Radiofrequency EMFs and Health Risks

This article is separated into 8 sections, each of which can be individually downloaded. It is a 'work in progress' incorporating new information whenever time permits.

Section 6
Animals, Birds, Insects and Plants

1. Introduction; RF broadcast transmitters (radio & TV); DAB transmitters; radar; mobile phone masts; Internet of Things (IoT); safety zones; Lloyd's of London insurance refusal

2. The research – General; addiction; autism; behaviour changes; blood-brain barrier; blood changes; blood pressure; bone and muscle development; brain activity; cancer; Non-Hodgkin's lymphoma; cellular changes; central nervous system; cognitive changes; dementia; diabetes; DNA; emotional effects; epilepsy; eyes; headaches; hearing

3. The research – heart; effects on heart pacemakers; immune system; kidney effects; lifespan; limb changes in utero; liver damage; medical interference; microwave therapy; multiple sclerosis; neurological changes; effects on the nose; occupational exposure, including pulsed RF; oxidative stress; pain; psychiatric symptoms; skin effects; effects on sleep; spine; spleen and thymus; synergistic effects; thyroid effects; other biological changes; protection; the need for precaution with respect to children; synergistic effects; campaigning organisations

4. General reproductive effects; Radiofrequency (microwave) (RF) exposure and reproductive effects; Mobile phones or phone-type exposure and male sperm; Radiofrequency exposure and effects on female reproduction; Radiofrequency exposure and effects during pregnancy

5. Driving – car systems; tracking vehicles; when your car lock doesn't work; driverless vehicles; road trains; charging electric vehicles; mobile phones; motorbikes; speed limiting devices; traffic control sensors; other in-car devices; interference with electric vehicles

6. Animals; birds and bats; tadpoles; fishes; insects; ants; bees; butterflies; cockroaches; flies; effects on plants

7. References – 595 references

8. Appendix; table of symptoms, by study; Santini 2002; Freiburger Appell 2002; Navarro 2003; Oberfeld 2004; open letter to Edmund Stoiber, President of Bavaria; Balmori 2005; Hutter 2006; Abdel-Rassoul 2007; Preece 2005; UK Parent-Teacher study 2000; Bortkiewicz 2004; Eger 2004; Wolf & Wolf 2004;

Eberhardt 2008; Augner 2010; Alazawi 2011; Santini 2003; Eger & Jahn 2010; Singh 2016; Kato & Johansson 2012; Gomez-Perretta 2013; Bortkiewicz 2012

Animals, Birds, Insects and Plants

The people whose studies put reported symptoms as a result of proximity to mobile phone base stations down to psychological reasons (Baliatsas 2011), should wonder why animals, birds, insects and plants experience problems too.

Information was collected from 113 studies on the potential ecological effects of radiofrequency electromagnetic fields (RF-EMF) in the range of 10 MHz to 3.6 GHz. In 65% of the studies, ecological effects of RF-EMF (50% of the animal studies and about 75% of the plant studies) were found both at high as well as at low dosages. The very low dosages are compatible with real field situations, and could be found under environmental conditions (Cucurachi 2013, Balmori 2014).

Due to concern that the radiation from mobile phone masts were having a negative impact on wildlife especially birds and bees, the Indian Environment Ministry said in August 2012 (ZEE news) that new towers should not be permitted within a radius of one kilometre of existing ones.

Exposure to RF levels that are found in the environment (in urban areas and near base stations) may particularly alter the receptor organs that orient to the magnetic field of the earth. This could have important implications for migratory birds and insects, especially in urban areas, but could also apply to birds and insects in natural and protected areas where there are powerful base station emitters of radiofrequencies (Balmori 2015).

Animals

As a result of exposure from mobile phone base stations during pregnancy, especially the first trimester, 32% of calves developed nuclear cataracts, 3.6% severely. In another study, Hässig (2012) found that calves born near a mobile phone base station had a 3.5 times higher risk for heavy cataract, compared with the Swiss average. Oxidative stress was increased in the eyes with cataracts, and there was an association between oxidative stress and the distance to the nearest mast (Hässig 2009).

Professor Andras Varga form the University of Heidelberg found that chicks exposed to microwaves in the egg died or hatched with deformities. Andrew Goldsworthy says *"when electromagnetic fields interfere with the permeability of cell membranes, we can expect them to interfere with the patterns of growth of the embryo and have all sorts of unwanted effects."*

Birds and bats

Reproductive and co-ordination problems and aggressive behaviour was identified in the study by Balmori (2005) of a population of storks nesting in Valladolid, Spain. Any study on animals may not be directly applicable to humans, but rules out the psychosomatic effect that is often referred to by industry and top scientific advisers (people develop symptoms because they are worried by the mast they can see).

Balmori produced another paper (2009) gathering together the literature on a number of bird species (white storks, house sparrows and urban park bird life), and concluded that *"the modern mobile telecommunication systems are severely affecting wildlife, the full effects of which we are not able to fully predict."*

Ritz (2004) reported that at a frequency range that included most mobile telecommunications, including mobile phones, DECT cordless phones and WiFi, birds became completely unable to respond to the Earth's magnetic field by which they navigate. Migratory birds are unable to use their magnetic compass in the presence of urban electromagnetic noise (Engels 2014). Birds in experimental cages, deprived of visual information, showed the seasonally appropriate direction of intended flight with respect to the magnetic meridian. Weak radiofrequency (RF) magnetic field (190 nT at 1.4 MHz) disrupted this orientation ability (Kavokin 2014).

Beason & Semm (2002) investigated the effects of an RF signal similar to that from mobile phones on the neurons of the avian brain. They found changes in the amount of neural activity in more than half of the brain cells. Most of the responding cells increased their rates of firing by an average 3.5-fold. The other responding cells exhibited a decrease in their rates of spontaneous activity. Such responses indicate potential effects on humans using hand-held cellular phones.

Chryptochrome pigments, found in the eyes, are also affected by EMFs, so that birds could not compensate accurately for the position of the sun. Without these solar and magnetic landmarks, they would become completely lost.

European robins' responses to RF exposure depended on the alignment of the field with respect to the static geomagnetic field: when the 1.315 MHz field was aligned parallel with the field lines, birds significantly preferred northerly directions in spring and southerly directions in autumn. These preferences reflect normal migratory orientation. However, in the 1.315 MHz field aligned at a 24 degrees angle to the field lines, the birds were disoriented in both seasons, indicating that the high frequency field interfered with magnetoreception (Thalau 2005).

There was a significant relationship between the number of house sparrows and the levels of field strength from mobile phone base stations in studies by Everaert & Bauwens (2007) and Balmori & Hallberg (2007). The stronger the field, the smaller the number of sparrows, though the fields in question were seldom higher than 1 volt per metre. The authors concluded *"Long term exposure to higher levels of radiation negatively affects the abundance or behaviour of House Sparrows in the wild."* In a personal communication, we were told that in 1956, when a new radar system was being tested that used a fast rise time and very short duration pulse (similar to that used in modern digital communications systems), a large flock of thousands of migrating birds (mainly swifts and house martins) were found dead, or dying, over a wide area of the South Downs.

Several million birds are estimated to die each year from collisions with telecommunications masts in the USA during migration. It is believed that the microwave radiation could distort the earth's magnetic field that the birds use for navigation. Birds are good candidates as biological indicators for low-intensity electromagnetic radiation; they have thin skulls, their feathers can act as dielectric receptors of microwave radiation, many species use magnetic navigation and possible psychosomatic effects are absent.

Apparently, according to a BBC news report in 2008, bats are proving sensitive to air pressure changes around the blades of wind turbines that are proving fatal to numbers of them. A group, including Aberdeen University, are suggesting that radar emissions may keep the bats away from wind farms, adding to emissions (though very localised) in the vicinity of the turbines.

Tadpoles

Tadpoles were exposed to electromagnetic radiation from 3 sources 140 metres away. The study found in the exposed tadpoles, low coordination of movements, asynchronous growth, and a high mortality rate (90%). The author (Balmori 2010) believes these findings have implications for the exposed natural world.

Mortazavi (2015) supported early reports which indicated a wide variety of non-thermal effects of electromagnetic radiation on amphibians including the effects on the pattern of muscle extractions.

Fishes

Antarctic krill were disoriented after being exposed to RF. Orientation was lost not only in an RF field with a magnetic flux density of 20 nT, as expected according to the literature, but even under the 2 nT originally intended as a control. Our results (Tomanova & Vacha 2016) extend recent findings of the extraordinary sensitivity of animal magnetoreception to weak RF fields in marine invertebrates.

Insects

Other animal studies have been done which suggest that RF radiation may be affecting even vital insect life and populations. Liboff (personal communication) suggests that the situation could be further complicated by the fact that the earth's magnetic field may have begun its next reversal, adversely affecting the bee population. Geronikolou (2014) suggested a possible radiofrequency sensitivity difference in insects and that lower frequencies tended to increase radiofrequency effects.

However, with respect to female mosquitoes, several RF frequencies apparently showed up to 0.2-70% shift in both lateral and vertical positions, but without repeatability (Poh 2017). This may offer a positive way of controlling both mosquitoes and midges in their breeding season, and thus reducing the effect on insect borne illnesses. It needs to be determined as to whether these frequencies may affect other insects within the exposed area.

Ants

Experiments were conducted on 6 identical colonies of ants, exposing them to RF radiation similar to those surrounding GSM and other communications masts (Cammaerts 2012). Under this exposure, no association between food and either olfactory or visual cues occurred. After a recovery period, the ants were able to make such an association but never reached the expected score. Such ants having acquired a weaker olfactory or visual score and still undergoing olfactory or visual training were again submitted to RF EMFs. Not only did they lose all that they had memorised, but also they lost it in a few hours instead of a few days (as under normal conditions when no longer trained). They kept no visual memory at all (instead of keeping 10% of it as they normally do). The impact of GSM 900 MHz radiation was greater on the visual memory than on the olfactory one. This radiation may have such a disastrous impact on a wide range of insects using olfactory and/or visual memory i.e. on bees. Cammaerts (2014, 2014b) concluded that 900 MHz radiation might have a severe impact on the nerve cells of exposed ants suggesting that electromagnetic radiation may have an impact on the orientation behaviour and navigation of animals that use magnetic fields to find their way. A further study by Cammaerts (2013) showed similar catastrophic behaviour changes and colony deterioration. RF severely affected the ants' social behaviour and physiology.

Bees

The current problem is thought to be a combination of different factors. Pesticides are weakening the bees without killing them, making them more susceptible to other environmental pollutants. The bees seem to leave the hive looking for nectar and fail to return.

According to Dr Ulrich Warnke, University of Saarland (2007) there are 6 main points outlining why bees are sensitive to electromagnetic pollution.

- The integuments of bees (and bird feathers) have semiconductor and piezoelectric functions. This means they are transducers of pulse modulated high frequency microwave fields into an audio frequency range. Several constructions of the integument work like dielectric receptors of electromagnetic radiation in the microwave region.
- In the abdomen of bees are found magnetite nanoparticles.
- Magnetite is an excellent absorber of microwave radiation at frequencies between 0.5 and 10.0 GHz through the process of ferromagnetic resonance. Pulsed microwave energy absorbed by this process is first transduced into acoustic vibrations (magneto acoustic effect).
- It has been demonstrated that free-flying honeybees are able to detect static intensity fluctuations and ultra low frequency magnetic fields as weak as 26 nT against the background earth-strength magnetic field.
- Magnetic field bursts at a frequency of 250 Hz oriented parallel to the field-lines of the earth's magnetic field induce unequivocal jumps of misdirection of up to $+10^{o}$.
- The magnetic induction levels to day in the environment are in the extremely low frequency range usually between 0.001 and 170µT; in the high frequency range between several nT and several µT. So these levels are commonly higher than the threshold of sensibility of bees to variations of magnetic fields.

He concludes that the orientation and navigation of bees may be disturbed by man-made technical communications fields.

It may be due to the effects on their cryptochrome pigments, which they use for both solar and magnetic navigation, and is highly sensitive to radio frequency radiation. Cryptochromes absorb light and use its energy to repair damaged DNA. They also regulate the timing of their natural circadian rhythms.

Animals that navigate using the earth's magnetic field also use cryptochromes to sense the direction of the field. Cryptochrome can detect the direction of the field because it uses the energy of light to flip an electron between two parts of the molecule to generate a pair of unstable magnetic free radicals. The electron tries to return to its original position, but the rate at which it does so depends on the direction of the earth's field relative to the molecule, and gives an indication of the direction of the field.

Bees use internal 'clocks' for navigation. Mobile phone radiation can disrupt these biological clocks. Once disrupted in bees, they are no longer able to compensate for the changing position of the sun throughout the day, causing them to fly in the wrong direction, away from the hive (Andrew Goldsworthy).

The cause seems to be more likely to be outside than inside the hive, although bees that would normally raid an abandoned hive are not doing so.

A recent study reported in a beekeepers journal, in German reported problems in the bee population after the installation of mobile phone equipment nearby http://www.mikrowellensmog.info/bienen.html. 37.5% of the bees were more aggressive, 25% of the bees tended to leave the hive, and 62.5% reported collapses of the bee population. This raises significant questions, as bees are so important for food production, and the rise in price of foodstuffs will reflect this. Bees are responsible for pollinating a third of the crops, such as apples, strawberries, almonds and onions, produced in America, the world's biggest food supplier.

Siegfried Vogel holds the mobile telecommunications radiation responsible for the loss of his four bee colonies. The aluminium lining protected the bee colonies of his son, the metal effectively shielding the insects against the radiation.

Stever (2005) showed that when 2 hives of bees were exposed to a DECT phone, out of 25 bees released 800 metres away from each, only 6 bees returned to one hive and none to the other. 21% fewer cells were constructed in the frames of the exposed hives. A member of the Suffolk Beekeepers Association said that Beekeepers needed more research done into the effects radio waves and mobile phone masts have on bee orientation. He says when he wears his digital hearing aid the bees won't leave him alone, and if his mobile rings when he is working with the bees, they will swarm around it.

Radiation from a mobile phone was found to influence honey bees' behaviour and physiology, reducing motor activity of worker bees on the comb initially, followed by en masse migration and movement (Kumar 2011) and other signs of a disturbed bee colony (Favre 2011), even colony collapse (Sharma & Kumar 2010). The initial quiet period was characterised by a rise in the concentration of biomolecules, including proteins, carbohydrates and lipids, perhaps due to stimulation of the body's mechanism to fight the stressful condition created by the radiation.

Rubin (2006) discovered that the molecular structure of the biological clock of the honey bee is more similar to the biological clock of mammals than that of other insects, including the circadian production of melatonin. The central biological clock is located in the brain and is made up of groups of 'clock cells'. Circadian rhythms are generated by complex interactions between 'clock genes' that accumulate in the cells. These clock genes are involved, in humans, in a variety of illnesses such as mental disturbances, alcoholism, problems of overweight and drug addiction, as well as in processes relating to ageing. The clock is also essential for navigation that uses the sun as a compass because the sun moves during the day from east to west.

EMFs from telecommunications infrastructures could interfere with bees' biological clocks that enable them to compensate properly for the sun's movements and may fly in the wrong direction when attempting to return to the hive. They could disappear mysteriously. This phenomenon has been widely reported in the past months.

Butterflies

It is also possible that the magnetoreception system in Monarch butterfly orientation (Guerra 2014) may be suffering from interference from RF, which may be a cause of their population decline.

Cockroaches

Animal navigation in the Earth's magnetic field is disrupted by even weak radio waves (Vácha 2009). The frequencies in this study are lower than the 'carrier' frequencies used by mobile phones, but they are nevertheless generated as 'out-of-band' radiation when they are modulated to carry speech or information.

Again, it is to do with cryptochrome which regulates insect's immune systems, so RF makes them more susceptible to pathogens.

Flies

Exposing fruit flies to 2G radiation at 900 MHz & 1800 MHZ for a few minutes per day for the first 6 days of their adult life, in both cases resulted in DNA fragmentation (Panagopoulos 2007).

A further study (Panagopoulos 2012) showed that the ovarian size of exposed flies was significantly smaller, due to destruction of egg chambers by GSM radiation. Continuous and intermittent exposure both brought about a large decrease in the flies reproductive capacity, due to DNA fragmentation (Chavdoula 2010).

Pourlis (2009) said "*according to the majority of the investigations*" he looked at "*no strong effects resulted regarding the exposure to EMF of mobile telephony in the animal reproduction and development*", but commented that "*further research should be done in order to clarify many unknown aspects of the impact of EMF in the living organisms.*"

Effects on plants

Tkalec (2007) exposed duckweed (Lemna minor L) to radiofrequency radiation at 400 and 900 MHz. Their conclusion was that non-thermal exposure to RF fields induced oxidative stress in duckweed as well as unspecific stress responses, especially of antioxidative enzymes. They also found that the observed effects markedly depended on the field frequencies applied as well as on other exposure parameters, such as strength, modulation and exposure time (Tkalec 2005). RF EMF generated by transmitting antennas resulted in alanine accumulation in plant cells, a phenomenon we have previously shown to be a universal stress signal (Monselise 2011).

Parrot feather (pictured right), was exposed to RF radiation at a non-thermal level, which reduced its growth, and no significant recovery was found after exposure (Senavirathna 2014).

Roux (2008) exposed tomato plants to low level RF radiation. They concluded that the accumulation of stress-related mRNA was typical of an environmental stress response, and a direct consequence of RF radiation. They concluded that the plants perceived the radiation as an injurious stimulus.

Grémiaux (2016) exposed rose bushes during a period of growth. Exposure to 900 MHz radiation of the rooted cuttings resulted in delayed and significant reduced growth (45%).

RF exposure impaired the early growth of vigna radiata (mung bean) seedlings by inducing biochemical changes (Sharma 2010). In a study of three different plant species (parsley, celery & dill), Soran (2014) found a direct relationship between microwave-induced structural and chemical modifications. The authors concluded that human-generated microwave pollution, particularly wLAN routers and GSM phones could potentially constitute a stress to the plants.

Katie Haggerty, an independent researcher suggests that the manmade RF environment may be adversely affecting growth, dormancy, and resistance to fungus in aspen seedlings. Inhibition of growth in aspen caused by exposure to the RF background would limit their ability to take up CO_2 and sequester carbon. This RF interaction with plants may, therefore, be indirectly contributing to the ongoing increase in atmospheric CO_2.

Trees make very good RF antennas and convert the radiation into weak RF electric currents that travel down the trunk, through the roots and into the soil. On their way into the soil, they have to cross a barrier called the endodermis (analogous to the blood-brain barrier in animals) which normally prevents the entry of unwanted materials and pathogens. Damage to this barrier due to the currents causing cell leakage would make the tree more susceptible to a range of soil-borne pathogens (Andrew Goldsworthy).

The effect of right-handed polarized electromagnetic radiation **increases** and the influence of left-handed polarized one **reduces** the germinating capacity of seeds compared to the effect of the linearly polarized electromagnetic radiation (Polevik 2013), which could explain differences in experimental results.

Vian (2016) concluded that nonionizing HF-EMF radiation is an environmental factor that readily evokes changes in plant metabolism.

Halgamuge (2017) reviewed 45 peer-reviewed scientific publications describing 169 experimental observations and concluded that about 90% show physiological effect on plants. These included maize, roselle, pea, fenugreek, duckweeds, tomato, onions and mungbean plants.