Exploring the Interplay Between Electromagnetic Wave and Vertebrate Health: Insights from Avian Studies

Jagdish Prasad Meena

Dr.Bhimrao Ambedkar Govt. P.G. College Mahwa

Abstract

Electric power lines are widespread in developed regions and urban areas of developing countries. All electrical currents, including those in power lines, create electric and magnetic fields (EMFs). Birds utilize power line structures for perching, hunting, and nesting, exposing them to EMFs similar to humans. Research suggests that EMFs may impact various aspects of human health, such as leukemia, brain cancer, depression, and Alzheimer's disease. There is ongoing debate about the effects of EMFs on vertebrates' cellular, endocrine, immune, and reproductive systems. Studies using mice, rats, chickens, and wild birds aim to understand these implications. Generally, research on birds indicates that EMF exposure can alter behavior, reproductive success, growth, development, physiology, and oxidative stress. Future research may offer additional insights into the impact of EMFs on vertebrate health and conservation.

Keywords: Electromagnetic wave; Behavior

1. Introduction

High-voltage electric power lines are prevalent in developed regions and urban areas of many developing nations. For instance, as of 1999, Sweden boasted 220,000 km of power lines across 450,000 km², while South Africa, the most advanced African country, possessed 255,745 km of electricity-carrying lines over 1,185,000 km² (1). In the coming decades, a substantial number of kilometers of power lines will be established globally, with the majority being overhead due to the exorbitant cost of underground installation (£500,000 per km compared to £10 million per km respectively; National Grid website, http://www.nationalgrid.com). In England and Wales, the relatively high costs of underground power line installation are reflected in the scarcity of underground lines in the transmission system. Similar to any device carrying an electric current, power lines generate electric and magnetic fields collectively known as electromagnetic fields (EMFs). Electric fields are measured in kilovolts per meter (kV/m), and magnetic fields in microteslas (μT).

Studies by Hydro-Québec, a Canadian power company, revealed that the ambient magnetic field produced by all electric currents inside and outside a Canadian home ranges from 0.01 to 1 μT, while household appliances alone may generate magnetic fields of up to 4 μT (8,9). The strength of electric and magnetic fields depends on the current intensity carried through a conductor and the distance of exposure from the source. Both fields are highest immediately around a power line and diminish rapidly with distance from the source. In North America, the maximum voltage of alternating current power lines is 735 kV, and their respective electric and magnetic fields are 10 kV/m and 60 μT at 0 m; 6 kV/m and 35 μT at 20 m; and 2 kV/m and 14 μT at 40 m from the power line.

However, direct-current power lines in North America are much larger with stronger EMFs; the Pacific Northwest Intertie, a crucial power line distributing hydroelectric power at 1150 kV DC, exemplifies this. Currently, in Canada, there is an 80-meter-wide exclusion zone around each power line, within which residential homes are not constructed (8-9). The debate continues regarding potential risks of EMFs to public health (NIEHS, 1999).
Among over 7,000 scientific publications on the potential effects of EMF exposure, numerous reviews have been written concerning EMF exposure and human health (10). Controversy surrounds studies that found EMFs increase the risks of life-threatening illnesses such as childhood (5,6) and adult (3,4,7), amyotrophic lateral sclerosis (8), clinical depression (7), suicide (7-9), and Alzheimer's disease (6).
Recent studies also indicate indirect effects of power lines, adding to concerns about power lines and mammalian health. Corona ions generated by the electric fields of power lines may increase concentrations and deposition of particles and other environmental pollutants (2). Exposure to static magnetic fields altered various functional parameters of immune cells, particularly macrophages, spleen lymphocytes, and increased apoptosis of thymic cells (8). These studies, along with other recent findings, intensify the focus on potential dangers of EMFs to public health, possibly leading to significant pressure on governments to restrict building new homes within specified distances of high-voltage power lines.
Studies have demonstrated that EMFs influence the development, reproduction, and physiology of insects (1) and mammals (6). However, this review's purpose is to explore the breeding biology of a taxon (i.e., birds) that intimately coexists with power lines and, therefore, is exposed to EMFs. Numerous instances highlight the detrimental effects of power lines (8) on birds, including collisions (6) and electrocutions (9). Birds can disrupt electricity supply through short circuits caused by electrocutions, accumulation of droppings, and material delivered to nests. Successful measures, such as reconfiguring cross-arms, conductors, and power lines (8), and deterring birds from approaching wires using colored plastic spirals and balls (4) and raptor models (1), have been implemented to reduce outages and bird mortality at highrisk sites. Plastic sheaths and platforms above wires, where birds can perch and nest, help keep birds away from conducting wires at transmission towers (9).

2. Reproductive Performance

The reproductive success of birds encompasses metrics such as fertility, hatching outcomes, and fledgling achievements. Hatching success is influenced by egg characteristics, along with chick growth and development, contributing to postnatal fledging success. Four studies have scrutinized the reproductive outcomes of birds under electromagnetic field (EMF) conditions, with three noting adverse effects on reproduction across various species. (3) investigated ravens and raptors nesting on a transmission line in an Idaho area where a scarcity of natural nesting sites constrained the breeding population's size. They observed significantly higher nesting success for ferruginous hawks on transmission towers, offering secure nesting spots protected from range fires and mammalian predators. This elevated success is particularly beneficial for the threatened ferruginous hawk species. Towers provided a refuge from heat stress compared to natural sites with reduced wind and air circulation. Contrastingly, (7) found no notable decline in reproductive success for ferruginous hawks nesting on transmission-line towers compared to those on other substrates. (6) similarly detected no significant EMF effects on the reproductive success of eastern bluebirds and house wrens nesting below 765- and 69-kV power lines, although tree swallows experienced fewer fledglings and reduced overall reproductive success near power lines. (8) examined the breeding performance of hole-nesting passerine species near 100 kV, 50 Hz transmission lines in Germany. Over six years, they identified inter-specific variations in reproductive parameters in response to EMF exposure. For instance, egg size remained unaffected in nuthatches and coal tits, decreased in great tits, and

increased in blue tits. Clutch initiation dates were unaffected, but clutch size decreased for great tits, and nuthatches experienced more frequent total brood loss at EMF-exposed sites.

In a comprehensive study, (5) investigated various components of overall breeding success. They found that EMF exposure, while enhancing fertility, egg size, and fledging success in captive kestrels, led to reduced eggshell thickness and hatching success. Additionally, a laboratory experiment exposed domestic chicken embryos to EMFs from computers and televisions, resulting in significantly higher fetal mortality compared to sham-exposed embryos (15).

Ethical approval: Not applicable.

Consent to publication: All authors are agreeing for publication.

Consent to participate: All authors are participated in this work.

Author's contribution: JP conceived the idea; JP wrote the whole manuscript. The complete manuscript was revised and edited by JP and TB.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests: The author declare that they have no competing financial interest or personal relationship that could have appear to influence the work reported in this paper.

Availability of data and materials: The data and materials that support he findings of the study are available from the corresponding author upon request.

Acknowledgment: Author would like to thanks Tansukh Barupal Assistant professor, SBK Govt. P.G. College Jaisalmer, Rajasthan.

References

1. Adey, W. R. 2003. Evidence for nonthermal electromagnetic bioeffects: potential health risks in evolving lo-frequency and microwave environments. In Electromagnetic environments and health in buildings, ed. D. Clements-Croome, pp. 35–51. London: Spon Press.
2. Bennett, A. T. D., Cuthill, I. C., Partridge, J. C., and Maier, E. J. 1996. Ultraviolet vision and mate choice in zebra finches. Nature 380:433–435.
3. Bevanger, K. 1998. Biological and conservation aspects of bird mortality caused by electricity power lines: A review. Biol. Conserv. 86:67–76.
4. Dawson, A. 1998. Photoperiodic control of the termination of breeding and the induction of moult in house sparrows Passer domesticus. Ibis 140:35–40.
5. Farrell, J. M., Litovitz, T. L., Penafiel, M., Montrose, C.J., Doinov, P., Barber, M., Brown, K. M., and Litovitz, T. A. 1997. The effect of pulsed and sinusoidal magnetic fields on the morphology of developing chick embryos. Bioelectromagnetic 18:431–438.
6. Fogden, M. P. L., and Fogden, P. M. 1979. The role of fat and protein reserves in the annual cycle of the grey-backed camaroptera in Uganda (Aves: Sylvidae). J. Zool., Lond. 189:233–258.
7. Greenberg, B., Bindokas, V. P., and Gaujer, J. R. 1981. Biological effects of a 760 kV transmission line: Exposures and thresholds in honeybee colonies. Bioelectromagnetic 2:315.
8. Hamann, H.-J., Schmidt, K.-H., and Wiltschko, W. 1998. Mögliche Wirkungen elektrischer und magnetischer Felder auf die Brutbiologie von Vögeln am Beispiel einer Population von höhlenbrütenden Singvögeln an einer Stromtrasse. Z. Vogelk. Natursch. Hessen Vogel Umwelt 9:215–246.
9. Hontela, A. 1997. Endocrine and physiological responses of fish to xenobiotics: Role of glucocorticosteroid hormones. In Reviews in toxicology—Environmental toxicology, pp. 1–46. New York: IOS Press.

10. Johansen, C., and Olsen, J. 1998. Mortality from amyotrophic lateral sclerosis, other chronic disorders and electric shocks among utility workers. Am. J. Epidemiol. 148:362–368.
11. Lahijani, M. S., and Ghafoori, M. 2000. Teratogenic effects of sinusoidal extremely low frequency electromagnetic fields on morphology of 24 hr chick embryos. Indian J. Exp. Biol. 38:692–699.
12. London, S. J., Thomas, D. C., Bowman, J. D., Sobel, E., and Peters, J. M. 1991. Exposure to residential electric and magnetic fields and risk of childhood leukemia. Am. J. Epidemiol. 134:923–937.
13. Reynolds, S. J., Schoech, S. J., and Bowman, R. 2003. Diet quality during pre-laying and nestling periods influences growth and survival of Florida scrub-jay (Aphelocoma coerulescens) chicks. J. Zool. Lond. 261:217–226.
14. Sikov, M. R., Montgomery, L. D., Smith, L. G., and Phillips, R. D. 1984. Studies on prenatal and postnatal development in rats exposed to 60 Hz electric fields. Bioelectromagnetic 5:101–112.
15. Williams, T. D. 2001. Experimental manipulation of female reproduction reveals an intraspecific egg size-clutch size trade-off. Proc. R. Soc. Lond. B 268:423–428.