Dr. Magda Havas, B.Sc., Ph.D.,
TRENT SCHOOL OF THE ENVIRONMENT
1600 West Bank Drive, Peterborough, ON, Canada, K9L 0G2
phone: 1 705 7481011 x7882
mhavas@trentu.ca www.magdahavas.com

December 6, 2016.

The Honourable Deborah Schulte, M.P.,
Chair, Standing Committee on Environment & Sustainable Development,
House of Commons, Ottawa, ON, K1A 0A6
By Email: ENVI@parl.gc.ca

Re: Canadian Environmental Protection Act (CEPA) Review
Briefing: Electrosmog[1] Effects on Biota

Dear Ms Schulte,

I am a professor and research scientist at Trent University and this Briefing Note is from me and not my university or my program.

For the past 20 years I have studied the biological effects of electromagnetic pollution and have come to the following conclusions:

1. The various forms of electromagnetic frequencies from low frequency electric and magnetic fields (associated with power generation, transmission and distribution); radio frequency radiation (generated by broadcast antennas); and microwave radiation (produced by cell phone antennas, radar, smart meters) are adversely affecting both plants and animals.
2. Adverse biological effects occur well below existing guidelines provide by
    a. Health Canada (Safety Code 6) and enforced by Industry Canada; and by
    b. Provincial Ministries of Energy/Environment for ground current pollution.
3. No one seems to be taking any leadership in this area as the focus has been primarily on chemical pollutants and not on electromagnetic pollutants when it comes to toxins in the environment.
4. Levels of exposure to electrosmog (non-ionizing electromagnetic pollution) are increasing exponentially and will continue to increase until steps are taken to lower the guidelines to levels that do not endanger biota or public health.

Recommendation: That CEPA examine the research related to the harmful effects of electromagnetic pollutants on biota and provide recommendations to other agencies responsible for their protection.

Sincerely,
Magda Havas

[1] Electrosmog refers to electromagnetic pollution that ranges includes extremely low frequency electric and magnetic fields (less than 300 Hz); intermediate frequencies (kHz range); radio frequencies (up to 300 GHz) that also includes microwave radiation (300 MHz to 300 GHz).

Re: Canadian Environmental Protection Act (CEPA) Review

Briefing: Electrosmog Effects on Biota

Magda Havas, B.Sc., Ph.D.
Trent School of the Environment, Trent University, Peterborough, ON, Canada
mhavas@trentu.ca

Overview:

An increasing number of publications have appeared during the past few years on the effects of non-ionizing radiation (NIR) on plants and animals. These studies include pollution that flows through the air, along wires, and along the ground commonly referred to as *electrosmog*. These studies include effects on biota living under natural conditions and recently exposed to electromagnetic pollution; as well as effects on various species exposed to electrosmog in controlled laboratory experiments. There are now hundreds of such studies available (Balmori 2006; Warnke 2009; Expert Group 2010; Hillman et al. 2013; Halgamuge 2016; Manville 2016). This briefing note is intended to provide an *overview* that highlights some key research in this area.

Electrosmog in the form of power frequency (50/60 Hz) electric and magnetic fields; dirty electricity (kHz); radio frequency and microwave radiation (kHz to GHz) has been associated with adverse health and reproductive effects in animals and with adverse effects on plants (Figure 1). The effects include the following:

1. Bees: aggressive behavior, reduced productivity, swarming, abandonment of hive (colony collapse disorder);
2. Birds: impaired reproduction, aggressive behavior, interference with migratory behavior, bird deaths;
3. Mammals like dairy cows: reduced milk yield, altered milk quality, reduced fertility and impaired reproduction, miscarriages and deformities in offspring, infections that won't heal with antibiotics, behavioral changes, sudden death; other farm animals are also affected.
4. Amphibians: deformities, population decline;
5. Plants: reduced growth, stunted roots, reduced yield, increased infections.

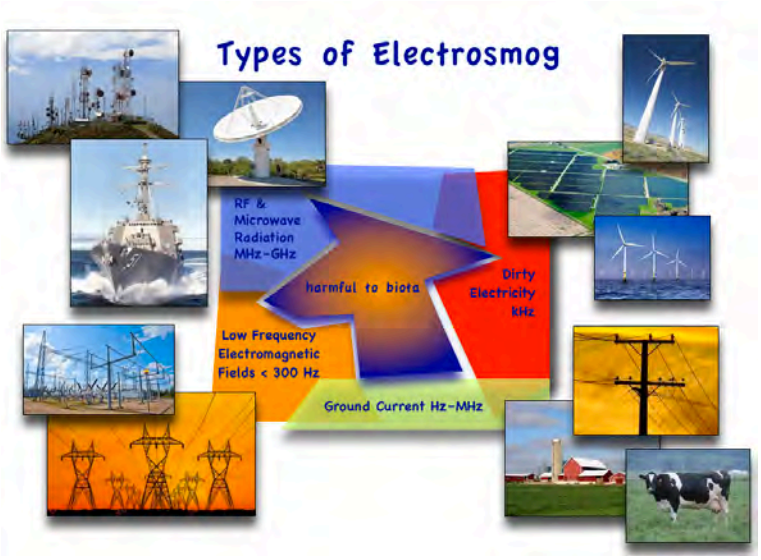

Figure 1. Types of electrosmog discussed in this briefing note showing sources.

Bee Populations

Considerable concern has been raised worldwide regarding the sudden disappearance of bees from their hives, referred to as colony collapse disorder (CCD). Bees are responsible for the pollination of approximately 85% of all flowing plants that result in fruit and seed production. Without bees, production of fruits (cherry, apple, pear and plum); vegetables (tomato, cucumber, pumpkin); and agricultural crops (rap, sunflower, red clover, horse bean) would be severely reduced (Warnke 2009).

CCD has been reported in Canada, U.S., Germany Switzerland, Austria, Italy, Spain, Poland and New Zealand. Losses of bee colonies range from less than 10% to greater than 90% depending on location. Beekeepers agree that the bees are not developing properly, and while they may survive the winter, in spring they disappear leaving the colony empty. Only the brood remains in the hives and they are unable to survive without the care of the older bees (cited in Warnke 2009).

Several hypotheses have been put forward as to why bees are disappearing that include natural parasites and predators, extreme weather conditions and manmade stressors such as pesticides, genetically modified food crops, monocultures and electrosmog. While it is likely that all of these are adversely affecting bee colonies, this briefing note will focus on a few studies documenting the effects of electrosmog.

Ferdinand Ruzicka, scientist and beekeeper reports (Ruzicka, 2003 as cited in Warnke 2009):

> *"I observed a pronounced restlessness in my bee colonies (initially about 40) and a greatly increased urge to swarm. As a frame-hive beekeeper, I use a so-called high floor, the bees did not build their combs in this space in the manner prescribed by the frames, but in random fashion. In the summer, bee colonies collapsed without obvious cause. In the winter, I observed that the bees*

went foraging despite snow and temperatures below zero and died of cold next to the hive. Colonies that exhibited this behavior collapsed, even though they were strong, healthy colonies with active queens before winter. They were provided with adequate additional food and the available pollen was more than adequate in autumn. The problems only materialised from the time that several transmitters were erected in the immediate vicinity of my beehives."

Several experiments have been performed to determine how microwave radiation from cell phones affects bees in their hives. The following observations have been documented:

1. Bees tend not to return to hives that are exposed to microwave radiation and the weight of the exposed hives is lower (less honey) at the end of the growing season compared to non-exposed hives (Harst et al. 2005).

2. Bees make a piping sound when exposed to cell phone radiation which signals that they are agitated and are ready to swarm (leave the hive) (Favre (2011).

3. If exposure is sufficiently prolonged (5 to 10 days) the colony collapses leaving the queen, eggs, and immature bees unprotected (Pattazhy 2009).

Collectively these studies indicate that bees are able to sense and react to microwave radiation generated by cell phones (and presumably cell phone base station antennas). If exposure is sufficiently prolonged (several days), workers bees leave the hive and the remaining brood and queen remain defenseless with no ability to survive. This could very well be contributing to colony collapse disorder globally since microwave exposure from wireless telecommunication antennas is now widespread.

Bird Populations: Wild and Domesticated

Research on the effects of electromagnetic fields on bird populations includes studies of behavioral changes and nesting success in the field and experimental exposure of eggs (mostly chicken eggs) under controlled laboratory conditions.

Research of wild bird populations indicates that birds, like the house sparrow, avoid areas with high levels of electrosmog coming from cellular base stations and that populations of this species are declining in European cities (Balmori and Hallberg 2007; Everaert and Bauwens 2007).

Other studies show that white stock populations that nest within 200 meters of phone masts compared to those nesting more than 300 meters away become aggressive and have difficulty building their nests resulting in breeding failure (Balmori 2004).

Similarly electrosmog seems to reduce the hatching success of wild kestrels, which could put the population at risk (Fernie et al. 2000).

White leghorns chickens exposed to low intensity continuous wave microwave radiation at 7.06 GHz for 248 days produced more eggs but also had twice the mortality rate of unexposed birds. The irradiated birds that survived showed a profound deterioration in health when autopsied (Tanner and Romero-Sierra 1982).

Grigoriev (2003) Chicken eggs exposed to electrosmog from a cell phone for 21 days during embryonic development had increased mortality (75%) compared with the controls (16%). Similar results were obtained for chick eggs exposed to 900 MHz frequencies (Ingol and Ghosh, 2006). Developmental abnormalities were observed in chick eggs exposed to 100 Hz, 2.1 µs pulse, at 1 µT magnetic field (Ubeda et al. 1994).

Collectively these studies show that birds are sensitive to microwave radiation and to lower frequencies (100 Hz) and that this radiation affects behavior and reproductive success.

Migratory Populations

Birds that migrate great distances navigate with several redundant systems that include visible clues of landscape, location of the sun, and the earth's geomagnetic field for which they have magneto-receptors in their skull. Power lines, antennas for radar, broadcast, and cell phone communication can interfere with their magnetic compass and put them off course permanently or temporarily until other cues are able to correct their course. Factors that increase energy consumption of migratory birds, decrease their ability to survival. Another concern is collisions with towers or power lines or wind turbines.

According to a review of 14 studies, an estimated 12 to 64 million birds are killed annually in the U.S. by power lines; 8 to 57 million by collision, and 0.9 to 11.6 million by electrocution (Loss et al. 2014). Authors conclude that the amount of bird mortality at U.S. power lines is substantial and that conservation management and policy is necessary to reduce this mortality.

Wiltschko et al. (2015) noted that radio frequency fields in the MHz range disrupted birds' orientation. In one experiment birds were unable to navigate as long as the RFR was present. Two different exposures were used: 7 MHz at 480 nT and 1.315 MHz at 15 nT. Once the field was turned off, birds were able to orient to the local geomagnetic field.

Engels et al. (2015) demonstrated in a double blind experiment with European robins that migratory birds were unable to use their magnetic compass in the presence of urban electromagnetic pollution that ranged from 50 kHz to 5 MHz.

Birds are not the only flying species that are adversely affected by technology. Nicholls and Racey (2007) noted that many bats are killed by colliding with wind turbines. Wind turbines provide electricity to the power grid and should not be placed in migratory pathways.

Dairy Cows, Ground Current[2] and Radio frequency Radiation

By far the most information on the effects of electrosmog on livestock comes from studies with dairy cows. Hillman et al. (2013) provide a concise literature review as well as a field study based on thirteen farms with serious ground current pollution in Wisconsin and Michigan. They show that dirty electricity flowing along the ground as ground current has serious effects on cow

[2] "Ground current", also referred to as "stray voltage" refers to electrons flowing along the ground and can come from off-farm sources being distributed by the power grid and influenced by technology that is connected to electricity (wind turbines, broadcast antennas, mobile phone base stations, nearby factories, etc.).

health and productivity. Levels at which this happens are well below existing guidelines in both Canada and the U.S.

Cows exposed to ground current above a 10 mV at kHz frequencies experience mastitis, foot sores that won't heal, swollen hocks. They have difficulty getting pregnant and produce less milk. Some become ill, refuse to eat, and once this happens there is little the farmer can do to prevent them from dying. In a dairy barn with a serious ground current problem, cows are seen lifting their feet off the ground as though they were "dancing". This lifting of the foot, temporary reduces the electrical current flowing through their body. Little is being done to help farmers or to protect livestock despite two private member's bills being considered in the Ontario Legislative Assembly during the past 10 years.

Microwave radiation also seems to adversely affect cows. On a dairy farm in Germany, after a mobile phone base station was erected nearby, calves born on this farm had a higher incidence of cataracts compared with the Swiss average (Hässig et al. 2012). Neither chemical poisons nor infection could explain these findings. Microwave radiation is known to cause cataracts (Glaser 1971).

Löscher and Kas (1998) studied a herd of dairy cows on a farm near a TV and cell phone-transmitting antenna over a two-year period and reported reduced milk yield, increasing health problems and behavioral abnormalities. Radiation from the antennas was monitored and ranged in frequency from 2.2 to 734 MHz. The highest power density reading in and around the stable was 4.5 mW/m^2 at 512 MHz (well below international and Health Canada guidelines).

The following symptoms were observed:

1. Most animals in the herd showed conjunctivitis with strong tear flow (constant wet cheeks) and eye itching (some animals were constantly scratching their eyes on reachable stable arrangements or neighboring animals).
2. Many animals squeezed with their heads the breast area of their neighboring animal; thus, all animals ended up positioning their heads in the same direction.
3. One animal showed remarkable head motions, periodically moving the head back and forth; periods of calmness were superseded by the above described behavior which could last for as long as 30 minutes.
4. Calves and cows let out on the meadow grazed only for a few minutes, then they "took shelter" from the transmission tower behind the stable building.
5. Cows, mostly after the third or fourth calving, fell into decay. When they were getting up after having lain down, their legs started trembling, and this condition became worse very quickly. The decay happened within a few weeks, and then the animals died.

In this study, various tests were performed to determine what was affecting the cattle.

1. To rule out metabolic disturbances the **feed** was analyzed. Feed quality was high and the amounts given to the animals corresponded to their needs.

2. **Autopsy** of a four-year old cow indicated that death was caused by acute heart circulatory problems with internal bleedings in several organs. No signs of acute or chronic organ changes.
3. Analysis of **miscarriage** material provided no microscopic or serological evidence of germs that could have caused the miscarriages.
4. One animal with behavioral disturbances was **relocated** to a similar stable some 20 kilometers away from the transmission tower, together with another cow of the herd. After five days in the new stable the observed behavioral disturbances disappeared completely. The animals were brought home to the stable near the transmission station after two weeks. Already after a few days the symptoms could be observed in the animal again.
5. The symptoms experienced by these cows could not be explained by poor farm management and resemble effects documented for cows exposed to ground current (Hillman et al. 2013), another form of electrosmog.

Amphibians

Amphibians are considered bio–indicators of environmental quality. Changes in their populations bode poorly for other species. Balmori (2006) reviewed the literature on amphibian declines and found that 32% of the 5743 populations studied, were in threat of extinction. Amphibians with deformed, absent or extra limbs are also found in the environment. Both these deformities and declines are due to complex ecosystem interactions. One factor that is receiving increasing attention is the increase in microwave and radio frequency radiation in the environment from mobile phone antennas base stations.

The following effects are summarized in Balmori's review:

1. Radiation of frogs at 30–60 $\mu W/cm^2$ altered heart rhythm;
2. Radiation of toad hearts with 1425 MHz at 0.6 $\mu W/cm^2$ increased heart rate and produced arrhythmia;
3. Experimental frog tadpoles development was delayed compared to control tadpoles;
4. Electromagnetic fields (EMF) caused allergies and changes in blood counts;
5. Amphibians are particularly sensitive to weak electrical fields and respond to frequencies from 0.1 Hz to 2 kHz;
6. EMFs increase tadpole morality;
7. Electromagnetic radiation (EMR) alters the immune, nervous, and endocrine systems;
8. EMR produces stress on the immune system that interferes with DNA;
9. Heat shock proteins may play a role in protecting animals exposed to EMR;
10. Susceptibility to EMR varies among species and among populations.

Plants

Plants are also sensitive to electrosmog in various forms, but especially radio frequency and microwave radiation. Halgamuge (2016) reviewed 45 scientific publications describing 169 experimental observations to detect changes in plants exposed to weak radio frequency radiation. Almost 90% of the studies documented physiological and/or morphological effects. Maize,

roselle, pea, fenugreek, duckweeds, tomato, onions and mungbeans were particularly sensitive to RF-EMFs. Frequencies with the greatest effect were from 0.8 to 1.5 GHz; 1.5 to 2.4 GHz; and 3.5 to 8 GHz. Biological effects relied on field strength and amplitude modulation of the applied field. The effects were more pronounced in short-term (up to 13 weeks) rather than long-term (3 months to 6 six years) exposure studies implying there may be some adaption to this exposure.

In 1990, permanent plots were established near the Skrunda Radio Station in Latvia, which had been operating for the previous 20 years, and a nearby control area to test the growth of pine trees using tree ring data and examining annual growth rate (Balodis et al. 1996). The annual growth rate can be determined by tree ring radius. There was a significant negative relationship ($p<0.01$) between the annual increment in tree growth and the intensity of the electric field that was traced back to 1970 when the station began operation. No other environmental factor could account for this response except the radiation from the radio station.

Tree decline is one indicator of environmental stress as the declines are often associated with infestations (insects, fungi, etc.), air pollution, or altered climatic conditions. Since 2004, rapid declines in aspen clones have been documented in Colorado, and the hypothesis that this decline was associated with RFR from nearby broadcast and cellular antennas was investigated (Haggerty 2010).

Seedlings were grown in shielded (aluminum screen) faraday cages and with mock-shielding (fiberglass screen). Conditions in the shielded and mock-shielded enclosures were similar except for the difference in RF background intensities.

Plants in the shielded and mock-shielded enclosures looked different at the end of the study. The RF background appeared to be adversely affecting leaf and shoot growth and inhibiting fall colors associated with leaf senescence in trembling aspen seedlings. The mock-shielded plants had many more necrotic spots on the leaves than the shielded plants. According to the author, these effects suggest that exposure to the RF background may be an underlying factor in the recent rapid decline of aspen populations in Colorado.

Another experiment was conducted under controlled conditions testing the effect of radiation from a Wi-Fi router on the germination and growth of edible and fast germinating seedlings (garden cress, broccoli, red clover and pea) (Havas and Symington 2016). Radiation levels were 0.0001 mW/m^2 for the controls. The mean and maximum exposure levels for the RF-exposed seedlings were 20–40 mW/m^2 and 96 mW/m^2 respectively. These levels are well below International and Health Canada's guidelines for RF exposure (10,000 mW/m^2) (ICNIRP 1998).

There were no effects on germination of the seedlings. However, dry weight of the broccoli and peas (Plate 1) exposed to Wi-Fi radiation was much lower than controls at the end of the experiment ($p<0.01$). Wi-Fi exposure inhibited root growth of several species. It also caused root tips to turn brown and reduced root hairs of cress compared with the reference treatment. Broccoli seedlings closest to the Wi-Fi router grew away from the router; cress seedlings had larger leaves and were chlorotic compared with controls; and several of the Wi-Fi replicates had obvious growth of mould in Petri plates with unhealthy seedlings. Radiation generated by Wi-Fi routers can adversely affect plant growth and may interfere with a plant's ability to protect itself from opportunistic mould. With city-wide Wi-Fi and Wi-Fi in parks and on crown land a

growing area is exposed to this type of electromagnetic pollution. Cell phone base stations also generate microwave frequencies and the ones in the country are spaced further apart and are more powerful than those in urban centres.

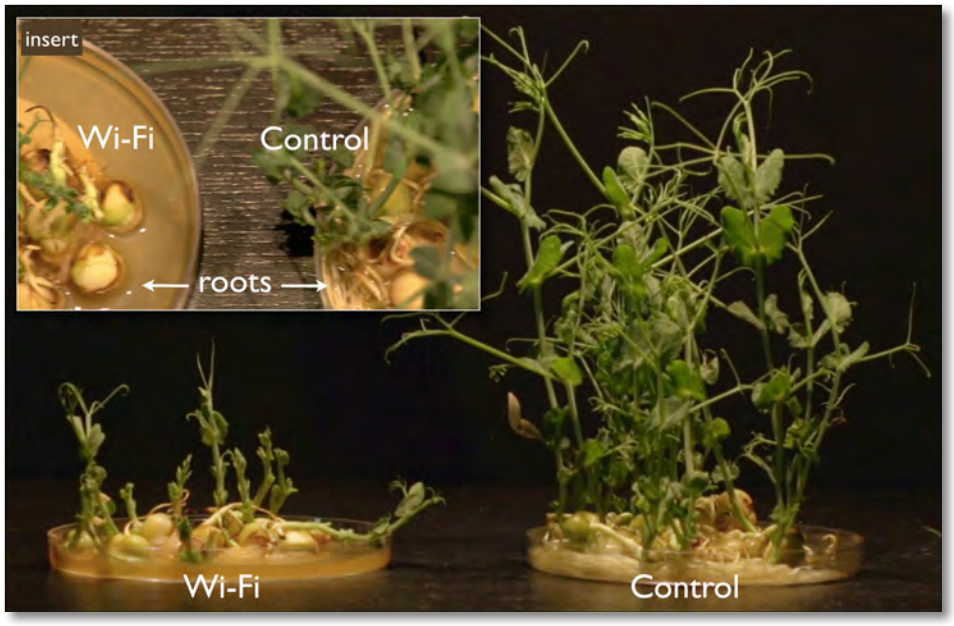

Plate 1. Growth of pea seedlings exposed to Wi-Fi radiation for one month compared with controls that were not exposed to radiation. Wi-Fi radiation reduced root growth (insert) and reduced above ground biomass. [Source: Havas and Symington (2016)]

Final Comments

Overall, the studies examining the effects of various types of electromagnetic pollution from power frequency electric and magnetic fields to microwave radiation are documenting adverse effects on reproduction, health and longevity of wildlife as well as reduced productivity in agriculturally and commercially important animals, insects and plants. These effects cannot continue to be ignored. As levels of electromagnetic pollution continue to increase and as the areas of exposure continue to expand a growing number of species are being placed at risk. Some of these species have critical functions in ecosystems and their disappearance can have widespread adverse effects on societies around the world.

Recommendation: That CEPA examine the research related to the biological effects of electromagnetic pollutants on biota and provide recommendations to other agencies responsible for their protection.

References Cited

Balmori, A. 2004. Electromagnetic Biology and Medicine 24: 109–119

Balmori, A. 2006. Toxicological & Environmental Chemistry 88 (2): 287–299.

Balmori A and O Hallberg. 2007. Electromagnetic Biology and Medicine 26 (2): 141-151.

Engels S., N-L Schneider, N Lefeldt, et al. 2015. Nature 509: 353.

Everaert J and D Bauwens. 2007. Electromagn Biol Med. 26 (1): 63-72.

Expert Group. 2010. Report on Possible Impacts of Communication Towers on Wildlife including Birds and Bees. Ministry of Environment and Forests, Government of India, 88 pages.

Favre, D. 2011. Apidologie 42 (3): 270–279.

Fernie KJ, DM Bird, RD Dawson, and PC Laguë. 2000. Physiol Biochem Zool. 73 (1): 60-65.

Fernie KJ and DM Bird. 2001. Environ Res. 86 (2): 198-207.

Glaser, ZR. 1971. Bibliography of Reported Biological Phenomena ('Effects') and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation, Research Report. Project MF12.524.015-00043, Report No. 2 Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland 20014, U.S.A.

Grigoriev Y. 2003. Radiats Biol Radioecol. 43 (5): 541-543.

Halgamuge MN. 2016. Electromagn Biol Med. 2016 Sep 20:1-23.

Haggerty K. 2010. International Journal of Forestry Research 2010, 7 pages.

Harst W, J Kuhn, and H Stever. 2006. Acta Systematica – IIAS Intern. J. 6: 1–6.

Hässig M, F Jud, and B Spiess. 2012. Schweiz Arch Tierheilkd. 154 (2): 82-86.

Havas M and MS Symington. 2016. Current Chemical Biology 10 (1): 65 – 73.

Hillman D, D Stetzer, M Graham, et al. 2013. Science of the Total Environment 447: 500–514.

ICNIRP. 1998. Health Physics 74(4): 494-522.

Ingol, IV and SK Ghosh. 2006. Biomedical Research 17 (3): 205-210.

Löscher, W, and G Käs. 1998. Der Praktische Tierarz 79 (5): 437-444.

Loss SR, T Will and PP Marra. 2014. PLoS One. 9 (7): e101565.

Manville, AM. 2016. A Briefing Memorandum: What We Know, Can Infer, and Don't Yet Know about Impacts from Thermal and Non-thermal Non-ionizing Radiation to Birds and Other Wildlife — for Public Release, Wildlife and Habitat Conservation Solutions.

Nicholls B and PA Racey. 2007. PLoS One. 2007 Mar 14;2(3):e297.

Pattazhy S. 2009. The Times of India, 31 August 2009. http://timesofindia.indiatimes.com/NEWS/Science/Mobile-phone-towers-a-threat-to-honeybees-Study/articleshow/4955867.cms .

Tanner JA and C Romero-Sierra. 1982. Journal of Bioelectricity 1 (2): 195–205.

Ubeda A, MA Trillo, L Chacon, et al. 1994. Bioelectromagnetics 15 (5): 385-398.

Warnke U. 2009. Bees, Birds and Mankind. Destroying Nature by 'Electrosmog' Effects of Wireless Communication Technologies, A Brochure Series by the Competence Initiative for the Protection of Humanity, Environment and Democracy, 47 pp.

Wiltschko, R, P Thalau, D Gehring, et al. 2015. J R Soc Interface 12(103).