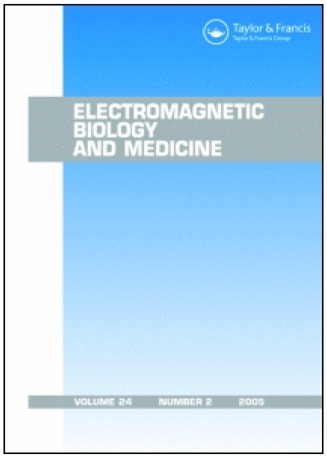

Electromagnetic Biology and Medicine

Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597249

The Urban Decline of the House Sparrow (**Passer domesticus**): A Possible Link with Electromagnetic Radiation

Online Publication Date: 01 April 2007
To cite this Article: Balmori, Alfonso and Hallberg, Örjan , (2007) 'The Urban Decline of the House Sparrow (**Passer domesticus**): A Possible Link with Electromagnetic Radiation', Electromagnetic Biology and Medicine, 26:2, 141 - 151
To link to this article: DOI: 10.1080/15368370701410558
URL: http://dx.doi.org/10.1080/15368370701410558

Electromagnetic Biology and Medicine, 26: 141–151, 2007

ISSN 1536-8378 print
DOI: 10.1080/15368370701410558

informa
healthcare

The Urban Decline of the House Sparrow (*Passer domesticus*): A Possible Link with Electromagnetic Radiation

ALFONSO BALMORI[1] AND ÖRJAN HALLBERG[2]

[1]Direccion General del Medio Natural, Consejería de Medio Ambiente, Valladolid, Spain
[2]Hallberg Independent Research, Trångsund, Sweden

During recent decades, there has been a marked decline of the house sparrow (Passer domesticus) population in the United Kingdom and in several western European countries. The aims of this study were to determine whether the population is also declining in Spain and to evaluate the hypothesis that electromagnetic radiation (microwaves) from phone antennae is correlated with the decline in the sparrow population.

Between October 2002 and May 2006, point transect sampling was performed at 30 points during 40 visits to Valladolid, Spain. At each point, we carried out counts of sparrows and measured the mean electric field strength (radiofrequencies and microwaves: 1 MHz–3 GHz range). Significant declines ($P = 0.0037$) were observed in the mean bird density over time, and significantly low bird density was observed in areas with high electric field strength. The logarithmic regression of the mean bird density vs. field strength groups (considering field strength in 0.1 V/m increments) was $R = -0.87$ ($P = 0.0001$).

The results of this article support the hypothesis that electromagnetic signals are associated with the observed decline in the sparrow population. We conclude that electromagnetic pollution may be responsible, either by itself or in combination with other factors, for the observed decline of the species in European cities during recent years. The appearently strong dependence between bird density and field strength according to this work could be used for a more controlled study to test the hypothesis.

Keywords Cellsites; Cellular phone masts; Decline; Electromagnetic fields; House sparrow; Microwaves; Non thermal effects; *Passer domesticus*; Urban bird populations.

Address correspondence to Alfonso Balmori, Direccion General del Medio Natural, Consejería de Medio Ambiente, Junta de Castilla y Leon, C/Rigoberto Cortejoso, 14, 47014 Valladolid, Spain; E-mail: balmaral@jcyl.es

Introduction

Recent declines in the house sparrow (*Passer domesticus*) population have been reported in the United Kingdom (U. K.) and in several western European countries. A massive decrease has led to almost complete extinction in some urban centres; for example, there was a 71% decline in London from 1994–2002 (Raven et al., 2003). Urban bird populations in south east England seem to be declining more rapidly than suburban or rural populations (Crick et al., 2002); there have been dramatic declines, almost to the point of extinction, in Glasgow, Edinburgh, Hamburg, and Ghent, although the species has actually increased in Scotland and Wales (Summers-Smith, 2003). In 2002, the house sparrow was added to the Red List of U.K. endangered species (Summers-Smith, 2003).

In Brussels, many populations of sparrows have disappeared recently (De Laet, 2004); similar declines have been reported in Dublin (Prowse, 2002). Dröscher (1992) reported that house sparrows had become a rarity in West Berlin, but remained relatively common in East Berlin, possibly reflecting a general lack of urban development under the former communist regime (Crick et al., 2002). Van der Poel (cited in Summers-Smith, 2003) suggested that sparrows might be declining in Dutch urban centres as well.

Detailed studies have shown that in the U.K., the decline of sparrows in human settlements has been erratic (Summers-Smith, 2003). It is critical that comparative studies and surveys of house sparrow populations be performed in order to assess differences in abundance within different areas of the same city and between cities with different socio-economic, technological and cultural characteristics (Crick et al., 2002).

A number of hypotheses have been proposed to explain the population decline of the house sparrow in urban areas. These include lack of food, particularly aphids, which adults feed to nestlings, pollution from vehicles running on unleaded fuel, increased predation by domestic cats or sparrowhawks (*Accipiter nisus*), cleaner streets providing reduced foraging opportunities, competition for food from other urban species, loss of nesting sites, particularly under the eaves and in the roofs of houses, pollution (air quality), both in terms of immediate toxicity and indirect toxicity through the food supply, increased use of pesticides in parks and gardens, and disease transmission (Crick et al., 2002; Summers-Smith, 2003). Finally, reduction of colony size below some critical value may impair breeding behaviour to the extent that breeding declines, resulting in the disappearance of the colony as a breeding unit (the Allee effect; Summers-Smith, 2003).

Before the 1990's, electromagnetic energy was emitted from a few radio and television transmitters located in remote areas and/or high elevations. Since then, mobile base stations masts have been spreading across urban centres and have increased electromagnetic pollution. In Vienna, the greatest portion of that exposure was from mobile telecommunications (geometric mean 73%; Hutter et al., 2006). In Germany, global system for mobile communication (GSM) cellular phone tower radiation is the dominant high-frequency source in residential areas (Haumann et al., 2002), and GSM radiation is also the dominant high-frequency source in Spain (personal observation). House sparrows usually live in the urban environment, where electromagnetic contamination is higher; for this reason, sparrows may be a good biological indicator for detecting the effects of this radiation.

Anecdotal evidence, as well as some published reports, suggests that sparrows tend to avoid places with high levels of electromagnetic signals (Balmori, 2002, 2003). The disappearance of the sparrow and the introduction of phone mast GSM towers correlate closely in terms of time (Balmori, 2002, 2003). Balmori proposes: "It is recommended that electromagnetic contamination in the microwave range be considered as a possible factor in the decline of some at-risk populations, especially for urban birds who are subjected to higher radiation levels" (Balmori, 2004a).

The main aims of this study were to investigate whether the sparrow population is declining in an average-sized city in Spain and to determine whether electromagnetic radiation (microwaves) is related to the marked population reduction observed in several European countries.

Materials and Methods

To monitor the populations of house sparrows (*Passer domesticus*) in Valladolid, Spain, 40 visits were made between October of 2002 and May of 2006 (approximately one per month) to perform point transect sampling at 30 points (Bibby et al., 2000). Sampling was performed between 7:00 and 10:00 a.m, by the same ornithologist (AB) following the same protocol. Each sampling took place on Sunday, since there is less traffic and noise that day. The sampling was done in selected areas (the same between October 2002 and May 2006): squares, urban parks, and tree-lined, relatively isolated streets that facilitated the counting process (with a well-known and delimited area). In each area, we counted all sparrows that were heard or seen, without differentiating the birds by sex or age. In addition, we measured the mean electric field strength (radio frequencies and microwaves, range: 1 MHz–3 GHz) in V/m, using a portable broadband electric field meter (model LX 1435, Nuova Elettronica, Bologna, Italy) set at 10% sensitivity, using a unidirectional antenna.

For the analysis, with a plane of the city we calculate the surface of each point. The bird density (number of sparrows/hectare) was calculated for each point and for each visit (the final data-set had 1,200 data points). This bird density cannot be extrapolated to the entire city, as the density fluctuates depending on the location where the sampling was performed, and one cannot predict the density at any given point. The results of this survey may have resulted in slightly inflated estimates, as the points we used as observation points were concentrated in areas where house sparrows are plentiful.

Excel 2002 (Microsoft, Inc, Redmond, WA, USA) and Statistica v. 6.0 (Statsoft, Tulsa, OK, USA) were used for statistical analyses.

Results

Figures 1 and 2 shows the sparrow density vs. field strength with all reported data and 50, 90, and 95 percentiles.

We found that the number of house sparrows in Valladolid, Spain, varied cyclically throughout the year: the number of sparrows increased towards a mid-winter peak, then decreased again through the spring. Variation was independent of the long-term decline in numbers that occurred during the period of study (Fig. 3). If this trend continues (a 5% annual decrease in the population), the house sparrow may become extinct by 2020. A significant declining trend ($p = 0.0037$) was also

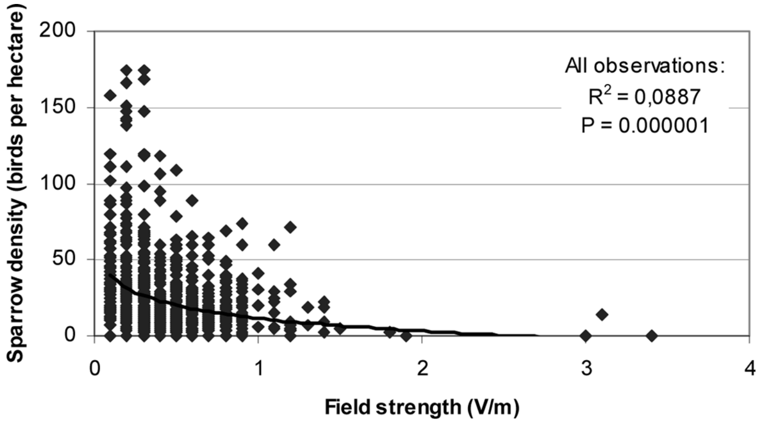

Figure 1. Sparrow density vs. field strength with all reported data.

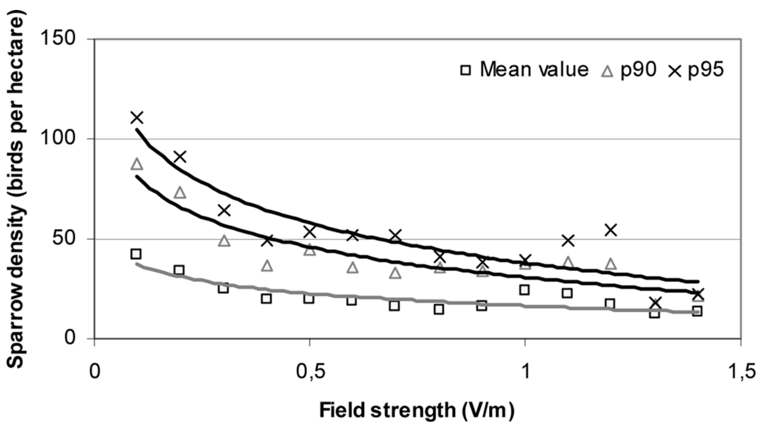

Figure 2. Sparrow density vs. field strength with 50, 90, and 95 percentiles.

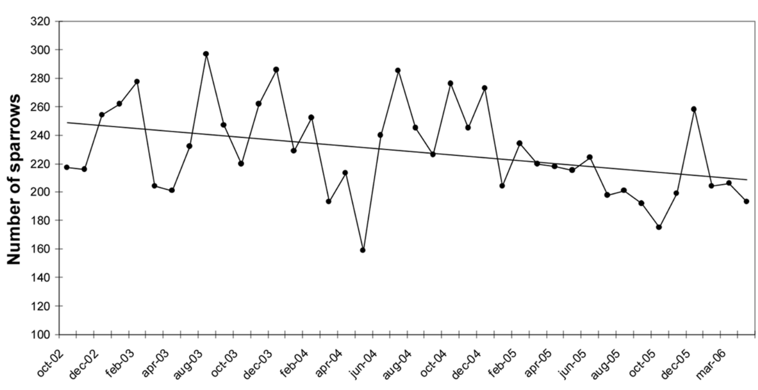

Figure 3. Changes in the total number of sparrows in the 30 sampled areas.

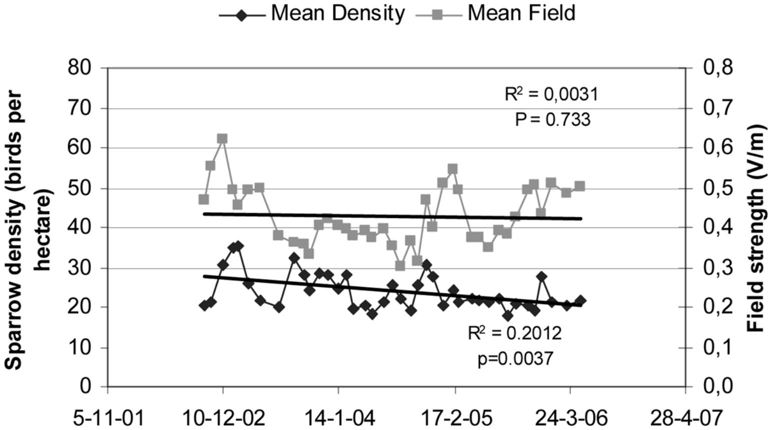

Figure 4. The mean sparrow density and mean electric field strength as a function of time in the 30 sampled areas.

observed in regards to the mean sparrow density over time for all monitored points, while the electromagnetic field intensity at these points fluctuated (Fig. 4).

The logarithmic regression of the mean bird density vs. field strength (considering field strength in 0.1 V/m increments) was: $R = -0.87$ ($p = 0.0001$; Fig. 5). According to this calculation, no sparrows would be expected to be found in an area with field strength >4 V/m.

Selecting the six sampling points with the highest and the six sampling points with lowest mean electromagnetic field strength, we see that the mean density of sparrows for the two groups are separated, and that the highest bird densities correspond to the lowest field intensity (Fig. 6).

In monitored Area 14, Plaza de la Libertad, a picocell was installed at the beginning of January 2005 and removed at the end of March 2005. Between January and March 2005, the mean field strength was greater than 3 V/m, and the number of sparrows decreased drastically (generally, the number of sparrows increases towards

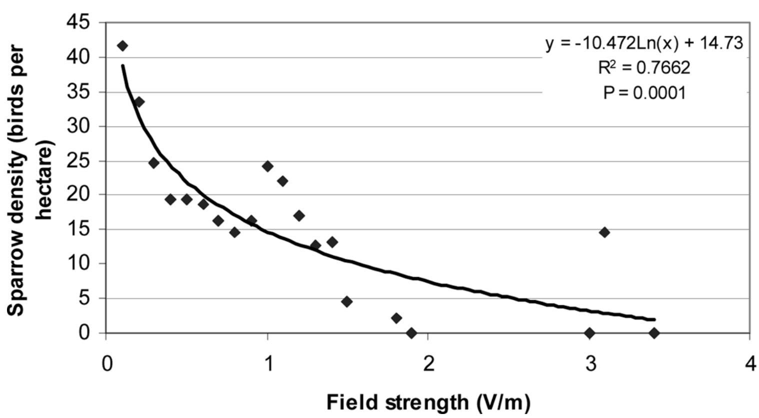

Figure 5. Mean sparrow density as a function of electric field strength grouped in 0.1 V/m.

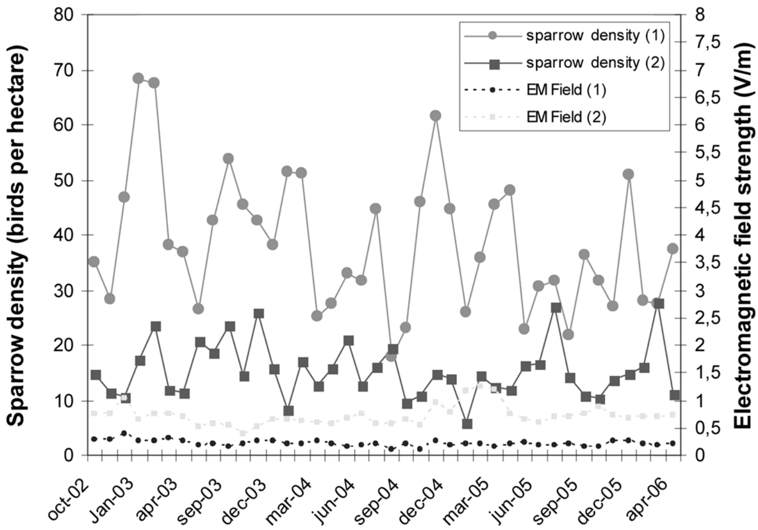

Figure 6. Comparison between the change in sparrow density (1) in the 6 least polluted sample areas (EM Field 1) and the change in sparrow density (2) in the 6 most polluted sample areas (EM Field 2).

a mid-winter peak). In April 2005, after the picocell was removed, the sparrows became abundant again.

Discussion

The pattern of sparrows number increased towards a mid-winter peak and decreased again through the spring. This pattern has previously been reported by (Crick et al., 2002). A long-term decline in numbers has occurred during the period of study. The disappearance of sparrows and the introduction of phone mast GSM towers are temporally correlated (Balmori, 2002, 2003). Our report shows that the number of sparrows correlates with electromagnetic pollution levels. Another recent study with sparrows in Flanders (Belgium) state: "Our data show that fewer House Sparrow males were seen at locations with relatively high electric field strength values of GSM base stations and therefore support the notion that long-term exposure to higher levels of radiation negatively affects the abundance or behaviour of House Sparrows in the wild" (Everaert and Bauwens, 2007).

In the U.K., where the allowed standard by law levels of electromagnetic radiation were until time very recently 20 times higher than those in Spain, a decline in several species of urban birds has recently taken place (Raven et al., 2003). The newspaper *The Observer* reported that mobile phones may be to blame for sparrow deaths (Townsend, 2003). In India, Dr. Vijayan pointed out that sparrows are disappearing from areas where mobile towers are installed and from cities where electromagnetic contamination is very heavy (Mukherjee, 2003).

Electromagnetic fields from powerlines affect reproductive success in birds (Doherty and Grubb, 1996; Fernie and Reynolds, 2005), and microwaves from phone masts were found to interfere with white stork reproduction (Balmori, 2005). A Greek study reported a progressive drop in the number of births of rodents exposed to radio frequencies: mice exposed to 0.168 $\mu W/cm^2$ become sterile after five generations, while those exposed to 1.053 $\mu W/cm^2$ became sterile after only three generations. The affect seems be mediated by the central nervous system rather than the reproductive organs (Magras and Xenos, 1997). Currently, comparable amounts of power density are present in many places, including in the countryside for several hundred meters surrounding phone masts. This is discussed in detail in Balmori (2004b).

The avoidance of radiation sources was observed in an experimental study with mammals. Rats spent more time in the halves of shuttle boxes that were shielded from irradiation by 1.2 GHz microwaves. Data revealed that rats avoided pulsed but not continuous radiation, and less than 0.4 mW/cm^2 average power density (<38 V/m power strength) was needed to produce aversion (Frey and Feld, 1975). The high frequency radio frequency (RF) fields produced a response in many types of neurons in the avian central nervous system (Beasond and Semm, 2002). The electromagnetic fields emitted by mobile phones affect the permeability of the blood-brain barrier and can damage some neurons in the brain (Salford et al., 2003).

It has been documented that electromagnetic radiation can affect biomolecules such as DNA (Goodman and Blank, 2002; Lai and Singh, 1995, 1996; Reflex, 2004), and can influence the immune system (Galeev, 2000), reproductive capacity (Davoudi et al., 2002; Fernie et al., 2000; Fejes et al., 2005; Panagopoulos, 2007), the brain and nervous system (Kramarenko and Tan, 2003; Marino et al., 2003; Salford et al., 2003), and intrauterine development and miscarriages (Berman et al., 1990; Magras and Xenos, 1997).

Mobile communications and multiple other sources result in the chronic exposure of humans and wild animals to microwaves at non-thermal levels (Belyaev, 2005; Lai, 2005). Electromagnetic fields and microwaves affect the reproductive success of birds (Balmori, 2005; Doherty and Grubb, 1996; Fernie and Reynolds, 2005), and increase the embryonic mortality of chickens (Farrel et al., 1997; Grigoriev, 2003; Youbicier-Simo et al., 1998). Microwaves emitted by phone antennae can also affect other taxa that live in the vicinity, such as insects (Panagopoulos, 2004, 2007; Stever et al., 2005), vegetables (Balmori, 2004b; Balodis et al., 1996; Selga and Selga, 1996; Stever et al., 2005) and humans (Hallberg and Johansson, 2004a,b; Hutter et al., 2006; Navarro et al., 2003; Salford et al., 2003). Small organisms are especially vulnerable: thinner skulls approach the size of the resonance frequency, facilitating radiation penetration into the brain (Hyland, 2000; Maisch, 2003).

The Erratic Nature of the House Sparrow Population Decline

House sparrows are generally gregarious, living in colonies of 20–40 birds. They are relatively sedentary birds, rarely moving more than 1 km from their colony site, and usually substantially less than that, once they are adults (Crick et al., 2002). Dispersal distances are very limited for house sparrows, so the main demographic processes that drive population declines are a combination of changes in productivity and survival (Crick et al., 2002). Detailed studies have shown that the decline of sparrows in U.K. has been erratic (Summers-Smith, 2003). Differences in abundance exist within different areas of the same city and between cities (Crick et al., 2002). The decline in London is not merely a function of reduction in colony size, but rather of increased dispersion of the colonies (Summers-Smith, 2003).

The results of the monitoring carried out in Valladolid, Spain provide some clues that may explain the decrease of sparrows in the U.K. According to the results of this study, the distribution of the antennas (and the field strength in each area of the city) appears to be related to the patchy distribution of sparrows. Telecommunication masts usually are installed in high places in order to achieve better signal coverage. For a given point, the field strength is inversely proportional to the distance to the source. The measured field strength depends on whether the cell site antenna is in line of sight and on the reflections or the attenuation by certain structures.

The British sparrow population has collapsed in cities, but not in small towns. In fact, the number of phone masts and the use of mobile phones in cities, in general, are much greater than in small towns. Cities usually have more electromagnetic pollution, but this varies in different areas according to the proximity of phone masts. Small towns usually locate the telecommunication masts away from the urban center, because that is sufficient to maintain coverage. This may be the reason that the birds are less affected in small towns and villages and that the population of sparrows, in general, has not declined there. Thus, the cause underlying the decline in sparrows may be the increasing establishment of base stations for mobile telecommunication. As soon as stricter planning controls are enforced for mobile phones masts, the number of sparrows should increase (Balmori, 2002).

Other factors that could potentially have led to the declines of house sparrows in urban situations include air quality (pollution; Crick et al., 2002). Pollution is a factor that could affect house sparrow both directly, as a result of immediate toxicity, and indirectly through effects on the sparrow food supply. Currently, air pollution (SO_2, NO_2, CO, and benzene) has decreased in Valladolid, although airborne particles and the ozone level have increased slightly. In a study in Bristol, England, there was no correlation between wards with high levels of benzene in the air and low house sparrow numbers (Crick et al., 2002).

The availability of invertebrates used to feed chicks in the nest has been proposed as a possible explanation for urban population declines. Key prey that is fed to chicks includes aphids (Aphidoidea), weevils (Curculionidae), grasshoppers (Orthoptera), and caterpillars (Lepidoptera) (Crick et al., 2002). Van der Poel (in Summers-Smith, 2003) suggested that the decline of sparrows in Dutch urban centers was due to a lack of insects, and electromagnetic pollution might affect the number of insects that house sparrows feed to their chicks for the first few days after hatching (Balmori, 2006; Panagopoulos, 2004, 2007; Stever et al., 2005).

Crick et al. (2002) suggested that some of the factors that caused the decline in sparrow survival, leading to the observed population decline, are still affecting house sparrows. The results of our study support the hypothesis that electromagnetic pollution may be responsible, by itself or in conjunction with other factors, for the reduced number of the species in European cities during recent years. The appearently strong dependence between bird density and field strength according to this work could be used for a more controlled study to test the hypothesis.

Acknowledgments

We thank Denise Ward, César Balmori, and CIDA for their assistance. This work is dedicated to Dr. Roger Santini (*In Memoriam*).

References

Balmori, A. (2002). Evidence of a conection between sparrow decline and the introduction of phone mast GSM, http://www.hese-project.de/de/emf/WissenschaftForschung/showAuthor.php?lang=pl&target=Balmori_Dr._Alfonso, accessed November 2, 2006.

Balmori, A. (2003). Aves y telefonía móvil. Resultados preliminares de los efectos de las ondas electromagnéticas sobre la fauna urbana. *El ecologista* 36:40–42.

Balmori, A. (2004a). Possible effects of the electromagnetic waves used in the wireless telephony on wildlife (in Spanish). *Ardeola* 51: 477–490.

Balmori, A. (2004b). Pueden afectar las microondas pulsadas emitidas por las antenas de telefonía a los árboles y otros vegetales? *Ecosistemas* 3:1–10. http://www.revistaecosistemas.net/articulo.asp?Id1/429&Id_Categoria1/41&tipo1/4otros_contenidos, accessed, November 2, 2006.

Balmori, A. (2005). Possible effects of electromagnetic fields from phone masts on a population of white stork (Ciconia ciconia). *Electromagn. Biol. Med.* 24: 109–119.

Balmori, A. (2006). Efectos de las radiaciones electromagnéticas de la telefonía móvil sobre los insectos. *Ecosistemas* http://www.revistaecosistemas.net/articulo.asp?Id=396&Id_Categoria=2&tipo=portada, accessed November 2, 2006

Balodis, V. G., Brumelis, K., Kalviskis, O., Nikodemus, D. Y., Tjarve, V. Z. (1996). Does the Skrunda radio location station diminish the radial growth of pine trees? *Sci. Total Environ.* 180:57–64.

Beasond, R. C., Semm, P. (2002). Responses of neurons to an amplitude modulated microwave stimulus. *Neurosci. Lett.* 33:175–178.

Belyaev, I. (2005). Non-thermal biological effects of microwaves. *Microwave Rev.* 11:13–29.

Berman, E. L., Chacon, D., House, B., Koch, A., Koch, W. E., Leal, J., Lovtrup, S., Mantiply, E., Martin, A. H., Martucci, G. I., Mild, K. H., Monahan, J. C., Sandstrom, M., Shamsaifar, K., Tell, R., Trillo, M. A., Ubeda, A., Wagner, P. (1990). Development of chicken embryos in a pulsed magnetic field. *Bioelectromagnetics* 11:169–187.

Bibby, C. J., Burgess, N. D., Hill, D. A., Mustoe, S. H. (2000). *Bird Census Techniques*. 2nd ed. London: Academic Press.

Crick, H. Q., Robinson, R. A., Appleton, G. F., Clark, N. A., Rickard, A. D. (2002). Investigation into the causes of the decline of starlings and house sparrows in Great Britain. BTO Research Report N° 290. Department for Environment, Food and Rural Affairs (DEFRA). London.

Davoudi, M., Brössner, C., Kuber, W. (2002). Der Einfluss elektromagnetischer wellen auf die Spermienmotilität. *J für Urol Urogynäkol* 9:18–22.

De Laet, J. (2004). Ligue Royale Belgue pour la Protection des Oiseaux avec l'Université de Gand, http://www.protectiondesoiseaux.be/content/view/801/74/, accessed November 2, 2006

Doherty, P. F., Grubb, T. C. (1996). Effects of high-voltage power lines on birds breeding within the power lines electromagnetic fields. *Sialia* 18:129–134.

Dröscher, V. B. (1992). Unse Spatz piepst das Lied von Tod. *Bunte* 30/1:78–81.

Everaert, J., Bauwens, D. (2007). A possible effect of electromagnetic radiation from mobile phone base stations on the number of breeding House Sparrows (*Passer domesticus*). *Electromagn Biol. Med.* 26:63–72.

Farrel, J. M., Litovitz, T. L., Penafiel, M. (1997). The effect of pulsed and sinusoidal magnetic fields on the morphology of developing chick embryos. *Bioelectromagnetics* 18:431–438.

Fejes, I. Z., Vaczki, Z., Szollosi, J., Kolosza, R. S., Daru, J., Kova, Cs. (2005). Is there a relationship between cell phone use and semen quality? *Arch. Androl.* 51:385–393.

Fernie, K. J., Bird, D. M., Dawson, R.D., Lague, P. C. (2000). Effects of electromagnetic fields on the reproductive success of American kestrels. *Physiol. Biochem. Zool.* 73:60–65.

Fernie, K. J., Reynolds, S. J. (2005). The effects of electromagnetic fields from power lines on avian reproductive biology and physiology: A review. *J. Toxicol. Environ. Health Part B* 8:127–140.

Frey, A. H., Feld, S. R. (1975). Avoidance by rats of illumination with low power nonionizing electromagnetic energy. *J. Comp. Physiol. Psychol.* 89:183–188.

Galeev, A. L. (2000). The effects of microwave radiation from mobile telephones on humans and animals. *Neurosci. Behav. Physiol.* 30:187–194.

Goodman, R., Blank, M. (2002). Insights into electromagnetic interaction mechanisms. *J. Cellular Physiol.* 192:16–22.

Grigoriev, Iu. G. (2003). Influence of the electromagnetic field of the mobile phones on chickens embryo, to the evaluation of the dangerousness after the criterion of this mortality. *J. Radiation Biol.* 5:541–544.

Hallberg, Ö., Johansson, O. (2004a). 1997 – A curious year in Sweden. *Eur. J. Cancer Prev.* 13:535–538.

Hallberg, Ö., Johansson, O. (2004b). Mobile handset output power and health. *Electromagn. Biol. Med.* 23:229–239.

Haumann, T., Munzenberg, U., Maes, W., Sierck, P. (2002). HF radiation levels of GSM cellular phone towers in residential areas. *2nd International Workshop on Biological Effects of EMFS*, Rhodes, Greece.

Hutter, H. P., Moshammer, H., Wallner, P., Kundi, M. (2006). Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occup. Environ. Med.* 63:307–313.

Hyland, G. J. (2000). Physics and biology of mobile telephony. *Lancet* 356:1–8.

Kramarenko, A. V., Tan, U. (2003). Effects of high-frequency electromagnetic fields on human EEG: a brain mapping study. *Int. J. Neurosci.* 113:1007–1019.

Lai, H. (2005). Biological effects of radiofrequency electromagnetic field. *Encyclopaedia of Biomaterials and Biomedical Engineering*. DOI: 10.1081/E-EBBE-120041846:1–8.

Lai, H., Singh, N. P. (1995). Acute low-intensity microwave exposure increases DNA single-strand breaks in rat brain cells. *Bioelectromagnetics* 16:207–210.

Lai, H., Singh, N. P. (1996). DNA single- and double-strand DNA breaks in rat brain cells after acute exposure to low-level radiofrequency electromagnetic radiation. *Int. J. Radiat. Biol.* 69:513–521.

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

Maisch, D. (2003). Children and mobile phones ... Is there a health risk? The case for extra precautions. *J. Austral. Coll. Nutr. Environ. Med.* 22:3–8.

Marino, A. A., Nilsen, E., Frilot, C. (2003). Nonlinear changes in brain electrical activity due to cell phone radiation. *Bioelectromagnetics* 24:339–346.

Mukherjee, A. (2003). More mobiles, and sparrows take flight. http://www.thehindubusinessline.com/2003/12/01/stories/2003120100431400.htm, accessed November 2, 2006.

Navarro, E. A., Segura, J., Portolés, M., Gómez Perretta, C. (2003). The microwave syndrome: a preliminary study in Spain. *Electromagn. Biol. Med.* 22:161–169.

Panagopoulos, D. J., Chavdoula, E. D., Nezis, I. P., Margaritis, L. H. (2007). Cell death induced by GSM 900-MHz and DCS 1800-MHz mobile telephony radiation. *Mutat Res.* 626:69–78.

Panagopoulos, D. J., Karabarbounis, A., Margaritis, L. H. (2004). Effect of GSM 900 MHz mobile phone radiation on the reproductive capacity of *Drosophila melanogaster*. *Electromagn. Biol. Med.* 23:29–43.

Prowse, A. (2002). The urban decline of the house sparrow. *Brit. Birds* 95:143–146.

Raven, M. J., Noble, D. G., Baillie, S. R. (2003). The breeding bird survey (2002). BTO Research Report 334. British Trust for Ornithology, Thetford.

Reflex. (2004). http://www.verum-foundation.de/cgi-bin/content.cgi?id=euprojekte01, accessed November 2, 2006.

Salford, L. G., Brun, A. E., Eberhardt, J. L., Malmgren, L., Persson, B. R. (2003). Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones. *Environ. Health Perspect.* 111:881–893.

Sandu, D. D., Goiceanu, C., Ispas, A., Creanga, I., Miclaus, S., Creanga, D. E. (2005). A preliminary study on ultra high frequency electromagnetic fields effect on black locust chlorophylls. *Acta Biologica Hungarica* 56:109–117.

Santini, R., Santini, P., Danze, J. M., Le Ruz, P., Seigne, M. (2003). Symptoms experienced by people in vicinity of base stations: II/ Incidences of age, duration of exposure, location of subjects in relation to the antennas and other electromagnetic factors. *Pathol. Biol.* 51:412–5.

Selga, T., Selga, M. (1996). Response of Pinus Sylvestris L. needles to electromagnetic fields. Cytological and ultraestructural aspects. *Sci. Total Environ.* 180:65–73.

Stever, H., Kuhn, J., Otten, C., Wunder, B., Harst, W. (2005). Verhaltensanderung unter elektromagnetischer Exposition. Pilotstudie. Institut für mathematik. Arbeitsgruppe. *Bildungsinformatik*. Universität Koblenz-Landau. http://agbi.uni-landau.de/, accessed November 2, 2006.

Summers-Smith, J. D. (2003). The decline of the House Sparrow: a review. *Brit. Birds* 96:439–446.

Townsend, M. (2003). Mobile phones blamed for sparrow deaths. *The Observer*: http://www.observer.co.uk/uk_news/story/0,6903,873195,00.html, accessed November 2, 2006.

Youbicier-Simo, B. J., Lebecq, J. C., Bastide, M. (1998). Mortality of chicken embryos exposed to EMFs from mobile phones. Presented at the Twentieth Annual Meeting of the Bioelectromagnetics Society, St. Pete Beach, FL, June 1998.