

“There is enough evidence to indicate we may be damaging non-human species at ecosystem and biosphere levels across all taxa from rising background levels of anthropogenic non-ionizing EMF from 0Hz to 300 GHz...

-Levitt, Lai, and Manville (2022), [Low-level EMF effects on wildlife and plants: What research tells us about an ecosystem approach.](#)

Environmental Health Trust has collected a selection of studies on the impact of wireless and other non ionizing electromagnetic fields to flora and fauna.

REVIEWS

Balmori A. (2024) [Radio-tracking systems emit pulsed waves that could affect the health and alter the orientation of animals.](#) Journal for Nature Conservation [Volume 77](#), January

Balmori A. (2021) [Electromagnetic radiation as an emerging driver factor for the decline of insects.](#) Science of the Total Environment. 767: 144913

Balmori, A. (2015). [Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation.](#) Science of The Total Environment, 518–519, 58–60.

Balmori A. (2014). [Electrosmog and species conservation.](#) Science of The Total Environment, 496:314-316

Balmori A. [Radiotelemetry and wildlife: Highlighting a gap in the knowledge on radiofrequency radiation effects.](#) Sci Total Environ. 2016 Feb 1;543

Balmori A. [Electromagnetic pollution from phone masts. Effects on wildlife.](#) Pathophysiology. 2009 Aug;16(2-3):191-9

Balmori, A. [The incidence of electromagnetic pollution on wild mammals: A new “poison” with a slow effect on nature?](#) Environmentalist 30, 90–97 (2010).

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.

Jérémy S. P. Froidevaux, Laura Recuero Virto, Marek Czerwiński, Arno Thielens, and Kirsty J. Park [Addressing Wildlife Exposure to Radiofrequency Electromagnetic Fields: Time for Action](#) Environmental Science & Technology Letters, 2024, 11, 1, 3–4

Klune J, Arhant C, Windschnurer I, Heizmann V, Schauburger G. Tracking Devices for Pets: Health Risk Assessment for Exposure to Radiofrequency Electromagnetic Fields. Animals. 2021; 11(9):2721. <https://doi.org/10.3390/ani11092721>

Thill A, Cammaerts MC, Balmori A. [Biological effects of electromagnetic fields on insects: a systematic review and meta-analysis](#). Rev Environ Health. 2023 Nov 23

Levitt BB, Lai HC and Manville AM II (2022) [Low-level EMF effects on wildlife and plants: What research tells us about an ecosystem approach](#). Front. Public Health 10:1000840. doi: 10.3389/fpubh.2022.1000840

Levitt, B. B., Lai, H. C., & Manville, A. M. (2021a). [Effects of non-ionizing electromagnetic fields on flora and fauna, part 1. Rising ambient EMF levels in the environment](#). Reviews on Environmental Health, 37(1), 81–122.

Levitt, B. B., Lai, H. C., & Manville, A. M. (2021b). [Effects of non-ionizing electromagnetic fields on flora and fauna, Part 2 impacts: How species interact with natural and man-made EMF](#). Reviews on Environmental Health, 37(3), 327–406.

Levitt, B. B., Lai, H. C., & Manville, A. M. (2021). [Effects of non-ionizing electromagnetic fields on flora and fauna, Part 3. Exposure standards, public policy, laws, and future directions](#). Reviews on Environmental Health.

Manville AM II, Levitt BB and Lai HC (2024) [Health and environmental effects to wildlife from radio telemetry and tracking devices—state of the science and best management practices](#). Front. Vet. Sci. 11:1283709.

Panda DK, Das DP, Behera SK, Dhal NK. [Review on the impact of cell phone radiation effects on green plants](#). Environ Monit Assess. 2024 May 21;196(6):565

[Sivani, S. and D. Sudarsanam. \(2012\): "Impacts of radio-frequency electromagnetic field \(RF-EMF\) from cell phone towers and wireless devices on biosystem and ecosystem-a review."](#) Biology and Medicine 4, no. 4 202-216.

Recuero Virto L, Thielens A, Czerwiński M, Froidevaux J. [The exposure of nonhuman living organisms to mobile communication emissions: A survey to establish European stakeholders' policy option preferences](#). Risk Anal. 2024 May 22.

Zhen C, Zhang G, Wang S, Wang J, Fang Y, Shang P. [Electromagnetic fields regulate iron metabolism in living organisms: A review of effects and mechanism](#). Prog Biophys Mol Biol. 2024 Mar 4;188:43-54.

BIRDS

Augustianath, T., Evans, D. A., & Anisha, G. S. (2023). [Teratogenic effects of radiofrequency electromagnetic radiation on the embryonic development of chick: A study on morphology and hatchability](#). Research in veterinary science, 159, 93–100.

Balmori A. (2022). [Corneal opacity in Northern Bald Ibises \(*Geronticus eremita*\) equipped with radio transmitters](#). Electromagnetic Biol Med.174-176.

Alfonso Balmori (2005) [Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stork \(*Ciconia ciconia*\)](#), Electromagnetic Biology and Medicine, 24:2, 109-119

Balmori A, Hallberg O. [The urban decline of the house sparrow \(*Passer domesticus*\): a possible link with electromagnetic radiation](#). Electromagn Biol Med. 2007;26(2):141-51.

Engels, S.; Schneider, N.L.; Lefeldt, N.; Hein, C.M.; Zapka, M.; Michalik, A.; Elbers, D.; Kittel, A.; Hore, P.J.; Mouritsen, H. [Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird](#). Nature 2014, 509, 353–356.

Everaert, J.; Bauwens, D. [A possible effect of electromagnetic radiation from mobile phone base stations on the number of breeding house sparrows \(*Passer domesticus*\)](#). Electromagn. Biol. Med.2007, 26, 63–72.

Islam, M. S., Islam, M. M., Rahman, M. M., & Islam, K. (2023). [4G mobile phone radiation alters some immunogenic and vascular gene expressions, and gross and microscopic and biochemical parameters in the chick embryo model](#). Veterinary medicine and science, 10.1002/vms3.1273. Advance online publication.

Leberecht, B., Wong, S. Y., Satish, B., Döge, S., Hindman, J., Venkatraman, L., Apte, S., Haase, K., Musielak, I., Dautaj, G., Solov'yov, I. A., Winklhofer, M., Mouritsen, H., & Hore, P. J. (2023). [Upper bound for broadband radiofrequency field disruption of magnetic compass orientation in night-migratory songbirds](#). Proceedings of the National Academy of Sciences of the United States of America, 120(28), e2301153120.

Fernie, K. J., & Reynolds, S. J. (2005). [The effects of electromagnetic fields from power lines on avian reproductive biology and physiology: A review](#). Journal of Toxicology and Environmental Health. Part B, Critical Reviews, 8(2), 127–140.

Fernie, K.J.; Bird, D.M. [Evidence of oxidative stress in American kestrels exposed to electromagnetic fields](#). Environ. Res. A 2001, 86, 198–207.

Muheim, R., & Phillips, J. B. (2023). [Effects of low-level RF fields reveal complex pattern of magnetic input to the avian magnetic compass](#). Scientific reports, 13(1), 19970.

Schwarze, S., Schneider, N.-L., Reichl, T., Dreyer, D., Lefeldt, N., Engels, S., Baker, N., Hore, P. J., & Mouritsen, H. (2016). [Weak Broadband Electromagnetic Fields are More Disruptive to Magnetic Compass Orientation in a Night-Migratory Songbird \(Erithacus rubecula\) than Strong Narrow-Band Fields](#). Frontiers in Behavioral Neuroscience, 10.

Sheridan, E.; Randolet, J.; DeVault, T.L.; Seamans, T.W.; Blackwell, B.F.; Fernández-Juricic, E. [The effects of radar on avian behavior: Implications for wildlife management at airports](#). Appl. Anim. Behav. Sci. 2015, 171, 241–252.

Shende, V.A.; Patil, K.G. [Electromagnetic radiations: A possible impact on population of house sparrow \(Passer Domesticus\)](#). Eng. Int. 2015, 3, 45–52.

Surendran, N.S.; Siddiqui, N.A.; Mondal, P.; Nandan, A. [Repercussion of electromagnetic radiation from cell towers/mobiles and their impact on migratory birds](#). In Advances in Air Pollution Profiling and Control; Springer: Singapore, 2020; pp. 193–202.

Tonelli, B. A., Youngflesh, C., & Tingley, M. W. (2023). [Geomagnetic disturbance associated with increased vagrancy in migratory landbirds](#). Scientific Reports, 13(1), Article 1.

Wiltschko, R., Thalau, P., Gehring, D., Nießner, C., Ritz, T., & Wiltschko, W. (2015). [Magnetoreception in birds: The effect of radio-frequency fields](#). Journal of The Royal Society Interface, 12(103), 20141103.

INSECTS

El-Gashingy, D., Meshrif, W., Mansour, D., Naiem, E., & Seif, A. (2024). [Effect of the electric field generated from high voltage power lines on the biology and behavior of the fruit fly, Drosophila melanogaster](#). Catrina: The International Journal of Environmental Sciences, 30(1), 51-63

Vilić, Marinko, Ivona Žura Žaja, Mirta Tkalec, Perica Tucak, Krešimir Malarić, Nato Popara, Nikolino Žura, Selim Pašić, and Ivana Tlak Gajger. 2024. ["Oxidative Stress Response of Honey Bee Colonies \(Apis mellifera L.\) during Long-Term Exposure at a Frequency of 900 MHz under Field Conditions"](#) Insects 15, no. 5: 372. <https://doi.org/10.3390/insects15050372>

- Tlak Gajger, I.; Vilić, M.; Tucak, P.; Malarić, K. [Effect of Electromagnetic Field on Some Behaviour Modality of Honeybee Colonies \(*Apis mellifera*\) in Field Conditions](#). J. Anim. Vet. Adv. 2001, 18, 61–64. ‘
- A. Lázaro, A. Chroni, T. Tscheulin, J. Devalez, C. Matsoukas, & T. Petanidou. (2016). [Electromagnetic radiation of mobile telecommunication antennas affects the abundance and composition of wild pollinators](#). Journal of Insect Conservation, 20(2), 315–324. <https://doi.org/10.1007/s10841-016-9868-8>
- Adelaja, O. J., Ande, A. T., Abdulraheem, G. D., Oluwakorode, I. A., Oladipo, O. A., & Oluwajobi, A. O. (2021). [Distribution, diversity and abundance of some insects around a telecommunication mast in Ilorin, Kwara State, Nigeria](#). Bulletin of the National Research Centre, 45(1), 222.
- Balmori A. (2021) [Electromagnetic radiation as an emerging driver factor for the decline of insects](#). Science of the Total Environment. 767: 144913
- Borre, E. D., Joseph, W., Aminzadeh, R., Müller, P., Boone, M. N., Josipovic, I., Hashemizadeh, S., Kuster, N., Kühn, S., & Thielens, A. (2021). [Radio-frequency exposure of the yellow fever mosquito \(*A. aegypti*\) from 2 to 240 GHz](#). PLOS Computational Biology, 17(10), e1009460.
- Cappucci, Ugo, Assunta Maria Casale, Mirena Proietti, Fiorenzo Marinelli, Livio Giuliani, and Lucia Piacentini. 2022. [Wi-Fi Related Radiofrequency Electromagnetic Fields Promote Transposable Element Dysregulation and Genomic Instability in *Drosophila melanogaster*](#), Cells 11, no. 24: 4036. <https://doi.org/10.3390/cells11244036>
- De Paepe S, De Borre E, Toribio Carvajal D, Bell D, Thielens A. (2022) [Pilot study of a new methodology to study the development of the blue bottle fly \(*Calliphora vomitoria*\) under exposure to radio-frequency electromagnetic fields at 5.4 GHz](#). Int J Radiat Biol. Aug 24:1-17
- Thill A, Cammaerts MC, Balmori A. [Biological effects of electromagnetic fields on insects: a systematic review and meta-analysis](#). Rev Environ Health. 2023 Nov 23
- Favre, D. (2011). [Mobile phone-induced honeybee worker piping](#). Apidologie, 42(3), 270–279.
- Fedele, G., Edwards, M. D., Bhutani, S., Hares, J. M., Murbach, M., Green, E. W., Dissel, S., Hastings, M. H., Rosato, E., & Kyriacou, C. P. (2014). [Genetic analysis of circadian responses to low frequency electromagnetic fields in *Drosophila melanogaster*](#). PLoS Genetics, 10(12), e1004804.
- Lee, K.-S., Choi, J.-S., Hong, S.-Y., Son, T.-H., & Yu, K. (2008). [Mobile phone electromagnetic radiation activates MAPK signaling and regulates viability in *Drosophila*](#). Bioelectromagnetics, 29(5), 371–379.

Li, S.-S., Zhang, Z.-Y., Yang, C.-J., Lian, H.-Y., & Cai, P. (2013). [Gene expression and reproductive abilities of male *Drosophila melanogaster* subjected to ELF-EMF exposure.](#) Mutation Research. Genetic Toxicology and Environmental Mutagenesis, 758(1–2), 95–103.

Lopatina, N. G., Zachepilo, T. G., Kamyshev, 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.

Lupi, D., Tremolada, P., Colombo, M., ..., Zambon, G., & Vighi, M. (2020). [Effects of Pesticides 23 and Electromagnetic Fields on Honeybees: A Field Study Using Biomarkers.](#) Int J Environ Res 24 14, 107–122.

Lupi, D., Palamara Mesiano, M., Adani, A., Benocci, R., Giacchini, R., Parenti, P., Zambon, G., Lavazza, A., Boniotti, M. B., Bassi, S., Colombo, M., & Tremolada, P. (2021a). [Combined Effects of Pesticides and Electromagnetic-Fields on Honeybees: Multi-Stress Exposure.](#) Insects, 12(8), 716.

Manta, A. K., Papadopoulou, D., Polyzos, A. P., Fragopoulou, A. F., Skouroliaou, A. S., Thanos, D., Stravopodis, D. J., & Margaritis, L. H. (2017). [Mobile-phone radiation-induced perturbation of gene-expression profiling. redox equilibrium and sporadic-apoptosis control in the ovary of *Drosophila melanogaster*.](#) Fly, 11(2), 75–95.

Mahmoud EA 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, (23 March).

Molina-Montenegro MA, Acuña-Rodríguez IS, Ballesteros GI, Baldelomar M, Torres-Díaz C, Broitman BR, Vázquez DP. (2023) [Electromagnetic fields disrupt the pollination service by honeybees.](#) Sci Adv. May 12;9(19)

Migdał, P., Berbeć, E., Bieńkowski, P., Plotnik, M., Murawska, A., & Latarowski, K. (2022b). [Exposure to Magnetic Fields Changes the Behavioral Pattern in Honeybees \(*Apis mellifera* L.\) under Laboratory Conditions.](#) Animals: An Open Access Journal from MDPI, 12(7), 855.

Manuel Reategui-Inga, Eli Morales Rojas, Daniel Tineo, Marcelino Jorge Aranibar-Aranibar, Wilfredo Alva Valdiviezo, Casiano Aguirre Escalante and Sandro Junior Ruiz Castre, 2023. [Effects of Artificial Electromagnetic Fields on Bees: A Global Review.](#) Pakistan Journal of Biological Sciences, 26: 23-32.

Migdal, P., Bieńkowski, P., Cebrat, M., Berbeć, E., Plotnik, M., Murawska, A., Sobkiewicz, P., Łaskiewicz, A., & Latarowski, K. (2023). [Exposure to a 900 MHz electromagnetic field induces a response of the honey bee organism on the level of enzyme activity and the expression of stress-related genes.](#) PloS one, 18(5), e0285522.

Migdał P, Murawska A, Strachecka A, Bieńkowski P, Roman A. [Changes in the Honeybee Antioxidant System after 12 h of Exposure to Electromagnetic Field Frequency of 50 Hz and Variable Intensity](#). Insects. 2020 Oct 18;11(10):713. doi: 10.3390/insects11100713. PMID: 33081029; PMCID: PMC7603132.

Migdal, P., Plotnik, M., Bieńkowski, P., Murawska, A., Berbeć, E., Sobkiewicz, P., ... Latarowski, K. (2024). Changes in honey bee nutrition after exposure to radiofrequency electromagnetic field. The European Zoological Journal, 91(1), 172–179. <https://doi.org/10.1080/24750263.2024.2308550>

Nikita, Grover, A., Kalia, P., Sinha, R., & Garg, P. (2022). [Colony collapse disorder: A peril to apiculture](#). Journal of Applied and Natural Science, 14(3), 729–739. <https://doi.org/10.31018/jans.v14i3.3502>

Nik Abdull Halim NMH, Mohd Jamili AF, Che Dom N, Abd Rahman NH, Jamal Kareem Z, Dapari R. [The impact of radiofrequency exposure on Aedes aegypti \(Diptera: Culicidae\) development](#). PLoS One. 2024 Feb 27;19(2):e0298738.

Odemer, R., & Odemer, F. (2019). [Effects of radiofrequency electromagnetic radiation \(RF-EMF\) on honey bee queen development and mating success](#). Science of The Total Environment, 661, 553–562.

Panagopoulos DJ. [Effect of microwave exposure on the ovarian development of Drosophila melanogaster](#). Cell Biochem Biophys. 2012 Jun;63(2):121–32.

Panagopoulos DJ, Karabarbounis A, Lioliousis C. [ELF alternating magnetic field decreases reproduction by DNA damage induction](#). Cell Biochem Biophys. 2013 Nov;67(2):703–16. doi: 10.1007/s12013-013-9560-5. PMID: 23526156.

Piechowicz B, Sadło S, Woś I, Białek J, Depciuch J, Podbielska M, Szpyrka E, Kozioł K, Piechowicz I, Koziorowska A. [Treating honey bees with an extremely low frequency electromagnetic field and pesticides: Impact on the rate of disappearance of azoxystrobin and λ-cyhalothrin and the structure of some functional groups of the probabilistic molecules](#). Environ Res. 2020 Nov;190:109989

Dimitris J. Panagopoulos, Andreas Karabarbounis & Lukas H. Margaritis (2004) [Effect of GSM 900-MHz Mobile Phone Radiation on the Reproductive Capacity of Drosophila melanogaster](#). Electromagnetic Biology and Medicine, 23:1, 29–43

Santhosh Kumar, S. (2018). [Colony Collapse Disorder \(CCD\) in Honey Bees Caused by EMF Radiation](#). Bioinformation, 14(9), 421–424.

Shepherd S, Lima MAP, Oliveira EE, Sharkh SM, Jackson CW, Newland PL. [Extremely Low Frequency Electromagnetic Fields impair the Cognitive and Motor Abilities of Honey Bees](#). Sci Rep. 2018 May 21;8(1):7932.

Thielens, A., Bell, D., Mortimore, D. B., Greco, M. K., Martens, L., & Joseph, W. (2018). [Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz](#). Scientific Reports, 8(1), 3924.

Thielens A, Greco MK, Verloock L, Martens L, Joseph W. [Radio-Frequency Electromagnetic Field Exposure of Western Honey Bees](#). Scientific Reports. 2020 Jan 16;10(1):461.

Treder M, Müller M, Fellner L, Traynor K, Rosenkranz P. [Defined exposure of honey bee colonies to simulated radiofrequency electromagnetic fields \(RF-EMF\): Negative effects on the homing ability, but not on brood development or longevity](#). Sci Total Environ. 2023 Oct 20;896:165211.

V. Jeladze, A. Thielens, T. Nozadze, G. Korkotadze, B. Partsvania and R. Zaridze, "[Estimation of the Specific Absorption Rate for a Honey bee Exposed to Radiofrequency Electromagnetic Fields from 2.5 to 100 GHz](#)," 2023 IEEE XXVIII International Seminar/Workshop on Direct and Inverse Problems of Electromagnetic and Acoustic Wave Theory (DIPED), Tbilisi, Georgia, 2023, pp. 180-185

Wang, Y., Jiang, Z., Zhang, L., Zhang, Z., Liao, Y., & Cai, P. (2022b). [3.5-GHz radiofrequency electromagnetic radiation promotes the development of Drosophila melanogaster](#). Environmental Pollution (Barking, Essex: 1987), 294, 118646.

Wang, Y., Zhang, H., Zhang, Z., Sun, B., Tang, C., Zhang, L., Jiang, Z., Ding, B., Liao, Y., & Cai, P. (2021). [Simulated mobile communication frequencies \(3.5 GHz\) emitted by a signal generator affects the sleep of Drosophila melanogaster](#). Environmental Pollution (Barking, Essex: 1987), 283, 117087.

Wyszkowska J, Maliszewska J, Gas P. [Metabolic and Developmental Changes in Insects as Stress-Related Response to Electromagnetic Field Exposure](#). Applied Sciences. 2023; 13(17):9893.

Wyszkowska J, Kobak J, Aonuma H. (2023). [Electromagnetic field exposure affects the calling song, phonotaxis, and level of biogenic amines in crickets](#). Environ Sci Pollut Res Int.

PLANTS

Aikaterina L. Stefi, Dido Vassilacopoulou, Lukas H. Margaritis, Nikolaos S. Christodoulakis, (2018) [Oxidative stress and an animal neurotransmitter synthesizing enzyme in the leaves of wild growing myrtle after exposure to GSM radiation](#), June

Valdis Balodis, Guntis Brūmelis, Kārlis Kalviškis, Oļģerts Nikodemus, Didzis Tjarve, Vija Znotiņa, (1996) [Does the Skrunda Radio Location Station diminish the radial growth of pine trees?](#) Science of The Total Environment

Abdelhaliem, E., Abdalla, H. M., Bolbol, A. A., & Shehata, R. S. (2023). [Assessment of protein and DNA polymorphisms in corn \(Zea mays\) under the effect of non-ionizing electromagnetic radiation.](#) Caryologia, 75(4).

Halgamuge, M. N., & Davis, D. (2019). [Lessons learned from the application of machine learning to studies on plant response to radio-frequency.](#) Environmental research, 178, 108634.

Halgamuge, M. N. (2017). [Review: Weak radiofrequency radiation exposure from mobile phone radiation on plants.](#) Electromagnetic Biology and Medicine, 36(2), 213–235.

Halgamuge, M. N., Yak, S. K., & Eberhardt, J. L. (2015). [Reduced growth of soybean seedlings after exposure to weak microwave radiation from GSM 900 mobile phone and base station.](#) Bioelectromagnetics, 36(2), 87–95.

Handa AP, Vian A, Singh HP, Kohli RK, Kaur S, Batish DR. [Effect of 2850 MHz electromagnetic field radiation on the early growth, antioxidant activity, and secondary metabolite profile of red and green cabbage \(Brassica oleracea L.\).](#) Environ Sci Pollut Res Int. 2023 Dec 30.

Haggerty, K. (2010). [Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings: Preliminary Observations.](#) International Journal of Forestry Research, 836278.

Kaur, S., Vian, A., Chandel, S., Singh, D. H., Batish, D., & Kohli, R. (2021). [Sensitivity of plants to high frequency electromagnetic radiation: Cellular mechanisms and morphological changes.](#) Reviews in Environmental Science and Bio/Technology, 20.

Marek Czerwiński, Alain Vian, Ben A. Woodcock, Piotr Goliński, Laura Recuero Virto, Łukasz Januszkiewicz. (2023). [Do electromagnetic fields used in telecommunications affect wild plant species? A control impact study conducted in the field.](#) Ecological Indicators. Volume 150. 110267.

Panda DK, Das DP, Behera SK, Dhal NK. [Review on the impact of cell phone radiation effects on green plants.](#) Environ Monit Assess. 2024 May 21;196(6):565

Sharma A, Sharma S, Bahel S, Katnoria JK. [A study on effects of cell phone tower-emitted non-ionizing radiations in an Allium cepa test system.](#) Environ Monit Assess. 2024 Feb 13;196(3):261. doi: 10.1007/s10661-024-12435-2. PMID: 38349609.

Sharma, S., Sharma, P., Bahel, S. et al. [Comprehensive analysis of genotoxic effects and antioxidative defence mechanisms in plant test system exposed to 1800 MHz electromagnetic](#)

[radiations: a root chromosomal aberration and FTIR spectroscopy approach](#). Toxicol. Environ. Health Sci. (2023).

Soran, M.-L., Stan, M., Niinemets, Ü., & Copolovici, L. (2014). [Influence of microwave frequency electromagnetic radiation on terpene emission and content in aromatic plants](#). Journal of Plant Physiology, 171(15), 1436–1443.

Stefi, A. L., Margaritis, L. H., & Christodoulakis, N. S. (2016). [The effect of the non ionizing radiation on cultivated plants of Arabidopsis thaliana \(Col.\)](#). Flora, 223, 114–120.

Tran, N. T., Jokic, L., Keller, J., Geier, J. U., & Kaldenhoff, R. (2023). [Impacts of Radio-Frequency Electromagnetic Field \(RF-EMF\) on Lettuce \(Lactuca sativa\)-Evidence for RF-EMF Interference with Plant Stress Responses](#). Plants (Basel, Switzerland), 12(5), 1082.

Waldmann-Selsam, C., Balmori-de la Puente, A., Breunig, H., & Balmori, A. (2016). [Radiofrequency radiation injures trees around mobile phone base stations](#). Science of The Total Environment, 572, 554–569.

Marek Czerwiński, Łukasz Januszkiewicz, Alain Vian, Amparo Lázaro, (2020) [The influence of bioactive mobile telephony radiation at the level of a plant community – Possible mechanisms and indicators of the effects](#), Ecological Indicators, Volume 108

Vian A, Davies E, Gendraud M, Bonnet P. [Plant Responses to High Frequency Electromagnetic Fields](#). Biomed Res Int. 2016;2016

Zhong, Z., Wang, X., Yin, X., Tian, J., & Komatsu, S. (2021). [Morphophysiological and Proteomic Responses on Plants of Irradiation with Electromagnetic Waves](#). International Journal of Molecular Sciences, 22(22), Article 22.

S. Pustake, V. Upadhyaya and M. Bunde, ["Study and Analysis of 4G-5G Spectrum Mobile Signals on Germination Seed and Further Growth."](#) 2022 IEEE Pune Section International Conference (PuneCon), Pune, India, 2022, pp. 1-7

Sharma, S., Sharma, P., Bahel, S. et al. [Comprehensive analysis of genotoxic effects and antioxidative defence mechanisms in plant test system exposed to 1800 MHz electromagnetic radiations: a root chromosomal aberration and FTIR spectroscopy approach](#) Toxicol. Environ. Health Sci. (2023).

A.L. Stefi, L.H. Margaritis, N.S. Christodoulakis (2017) [The aftermath of long-term exposure to non-ionizing radiation on laboratory cultivated pine plants \(Pinus halepensis M.\)](#) Flora, 234, pp. 173-186,

Ozel, HB, Cetin, M., Sevik, H., Varol, T., Isik, B., & Yaman, B. (2021). [The effects of base station as an electromagnetic radiation source on flower and cone yield and germination percentage in Pinus brutia Ten.](#) Biologia Futura , 72 (3), 359-365.

Pesnya DS, Romanovsky AV. [Comparison of cytotoxic and genotoxic effects of plutonium-239 alpha particles and mobile phone GSM 900 radiation in the Allium cepa test.](#) Mutat Res. 2013 Jan 20;750(1-2):27-33.

Pall. M., [Electromagnetic Fields Act Similarly in Plants as in Animals: Probable Activation of Calcium Channels via Their Voltage Sensor.](#) Current Chemical Biology, 2016, 10, 74-82

AMPHIBIAN

Balmori A. (2010). [Mobile phone mast effects on common frog \(Rana temporaria\) tadpoles: the city turned into a laboratory.](#) Electromagn Biol Med. Jun;29 (1-2): 31-5.

Balmori, A. (2006). [The incidence of electromagnetic pollution on the amphibian decline: Is this an important piece of the puzzle?](#) Toxicological & Environmental Chemistry, 88(2), 287–299.

ARACHNIDS

Šofranková L, Bañas M, Pipová N, Majláth I, Kurimský J, Cimbala R, Pavlík M, Mateos-Hernández L, Šimo L, Majláthová V. Effects of Electromagnetic Radiation on Neuropeptide Transcript Levels in the Synganglion of Ixodes ricinus [ticks]. Pathogens. 2023; 12(12):1398. doi: 10.3390/pathogens12121398.

MARINE

Hutchison, Z. L., Gill, A. B., Sigray, P., He, H., & King, J. W. (2020). [Anthropogenic electromagnetic fields \(EMF\) influence the behaviour of bottom-dwelling marine species.](#) Scientific Reports, 10(1), 4219.

Scott, K., Harsanyi, P., Easton, B. A. A., Piper, A. J. R., Rochas, C. M. V., & Lyndon, A. R. (2021). [Exposure to Electromagnetic Fields \(EMF\) from Submarine Power Cables Can Trigger Strength-Dependent Behavioural and Physiological Responses in Edible Crab, Cancer pagurus \(L.\).](#) Journal of Marine Science and Engineering, 9(7), Article 7.

Oliva, M., De Marchi, L., Cuccaro, A., Fumagalli, G., Freitas, R., Fontana, N., Raugi, M., Barmada, S., & Pretti, C. (2023). [Introducing energy into marine environments: A lab-scale static magnetic](#)

[field submarine cable simulation and its effects on sperm and larval development on a reef forming serpulid](#). Environmental pollution (Barking, Essex : 1987), 328, 121625.

Tang LS, Qiu CZ, Zhang HY, Ren DL. [Effects of 0.4 T, 3.0 T and 9.4 T static magnetic fields on development, behaviour and immune response in zebrafish \(Danio rerio\)](#). *Neuroimage*. 2023 Sep 29;282:120398.

Nirwane A, Sridhar V, Majumdar A. [Neurobehavioural Changes and Brain Oxidative Stress Induced by Acute Exposure to GSM900 Mobile Phone Radiations in Zebrafish \(Danio rerio\)](#). *Toxicol Res*. 2016 Apr;32(2):123-32

Albert L, Deschamps F, Jolivet A, Olivier F, Chauvaud L, Chauvaud S. [A current synthesis on the effects of electric and magnetic fields emitted by submarine power cables on invertebrates](#). *Mar Environ Res*. 2020 Jul;159:104958.

DL Woodruff VI Cullinan AE Copping KE Marshall [Effects of Electromagnetic Fields on Fish and Invertebrates Task 2.1.3: Effects on Aquatic Organisms](#) (2013) Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830

Keller BA, Putman NF, Grubbs RD, Portnoy DS, Murphy TP. [Map-like use of Earth's magnetic field in sharks](#). *Curr Biol*. 2021 Jul 12;31(13):2881-2886.e3. doi: 10.1016/j.cub.2021.03.103. Epub 2021 May 6. PMID: 33961785.

Mammals

Balmori, A. [The incidence of electromagnetic pollution on wild mammals: A new “poison” with a slow effect on nature?](#). *Environmentalist* 30, 90–97 (2010).

Bamikole, A. O., Olukayode, O. A., Obajuluwa, T., Pius, O., Ibidun, O. O., Adewale, F. O., & Adeleke, O. O. (2019). [Exposure to a 2.5 GHz Non-ionizing Electromagnetic Field Alters Hematological Profiles, Biochemical Parameters, and Induces Oxidative Stress in Male Albino Rats](#). *Biomedical and Environmental Sciences*, 32(11), 860–863.

Bodin, R., Seewooruttun, C., Corona, A. et al. (2023) [Sex-dependent impact of perinatal 5G electromagnetic field exposure in the adolescent rat behavior](#). *Environ Sci Pollut Res*

Cantürk Tan, F., Yalçın, B., Yay, A. H., Tan, B., Yeğin, K., & Daşdağ, S. (2022). [Effects of pre and postnatal 2450 MHz continuous wave \(CW\) radiofrequency radiation on thymus: Four generation exposure](#). *Electromagnetic Biology and Medicine*, 41(3), 315–324.

Çelik, Ö., Kahya, M. C., & Nazıroğlu, M. (2016). [Oxidative stress of brain and liver is increased by Wi-Fi \(2.45GHz\) exposure of rats during pregnancy and the development of newborns](#). *Journal of Chemical Neuroanatomy*, 75(Pt B), 134–139.

Falcioni, L., Bua, L., Tibaldi, E., Lauriola, M., De Angelis, L., Gnudi, F., Mandrioli, D., Manservigi, M., Manservigi, F., Manzoli, I., Menghetti, I., Montella, R., Panzacchi, S., Sgargi, D., Strollo, V., Vornoli, A., & Belpoggi, F. (2018). [Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission](#). Environmental Research, 165, 496–503.

Gautam R, Pardhiya S, Nirala JP, Sarsaiya P, Rajamani P. [Effects of 4G mobile phone radiation exposure on reproductive, hepatic, renal, and hematological parameters of male Wistar rat](#). Environ Sci Pollut Res Int. 2023 Dec 16

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.

Lerchl, A., Klose, M., Grote, K., Wilhelm, A. F. X., Spathmann, O., Fiedler, T., Streckert, J., Hansen, V., & Clemens, M. (2015). [Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans](#). Biochemical and Biophysical Research Communications, 459(4), 585–590.

Ibitayo, A. O., Afolabi, O. B., Akinyemi, A. J., Ojiezeh, T. I., Adekoya, K. O., & Ojewunmi, O. O. (2017). [RAPD Profiling, DNA Fragmentation, and Histomorphometric Examination in Brains of Wistar Rats Exposed to Indoor 2.5 Ghz Wi-Fi Devices Radiation](#). BioMed Research International, 2017, 8653286.

Kuybulu, A. E., Öktem, F., Çiriş, İ. M., Sutcu, R., Örmeci, A. R., Çömlekçi, S., & Uz, E. (2016). [Effects of long-term pre- and post-natal exposure to 2.45 GHz wireless devices on developing male rat kidney](#). Renal Failure, 38(4), 571–580.

Magras IN, Xenos TD. [RF radiation-induced changes in the prenatal development of mice](#). Bioelectromagnetics. 1997;18(6):455-61.

National Toxicology Program NI of EHS. (2018). [Toxicology and carcinogenesis studies in Hsd: Sprague Dawley SD rats exposed to whole-body radio frequency radiation at a frequency \(900 MHz\) and modulations \(GSM and CDMA\) used by cell phones](#) (National Toxicology Project Technical Report 595). U.S. Department of Health and Human Services, National Institutes of Health.

Saili, L., Hanini, A., Smirani, C., Azzouz, I., Azzouz, A., Sakly, M., Abdelmelek, H., & Bouslama, Z. (2015). [Effects of acute exposure to WIFI signals \(2.45GHz\) on heart variability and blood pressure in Albinos rabbit](#). Environmental Toxicology and Pharmacology, 40(2), 600–605.

Sangun, O., Dundar, B., Darici, H., Comlekci, S., Doguc, D. K., & Celik, S. (2015). [The effects of long-term exposure to a 2450 MHz electromagnetic field on growth and pubertal development in female Wistar rats](#). *Electromagnetic Biology and Medicine*, 34(1), 63–71.

Smith-Roe, S. L., Wyde, M. E., Stout, M. D., Winters, J. W., Hobbs, C. A., Shepard, K. G., Green, A. S., Kissling, G. E., Shockley, K. R., Tice, R. R., Bucher, J. R., & Witt, K. L. (2020). [Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure](#). *Environmental and Molecular Mutagenesis*, 61(2), 276–290.

Souffi, S., Lameth, J., Gaucher, Q., Arnaud-Cormos, D., Lévêque, P., Edeline, J.-M., & Mallat, M. (2022). [Exposure to 1800 MHz LTE electromagnetic fields under proinflammatory conditions decreases the response strength and increases the acoustic threshold of auditory cortical neurons](#). *Scientific Reports*, 12(1), 4063.

Yang, H., Zhang, Y., Wu, X., Gan, P., Luo, X., Zhong, S., & Zuo, W. (2022). [Effects of Acute Exposure to 3500 MHz \(5G\) Radiofrequency Electromagnetic Radiation on Anxiety-Like Behavior and the Auditory Cortex in Guinea Pigs](#). *Bioelectromagnetics*, 43(2), 106–118.

Yüksel, M., Nazıroğlu, M., & Özkaya, M. O. (2016). [Long-term exposure to electromagnetic radiation from mobile phones and Wi-Fi devices decreases plasma prolactin, progesterone, and estrogen levels but increases uterine oxidative stress in pregnant rats and their offspring](#). *Endocrine*, 52(2), 352–362.

Yu, G., Tang, Z., Chen, H., Chen, Z., Wang, L., Cao, H., Wang, G., Xing, J., Shen, H., Cheng, Q., Li, D., Wang, G., Xiang, Y., Guan, Y., Zhu, Y., Liu, Z., & Bai, Z. (2020). [Long-term exposure to 4G smartphone radiofrequency electromagnetic radiation diminished male reproductive potential by directly disrupting Spock3–MMP2–BTB axis in the testes of adult rats](#). *Science of The Total Environment*, 698, 133860.

Zhao, L., Yao, C., Wang, H., Dong, J., Zhang, J., Xu, X., Wang, H., Yao, B., Ren, K., Sun, L., & Peng, R. (2022). [Immune Responses to Multi-Frequencies of 1.5 GHz and 4.3 GHz Microwave Exposure in Rats: Transcriptomic and Proteomic Analysis](#). *International Journal of Molecular Sciences*, 23(13), 6949.

Hamed Akbari; Lobat Taghavi; Seyed Kamal Eshagh Hossaini; Mohammad Gholami Fesharaki; Seyed Alireza Hajiseyed Mirzahosseini. ["Effects of Radio Waves on the Immune System of an Animal Model"](#). *Trauma Monthly*, 28, 4, 2023

Bacteria and Antibiotic Resistance

Askaripour K, Žak A. [A systematic review on cellular responses of Escherichia coli to nonthermal electromagnetic irradiation](#). Bioelectromagnetics. 2023 Oct 8.

Barbora, A., Rajput, S., Komoshvili, K., Levitan, J., Yahalom, A., & Liberman-Aronov, S. (2021). [Non-Ionizing Millimeter Waves Non-Thermal Radiation of Saccharomyces cerevisiae—Insights and Interactions](#). Applied Sciences, 11(14), Article 14.

Crabtree, D.P.E., Herrera, B.J. & Kang, S. [The response of human bacteria to static magnetic field and radiofrequency electromagnetic field](#). J Microbiol. 55, 809–815 (2017)

I H., S.-S., F A., J., H H., Y., & M E., M. (2019). [Evaluation of Wi-Fi Radiation Effects on Antibiotic Susceptibility. Metabolic Activity and Biofilm Formation by Escherichia Coli 0157H7, Staphylococcus Aureus and Staphylococcus Epidermis](#). Journal of Biomedical Physics & Engineering, 9(5), 579–586.

Mortazavi, S. M. J., Taheri, M., Paknahad, M., & Khandadash, S. (2022). Effects of [Radiofrequency Electromagnetic Fields Emitted from Mobile Phones and Wi-Fi Router on the Growth Rate and Susceptibility of Enterococcus faecalis to Antibiotics](#). Journal of Biomedical Physics & Engineering, 12(4), 387–394.

Movahedi, M. M., Nouri, F., Tavakoli Golpaygani, A., Ataee, L., Amani, S., & Taheri, M. (2019). [Antibacterial Susceptibility Pattern of the Pseudomonas aeruginosa and Staphylococcus aureus after Exposure to Electromagnetic Waves Emitted from Mobile Phone Simulator](#). Journal of Biomedical Physics & Engineering, 9(6), 637–646.

Nakouti, I., Hobbs, G., Teethaisong, Y., & Phipps, D. (2017). [A demonstration of athermal effects of continuous microwave irradiation on the growth and antibiotic sensitivity of Pseudomonas aeruginosa PAO1](#). Biotechnology Progress, 33(1), 37–44.

Pegios, A., Kavvadas, D., Zarras, K., Mpani, K., Soukiourogrou, P., Charalampidou, S., Vagdatli, E., & Papamitsou, T. (2022). [The Effect of Electromagnetic Radiation Transmitted from Routers on Antibiotic Susceptibility of Bacterial Pathogens](#). Journal of Biomedical Physics & Engineering, 12(4), 327–338.

Sharma AB, Lamba OS, Sharma L, Sharma A. [Effect of mobile tower radiation on microbial diversity in soil and antibiotic resistance](#). In: International Conference on Power Energy, Environment and Intelligent Control (PEEIC). India: G. L. Bajaj Inst. of Technology and Management Greater Noida, U. P.; 2018.

Taheri, M., Mortazavi, S. M. J., Moradi, M., Mansouri, S., Hatam, G. R., & Nouri, F. (2017). [Evaluation of the Effect of Radiofrequency Radiation Emitted From Wi-Fi Router and Mobile Phone Simulator on the Antibacterial Susceptibility of Pathogenic Bacteria *Listeria monocytogenes* and *Escherichia coli*](#). Dose-Response: A Publication of International Hormesis Society, 15(1), 1559325816688527.

Torgomyan, H., & Trchounian, A. (2012). [*Escherichia coli* membrane-associated energy-dependent processes and sensitivity toward antibiotics changes as responses to low-intensity electromagnetic irradiation of 70.6 and 73 GHz frequencies](#). Cell Biochemistry and Biophysics, 62(3), 451–461.

Ushakov, V. L., Alipov, E. D., Shcheglov, V. S., & Beliaev, I. I. (2006). [The peculiarities of the microwave in the frequency range of 51-52 GHz spectrum effects on *E. coli* cells](#). Radiatsionnaia Biologiya, Radioecologiya, 46(6), 719–728.