers might do to help reduce exposure to our bees and ourselves. 

References:

- Aday, W.R. (1975) *Introduction: Effects of electromagnetic radiation on the nervous system*, Annals of the New York Academy of Science, 247:15-20
- Balmori, A. (2021) *Electromagnetic radiation as an emerging driver factor for the decline of insects*, Science of The Total Environment, (767):144913
- Blumenthal, Richard (2019) *At Senate Commerce hearing, Blumenthal raises concerns on 5G wireless technology's potential health risks*. <https://www.blumenthal.senate.gov/newsroom/press/release/at-senate-commerce>
- Cucurachi, S., Tamis, W.L.M., Vijver, M.G., Peijnenburg, W.J.G.M., Bolte, J.F.B., de Snoo, G.R. (2013) *A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF)*, Environment International, 51:116-140
- El Halabi, N., Achkar, R., Haidar, G.A. (2014) *The effect of cell phone antennas' radiations on the life cycle of honeybees*, Proceedings of the Mediterranean Electrotechnical Conference – MELECON DOI:10.1109/MELCON.2014.6820569
- Harst, W., Kuhn, J., Stever, H. (2007) *Can electromagnetic exposure cause a change in behavior? Studying possible non-thermal influences on honey bees – An approach within the framework of Educational Infomratrics*
- Kimmel, S., Kuhn, J., Harst, W., Stever, H. (2007) *Effects of electromagnetic exposure on the behavior of the honeybee (Apis mellifera)*, Environmental Systems Research, 8: 1-8
- Lopatina, N.G., Zachepilo, T.G., Kamyshhev, N.G., Dyuzhikova, N.A., Serov, I.N. (2019) *Effect of Non-Ionizing Electromagnetic Radiation on Behavior of the Honeybee, Apis mellifera L. (Hymenoptera, Apidae)*, Entomological Review, 99(1): 24-29 DOI: 10.1134/S0013873819010032
- Lázaro, A., Chroni, A., Tscheulin, T., Devalez, J., Matsoukas, C., Petanidou, T. (2016) *Electromagnetic radiation of mobile telecommunications antennas affects the abundance and composition of wild pollinators*, Journal of Insect Conservation, 20:1-10
- Mall, P., Kumar, Y. (2014) *Effect of electromagnetic radiation on brooding, honey production, and foraging behaviour of European honey bees (Apis mellifera L.)*, African Journal of Agricultural Research, 9(13):1078-1085
- Mixson, T.A., Abramson, C.I., Nolf, S.L., Johnson, G.A., Serrano, E., Wells, H. (2009) *Effect of GSM cellular phone radiation on the behavior of honey bees (Apis mellifera)*, Science of Bee Culture, 1(2):22-27
- Patel, S. and Mall, P. (2019) *Effect of electromagnetic radiations on the foraging activity of Apis mellifera L.*, J. Exp. Zool. India, 22(1):449-451
- Sharma, V.P. and Kumar, N.R. (2010) *Changes in honey bee behavior and biology under the influence of cellphone radiations*, Research Communications, Current Science 98(10): 1376-1378
- Shepherd, S., Hollands, G., Godley, V.C., Sharkh, S.M., Jackson, C.W., Newland, P.L. (2019) *Increased aggression and reduced aversive learning in honey bees exposed to extremely low frequency electromagnetic fields*, PLOS ONE <https://doi.org/10.1371/journal.pone.0223614>
- Shepherd, S., Lima, M.A.P., Oliveira, E.E., Sharkh, S.M., Jackson, C.W., Newland, P.L. (2018) *Extremely low frequency electromagnetic fields impair the cognitive and motor abilities of honey bees*, Scientific Reports, 8:7932, doi:10.1038/s41598-018-26185-y
- Sivani, S., Sudarsanam, D. (2012) *Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystems and ecosystems – a review*, Biology and Medicine, 4(4):202-216
- Tay R.R., Deka, M.K., Rahman, A., Bathari, M. (2017) *Effect of electromagnetic radiation of cell phone tower on foraging behavior of Asiatic honey bee, Apis cerana F. (Hymenoptera: Apidae)*, J Ent & Zoo Studies 5(3): 1527-1529
- Thielens, A., Bell, D., Mortimore, D.B., Greco, M.K., Martens, L., Joseph, W. (2018) *Exposure of insects to radiofrequency electromagnetic fields from 2 to 120 GHz*, Nature Scientific Reports, 8:3924
- Warnke, U. (2007) *Bees, Birds and Man-kind: Destroying nature by 'electrosmog'*, Effects of wireless communication technologies, by the Competence Initiative for the Protection of Humanity
- Vilić, M., Gajger, I.T., Tucak, P., Štambuk, A. Srut, M., Klobucar, G., Malaric, K., Zaja, I.Z., Pavelic, A., Manger, M., Tkalec, M. (2017) *Effects of short-term exposure to mobile phone radiofrequency (900 MHz) on the oxidative response and genotoxicity in honey bee larvae*, Journal of Apicultural Research, 56:430-438

Subscribe to keep your Hives Alive!

Monthly Magazine
100+ pages every month

Science & How To
Articles that keep you informed about the latest scientific advancements and hive management techniques

Great Columnists
Including:
Peter Borst
Randy Oliver
Rusty Burlew
Wyatt Mangum
Alison McAfee
Scott McArt

Beekeeping Basics
Covering critical topics for beginners every month

And So Much More...



VOLUME 108 NO. 10

AMERICAN BEE JOURNAL

Should We Fear 5G? — 1107

Do-IT-YOURSELF BEAR FENCE — 1113

A Pollination Primer — 1125

www.americanbeejournal.com

AMERICAN BEE JOURNAL

Subscribe Now!

Stay informed every month for the price of a cup of coffee.

All prices good through December 31, 2022

☐ New Subscription Allow six weeks	☐ Renew Subscription Please include customer number	U.S.
☐ Order Back Issues Current year \$5.00 each plus postage For other back issues, write for prices	☐ 1 Year \$29.00	
☐ ABJ Magazine Binder \$24.95 postagepaid in U.S.	☐ 2 Years \$55.00	
☐ Change of Address Include address/label reference or customer number	☐ 3 Years \$78.00	
Date _____	Canada	
Name _____	☐ 1 Year \$60.00	
Address _____	☐ 2 Years \$95.00	
Address _____	Foreign	
City _____ State _____ Zip _____	☐ 1 Year \$60.00	
	☐ 2 Years \$110.00	
American Bee Journal 51 S. 2nd St., Hamilton, IL 62341 www.americanbeejournal.com	Digital	
Ph: 217-847-3324 Fax: 217-847-3660 1-888-922-1293	☐ 1 Year \$16.00	
	☐ 2 Years \$32.00	

Electromagnetic Radiation

And Honey Bee Health - Part 2

In the February edition of *Bee Culture* we looked at some of the scientific evidence of harm that radiofrequency electromagnetic radiation (RF-EMR) emitted by our modern communication devices like cell phones, WiFi, cell towers, smart meters can have on insects and honey bees. We continue this exploration this month beginning with a look at queens.

Queen Exposure

The impact of radiofrequency electromagnetic radiation (RF-EMR) on queen bees appears to be significant. The detrimental impacts include poor queen cell production, reduced successful emergence of queens, reduced weight gain, reduced egg laying and subsequently, poor brood production, decreased Winter survival and increases in queen failure and queen loss. (Greenburg et. al. 1981; Sarma and Kumar 2010; Sahib 2011; Odemer 2019) It should be noted that all these observations could be caused from reduced foraging and nutritional stress caused by the decreased cognitive function in EMR exposed worker bees noted in last month's article.

Real world multi-stress situations

It is clear that the EMR we rely on everyday has the potential to stress biological organisms but most of us and the wildlife around us are exposed to multiple simultaneous stressors daily. This led one group of researchers to look at the combined effects of both EMFs and pesticides

together on honey bee colonies. Three apiaries were established: one control site removed from direct human induced stress, one pesticide stress site, and one multi-stress site which added to the same pesticide exposure the presence of EMFs from a high voltage electric line. The multi-stress site exhibited the worst health conditions which included the potential for greater susceptibility for disease, queen issues and biochemical anomalies. (Lupi et. al. 2021).

Evidence of Potential Genetic Damage

It is well established that electromagnetic radiation significantly effects living organisms. The effect is so pronounced that some predict the use of EMFs for medical treatments, referred to as electromedicine. (Becker 1990) Unfortunately, not enough health and safety research has been done on the safety of the non-ionizing radiation emitted by our communications technology. This is partly because it has always been believed that the primary danger from non-ionizing radiation is the heating of skin and that EMFs do not have enough energy to alter DNA directly. Additional research has proven this assumption to be false.

One disturbing study found that when honey bees were exposed to a Samsung F400 mobile phone with a carrier frequency range of 900-1900 MHz, the bee stomach cells became damaged after just 10 minutes of exposure, and were completely decayed after 20 minutes. (Mahmoud and Gabarty 2021) Other observations indicating electromagnetic radiation may cause genetic disorders in drone semen (Kumar et. al. 2012) has the potential to further complicate queen issues.

Evidence suggesting that EMFs can alter DNA, and damage or destroy cells, is important because historically such agents have often been shown to cause cancer and birth defects in people.

Human Exposure

Mice are often used as a proxy for humans in toxicological research and

the study of EMR is no different. In one early study twelve pairs of mice were divided into two groups and repeatedly mated five times while in locations of an antenna park with different power densities ranging between 168 nW/cm² and 1053 µW/cm². Researchers found that over the generations there was a progressive decrease in the number of newborns which culminated in irreversible infertility. (Magras and Xenos 1997)

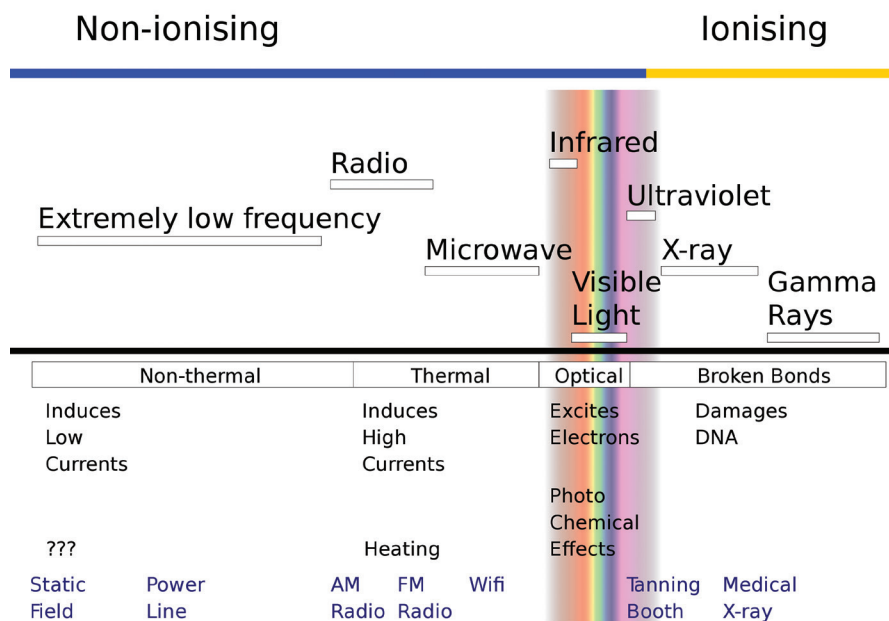
More recently, an American National Toxicology Program study (2016-2018) found a clear link between the near-field RF radiation from cell phones and malignant gliomas of the brain and schwannomas in the heart of rats. (Soffritti & Giuliani 2019) Additional rodent studies further support cancer findings with researchers concluding that there is clear evidence that RF radiation can cause various forms of cancer and should be classified as likely carcinogenic to humans. (Hardell & Carlberg 2019)

The initial potential for carcinogenic risk to humans from non-ionizing radiation exposure came way back in 1979 when a study showed that children exposed to extremely low-frequency electromagnetic fields were at risk of developing leukemia. (Wertheimer & Leeper 1979) Subsequent research led the International Agency for Research on Cancer (IARC) to rate 50/60 Hz EMF as a possible carcinogen and in 2001-2002 the World Health Organization (WHO) classified powerfrequency magnetic fields as possibly carcinogenic for childhood leukemia (Class 2B). By 2011 radiofrequency electromagnetic fields (RF-EMF) were classified as possibly carcinogenic for certain brain tumors (Class 2B) associated with wireless phone use. (WHO/ IARC 2011). The Class 2B category includes a variety of substances including lead, car exhaust, dry cleaning chemicals, DDT, and methyl mercury.

Natural forms of electromagnetic radiation are not typically harmful at natural intensities and common exposure rates. Natural background Radio Frequency Electromagnetic

Ross Conrad





Different types of electromagnetic radiation.
Source Wikipedia

fields (RF-EMF) exposure during normal cosmic activities is no more than 0.000001 $\mu\text{W}/\text{m}^2$. Current health guideline recommendations for much of Europe is 9,000,000 $\mu\text{W}/\text{m}^2$ at 1800 MHz, while in the USA it is 10,000,000 $\mu\text{W}/\text{m}^2$. This is much, much more than the natural background exposure rate (Johansson 2019). Current safe exposure rates are based on technical arguments and modeling based calculations that are decades old and focus on a single six to 10 minute acute exposure in an environment free of any other similar radiation for the rest of your life. Real-world exposures are 24/7 with an endless variety of electromagnetic background field and signal exposures. In case you're wondering, harm from direct or indirect exposure to electromagnetic radiation from our modern-day gadgets are no-longer covered by insurance companies.

No Scientific Proof

It is not clear under what circumstances EMFs will cause damage despite the clear potential for harm. Thus, more research is warranted but, that research needs to be focused and comprehensive. As a recent review of over 450 studies concluded "We recommend that in future studies, effects of EF, MF and EMF in the IF range should be investigated more systematically, i.e., studies should consider various frequencies to identify potential frequency-depen-

dent effects and apply different field strengths..." (Bodewein, et. al. 2019)

Industries are fond of using doubt and a lack of scientific certainty to counter concerns about health and the environment from the effects of their products and business practices. As we have reviewed in this two-part article, there is quite a bit of proof of potential harm from EMFs to bees and beekeepers. Unfortunately the large well-funded cell phone industry PR machine has successfully buried it, put pressure on journals not to publish damaging studies, and has had their disinformation specialists plant falsehoods that are often repeated by lay people and sincere, well-meaning experts and professionals which sows doubt and confusion. These are all actions we have come to expect from industries that deal with health and safety issues as a political and public relations problem and allow profits to take precedence over science.

Just as big tobacco was able to manipulate studies, capture much of the regulatory and legislative processes to prevent and slow meaningful action, and use public relations and the media to spread misinformation favorable to their bottom line, the pesticide industry, fossil fuel industry and now WiFi/Internet-reliant industries are following the same playbook. Make no mistake, there are huge financial interests working to make sure no clearly negative conclusions are made with regard to the effects of EMFs on people, bees

or the environment. Not only is the wireless industry one of the largest and fastest growing industries on earth, but many of today's biggest and most profitable corporations (e.g. Microsoft, Apple, Amazon, Facebook, Google) and the governments whose economies are heavily reliant on them and the jobs they provide, are counting on society to use more wireless/internet communications technology and not less. The beekeeping industry has even jumped on board with growth in the use of wireless in-hive monitors that track everything from temperature and humidity, to weight and the sounds a colony emits.

Political leaders who rely on corporate donations, regulatory agencies, and the wireless industry will cite studies showing contradictory results and the lack of a scientific consensus as evidence that there is no scientific proof of adverse effects of electromagnetic fields on humans, animals and plants. This is despite the warning of one of the industries own scientists that "The risk of rare neuro-epithelial tumors on the outside of the brain was more than doubled...in cell phone users"; there was an apparent "correlation between brain tumors occurring on the right side of the head and the use of the phone on the right side of the head"; and "the ability of radiation from a phone's antenna to cause functional genetic damage [was] definitely positive..." (Hertsgaard and Dowie 2018) Again, this situation echoes the experiences of the tobacco, fossil fuel and the pesticide industries all of which were told by their own scientists at one time or another that their products cause severe harm to environmental and human health but chose to cover up and ignore it.

Part of the trouble with trying to get a handle on the EMR issues is that it is not clear at what frequency and intensity EMR will cause harm in a given situation. Poor study designs, low sample sizes, and numerous undocumented variables such as the number of frequencies subjects are exposed to during trials and their intensity; make it easy for policy makers and regulators to dismiss concerns.

Given what we already know about the potential dangers of the other G's like 2G, 3G, and 4G as well as similar exposures from radio and television towers, smart household

devices and power lines, to not proceed with caution before immersing ourselves and the rest of nature in more and more artificial electrical fields such as 5G is irresponsible.

Cautionary approaches

Honey bee scientists are increasingly relying on radio-frequency identification (RFID) tags to track the movement of individual honey bees during studies. They have to be careful however as some researchers have found that honey bee mortality increases when exposed to RFID radiations. It is recommend that bees not be exposed to the EMR from an RFID tag for more than about two hours. (Darney et. al. 2016)

Meanwhile, what can beekeepers do to protect our bees from RF-EMR exposure? While the ubiquitous nature of cell phone transmission towers makes them hard to avoid, beekeepers can at least keep their bee yards away from high voltage power lines.

It would be prudent for us beekeepers to also take precautions to also protect ourselves where possible by limiting cell phone usage and keeping phones as far away from our bodies as reasonably possible. When making or taking a call, make it a habit to hold the phone away from your head and use the speaker phone, or use non-electric headphones or earbuds that plug into the phone (bluetooth systems give off their own EMR). Folks who use their phone as an alarm clock should consider using the airport mode setting to prevent prolonged exposure while they sleep.

An alternative to WiFi is fiber optic cable. A home wired with fiber has faster, more reliable internet with less

of an environmental footprint, while eliminating the high frequency radiation exposure associated with cell phone hotspots and WiFi computer access. Just plug your phone in to your home's fiber network to access information and make calls through the internet. Also consider limiting your purchases of "smart" devices, or at least reduce their use as much as possible. Finally, be wary of WiFi and EMF shielding products that claim to protect you from radiation. I have tested some with my TriField meter and they do not always work. 

Ross Conrad is the author of *Natural Beekeeping: Organic Approaches to Modern Apiculture*, 2nd Edition and co-author of *The Land of Milk and Honey: A history of beekeeping in Vermont*. Ross will be teaching an organic beekeeping for beginners class on Saturday and Sunday May 7-8th in Lincoln, Vermont and an advanced beekeeping class on Saturday May 21st in Middlebury, Vermont. For more information email dancinghoney@gmail.com or call 802-349-4279.

References:

- Becker, Robert, O. (1990) *Cross Currents: The Perils of Electropollution, the Promise of Electromedicine*, TarcherPerigee Publisher
- Bodewein, L., Schmiedchen, K., Dechent, D., Stunder, D., Graefrath, D., Winter, L., Kraus, T., Driessen, S. (2019) *Systematic review on the biological effects of electric, magnetic and electromagnetic fields in the intermediate frequency range (300 Hz to 1 MHz)*, *Environmental Research*, 171: 247-259
- Darney, K. Giraudin, A., Joseph, R., Abadie, P., Aupinel, P., Decourtye, A., Le Bourg, E., Gauthier, M. (2016) *Effect of high frequency radiations on survival of the honeybee (Apis mellifera L.)*, *Apidologie*, 47:703-710
- Greenberg, B., Bindokas, V.P., Frazier, M. J., Gauger, J.R. (1981) *Response of honey bees, Apis mellifera L., to high-voltage transmission lines*, *Environmental Entomology*, 10:600-610
- Hardell, L., Carlberg, M. (2019) *Comments on the US National Toxicology Program technical reports on toxicology and carcinogenesis study in rats exposed to whole-body radiofrequency radiation at 900 MHz and in mice exposed to whole-body radiofrequency radiation at 1,900 MHz*, *International Journal of Oncology*, 54(1):111-127

Hersgaard, M. and Dowie, M. (2018) *How Big Wireless Made Us Think That Cell Phones Are Safe: A special investigation*, The Nation, April 23, 2018

Johansson, O (2019) *To bee, or not to bee, that is the 5 "G" question*, Newsvoice, https://newsvoice.se/2019/05/5g-question-olle-johansson/?fbclid=IwAR3VzYuLVNRSQT6ZCi3uTZkFJTfsiuBNV2Mink-tZRnUNxCICgDiz_gi_3k0

Kumar, N.R., Taruna, V., Anudeep (2012) *Influence of cell phone radiations on Apis mellifera semen*, *Journal of Global Biosciences*, 1:17-19

Lupi, D., Palamara Mesiano, M., Adani, A., Benocci, R., Giacchini, R., Parenti, P., Zambon, G., Lavazza, A., Boniotti, MB., Bassi, S., Colombo, M., Tremolada, P. (2021) *Combined effects of pesticides and electromagnetic-fields on Honeybees: Multi-stress exposure*, *Insects*, 12(8): 716

Magras, I.N., Xenos, T.D. (1997) *RF radiation-induced changes in the prenatal development of mice*, *Bioelectromagnetics*, 18:455-461

Mahmoud, E.A. and Gabarty, A. (2021) *Impact of electromagnetic radiation on honey stomach ultrastructure and the body chemical element composition of Apis mellifera*, *African Entomology*, 29(1):32-41

Odemer, Richard and Franziska (2019) *Effects of radiofrequency electromagnetic radiation (RF-EMF) on honey bee queen development and mating success*, *Sci Total Environment*, (661)553-556

Sahib, S.S. (2011) *Electromagnetic radiation (EMR) clashes with honey bees*, *International Journal of Environmental Sciences*, 1(5):897-900

Sharma, V.P. and Kumar, N.R. (2010) *Changes in honey bee behavior and biology under the influence of cellphone radiations*, *Research Communications*, *Current Science* 98(10): 1376-1378

Soffritti, M., Giuliani, L. (2019) *The carcinogenic potential of non-ionizing radiations: The cases of S-50 Hz MF and 1.8 GHz GSM radiofrequency radiation*, *Basic & Clinical Pharmacology & Toxicology*, 125(3):58-69

Wertheimer, N., Leeper, E. (1979) *Electrical wiring configurations and childhood cancer*, *American Journal of Epidemiology*, 109:273-284

World Health Organization (WHO)/ International Agency for Research on Cancer (IARC), 2011, *Cell phones and cancer: Assessment classifies radiofrequency electromagnetic fields as possibly carcinogenic to humans*, *Science News* <https://www.sciencedaily.com/releases/2011/05/110531133115.htm>

Given what we know about EMR, caution should be taken when transporting bees. While the EMFs given off by this electric car stayed mostly in the low zone, the needle on the TriField meter would occasionally peg all the way over to the right suggesting that transporting bees over long distances in an electric vehicle may be problematic.

