HOUSATONIC RIVER COMMISSION

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"to coordinate on a regional basis the local management and protection of the Housatonic River Valley in northwestern Connecticut"

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January 13, 2011

Hon. Daniel F. Caruso, Chairman
Ct. Siting Council
10 Franklin Square
New Britain, CT 0651

Re: AT&T Application for Certificate of Environment Compatibility and Public Need
8 Barnes Road, Canaan

Dear Chairman Caruso:

I am writing on behalf of the Housatonic River Commission, which was created by the Towns of Canaan, Cornwall, Kent, New Milford, North Canaan, Salisbury and Sharon to advise the towns on issues affecting the Housatonic River. The Commission's prime objective is to protect the free flowing and scenic character of the River.

The River Commission has two major concerns with the proposed telecommunications tower proposed by AT&T for 8 Barnes Road in Canaan. First, the access road, which is to be widened and graveled, has slopes of 20% or more. The steepness of the proposed access road will make it difficult to control stormwater runoff and the resultant erosion. Any erosion will have an immediate and detrimental impact on the adjacent wetlands, and subsequently, on the Housatonic River itself.

Second, the proposed telecommunications tower would result in a serious degradation of the entire area's scenic quality – a quality that the River Commission and numerous other organizations and individuals have worked long and hard to protect. The proposed tower would, for example, be visible for long stretches of Route 7, a section of highway that the Connecticut Department of Transportation has designated as a scenic highway.

We are, therefore, requesting that the Siting Council deny the applicant's request for a tower at this location. I am available to answer questions at any time.

Sincerely,

William Tingley

William Tingley, Chairman
Housatonic River Commission

cc: file, HRC, P. Mechare, Area Legislators, Canaan Inland Wetlands Commission

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Mobile Phone Mast Effects on Common Frog (*Rana temporaria*) Tadpoles: The City Turned into a Laboratory

ALFONSO BALMORI

C/Navarra, Valladolid, Spain

*An experiment has been made exposing eggs and tadpoles of the common frog (*Rana temporaria*) to electromagnetic radiation from several mobile (cell) phone antennae located at a distance of 140 meters. The experiment lasted two months, from the egg phase until an advanced phase of tadpole prior to metamorphosis. Measurements of electric field intensity (radiofrequencies and microwaves) in V/m obtained with three different devices were 1.8 to 3.5 V/m. In the exposed group (*$n = 70$*), low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality (90%) was observed. Regarding the control group (*$n = 70$*) under the same conditions but inside a Faraday cage, the coordination of movements was normal, the development was synchronous, and a mortality of 4.2% was obtained. These results indicate that radiation emitted by phone masts in a real situation may affect the development and may cause an increase in mortality of exposed tadpoles. This research may have huge implications for the natural world, which is now exposed to high microwave radiation levels from a multitude of phone masts.*

Keywords Electromagnetic pollution; Microwaves; Phone masts; *Rana temporaria*; Tadpoles.

Introduction

In recent years, a large number of mobile phone antennae have been installed, especially in urban areas. The scientific literature review shows that pulsed telephony microwave radiation may produce effects, especially on nervous, cardiovascular, immune, and reproductive systems (Balmori, 2009), but few studies on effects from phone masts on wildlife in the cities have been conducted (Balmori, 2005; Balmori and Hallberg, 2007; Everaert and Bauwens, 2007).

Concerning the effects of electromagnetic radiation on amphibians, several investigations in the laboratory have been conducted (Levengood, 1969; Landesman and Douglas, 1990; Grefner et al., 1998), but as far as we know there have not been any published studies on effects from phone antennae on amphibian populations in their natural habitat.

Address correspondence to Alfonso Balmori, Junta de Castilla y Leon, C/Rigoberto Cortejoso, 14, Valladolid 47071, Spain; E-mail: abalmori@ono.com

Balmori (2006) suggested that microwaves from phone masts might be responsible along with other factors in the decline of some populations of amphibians.

The objective of this research was to investigate the possible effects of phone mast radiation on exposed tadpoles (*Rana temporaria*) in a real situation.

Materials and Methods

The experiment has been made in Valladolid (Spain) exposing eggs and tadpoles of the common frog (*Rana temporaria*) obtained from an anonymous supplier to several mobile (cell) phone antennae.

The tadpoles were placed in two tanks with oxygen and food every day, which were set out in the fifth floor terrace at a distance of 140 meters from four base stations located opposite. The base stations are on the roof of an eight story high building (see the picture at http://www.hese-project.org/hese-uk/en/issues/nature.php?id = frogs).

In both experimental and control groups ($n = 70$ in each) the experiment lasted two months, from the egg phase until an advanced phase of tadpole prior to metamorphosis. The control group was inside a Faraday cage (metallic shielding component: EMC-reinforcement fabrics 97442 Marburg Technic).

According to official database (Ministerio de Industria Turismo y Comercio, 2009), the type and frequency range of emissions was:

- Vodafone: GSM 948.0–959.8 MHz.
- Vodafone: DCS 1,830.2–1,854.8 MHz.
- Vodafone: UMTS 1,905–1,910; 1,950–1,965; 2,140–2,155 MHz.
- Amena (Orange): DCS 1,855.2–1,879.8 MHz.

However, as we shall see later, in reality there exist more frequencies than this, which do not correspond with the frequencies contained in the database official.

The measurements of electric field intensity (radiofrequencies and microwaves in V/m) in the two tanks containing the tadpoles were made with the following meters:

- Nuova Elettronica device Model LX 1435 with 10% sensitivity, with unidirectional probe (range: 1 MHz–3 GHz).
- PCE–EM 29 device with an isotropic probe and calibration certificate (range: 50 MHz–3.5 GHz). Resolution: 0.1 mV/m. Absolute error: $\pm$ 1.0 dB.
- Spectrum analyzer Advantest R-3272 (range: 9 KHz–26 GHz), probe Rhode & Schwarz HE-200 (Official measurements of the Ministry of Science and Technology from Spain).

Results

The results of electric field intensity to which the tadpoles were exposed with the different devices were:

- LX 1435: Electromagnetic field intensity 2.5–3.5 V/m.
- PCE–EM 29: Electromagnetic field intensity 1,847–2,254 V/m.
- Advantest R-3272: Results in decibels (Table 1).

Table 1
Results of spectrum analyzer advantest R-3272 (official measurements of the ministry of science and technology from Spain)

VODAFONE		VODAFONE		AMENA	
Frequency (MHz)	Decibels	Frequency (MHz)	Decibels	Frequency (MHz)	Decibels
88,5	69	93,1	67	98,1	67
104,5	64	487,25	43	671,25	43,9
727,25	37	751,25	37	949,2	81
953,8	77	957,2	76	958,8	57
935	57	1875,4	63	1875,6	61
1873,6	60	1871,2	62	1869	61

Note: The frequencies that exist in reality are several more and do not correspond with the frequencies contained in the database official.

Some observations on the tadpoles were as follows (Balmori, 2008; see the video clips at http://www.hese-project.org/hese-uk/en/issues/nature.php?id):

- Experimental group ($n = 70$).

Low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality (90%) was observed. Most of the deaths occurred after six weeks of continuous exposure.

The tadpoles' tails waved only slowly. Only about half of them reacted to a sudden stimulus in the form of a stroke on the wall of the aquarium. Some remained sideways or tilted and swam describing closed circles (Balmori, 2008; http://www.hese-project.org/hese-uk/en/issues/nature.php?id). Generally, their movements were uncoordinated. They showed low interest and few tadpoles reacted to the food. For lack of resources, we could not investigate the anatomical or physiological reasons for the problems observed.

- Control group ($n = 70$, under the same conditions but inside a Faraday cage).

The coordination of movements was normal, the development was synchronous, and a mortality of 4.2% was obtained. No deaths occurred at a particular time.

The tail moved fast and they reacted quickly to a sudden stimulus (a stroke on the wall of the aquarium). No tadpoles remained sideways or tilted and the direction of swimming was correct. Their movements were coordinated. When food was supplied most of them reacted quickly.

Discussion

The literature contains much data hinting at an important role for bioelectromagnetic phenomena as a mediator of morphogenetic information in many contexts relevant to embryonic development (Levin, 2003). The underlying mechanism by which an endogenous electrical field may exert an influence on development remains to be discovered. Most prevailing hypotheses suggest that a field acts to directionally guide the growth and migration of some embryonic cells (Hotary and Robinson, 1992).

Strong magnetic fields (1.74–16.7 T) disrupt cell division of exposed frog eggs (*Xenopus laevis*) (Denegre et al., 1998). Valles (2002) proposed a model to explain their influence.

Several studies on effects of electromagnetic fields on amphibians have been conducted in laboratories. When amphibian eggs and embryos of *Ambystoma maculatum* and *Rana sylvatica* were exposed to high magnetic fields (6.3×10^3 G), a brief treatment of early embryos produced several types of abnormalities, incuding microcephaly, retarded (abnormal) growth, edema, and scoliosis (Levengood, 1969).

Adult newts (*Notophthalmus viridescens*) exposed to a pulsed electromagnetic field (1 T and 0.15 V/m, approx.) for the first 30 days post forelimbs were amputated and produced more abnormalities in their skeletal patterns than the native limbs or the normal regenerates. Twelve percent exhibited unique abnormalities not observed in either the native or regenerate limb population. These forelimbs demonstrated one or more of the following gross defects: acheiria (lack of carpus and digits), aphalangia, or oligodactylia (loss of digits) as well as carpal bone and long bone (radius and ulna) abnormalities (Landesman and Douglas, 1990).

Exposed frog tadpoles (*Rana temporaria*) developed under electromagnetic field (50 Hz, 260 A/m) show an increase in mortality. Exposed tadpoles developed more slowly and less synchronously than control tadpoles and remained at the early stages for longer. Tadpoles developed allergies and EMF caused changes in their blood counts (Grefner et al., 1998). These results are consistent with the observations of this work.

Deformities and disappearance of amphibians and other organisms is part of the global biodiversity crisis (Blaustein and Johnson, 2003). Some authors consider that the electromagnetic pollution is destroying nature (Warnke, 2007; Firstenberg, 1997). Balmori (2006) proposed that electromagnetic pollution (in the microwave and radiofrequency range) along with other environmental factors is a possible cause for decline and deformations of some wild amphibian populations exposed. The results of this experiment conducted in a real situation in the city of Valladolid (Spain) indicate that the tadpoles that live near such facilities, exposed to relatively low levels of environmental electromagnetic fields (1.8–3.5 V/m) may suffer adverse effects (low coordination of movements, asynchronous growth, and high mortality), and this may be a cause (together with other environmental factors) of decline of amphibian populations.

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Declaration of Interest: The author report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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Electromagnetic pollution from phone masts. Effects on wildlife

Alfonso Balmori

Direccion General del Medio Natural, Consejería de Medio Ambiente, Junta de Castilla y Leon, C/Rigoberto Cortejoso, 14, 47014 Valladolid, Spain

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Abstract

A review on the impact of radiofrequency radiation from wireless telecommunications on wildlife is presented. Electromagnetic radiation is a form of environmental pollution which may hurt wildlife. Phone masts located in their living areas are irradiating continuously some species that could suffer long-term effects, like reduction of their natural defenses, deterioration of their health, problems in reproduction and reduction of their useful territory through habitat deterioration. Electromagnetic radiation can exert an aversive behavioral response in rats, bats and birds such as sparrows. Therefore microwave and radiofrequency pollution constitutes a potential cause for the decline of animal populations and deterioration of health of plants living near phone masts. To measure these effects urgent specific studies are necessary.

Keywords: Effects on wildlife; Effects on birds; Electromagnetic radiation; Mammals; Microwaves; Mobile telecommunications; Non-thermal effects; Phone masts; Radiofrequencies

1. Introduction

Life has evolved under the influence of two omnipresent forces: gravity and electromagnetism. It should be expected that both play important roles in the functional activities of organisms [1]. Before the 1990's radiofrequencies were mainly from a few radio and television transmitters, located in remote areas and/or very high places. Since the introduction of wireless telecommunication in the 1990's the rollout of phone networks has caused a massive increase in electromagnetic pollution in cities and the countryside [2,3].

Multiple sources of mobile communication result in chronic exposure of a significant part of the wildlife (and man) to microwaves at non-thermal levels [4]. In recent years, wildlife has been chronically exposed to microwaves and RFR (Radiofrequency radiation) signals from various sources, including GSM and UMTS/3G wireless phones and base stations, WLAN (Wireless Local Area Networks), WPAN (Wireless Personal Area Networks such as Bluetooth), and DECT (Digital Enhanced (former European) Cordless Telecommunications) that are erected indiscriminately without studies of environmental impact measuring long-term effects. These exposures are characterized by low intensities, varieties of signals, and long-term durations. The greater portion of this exposure is from mobile telecommunications (geometric mean in Vienna: 73% [5]). In Germany the GSM cellular phone tower radiation is the dominating high frequency source in residential areas [6]. Also GSM is the dominating high frequency source in the wilderness of Spain (personal observation).

Numerous experimental data have provided strong evidence of athermal microwave effects and have also indicated several regularities in these effects: dependence of frequency within specific frequency windows of "resonance-type"; dependence on modulation and polarization; dependence on intensity within specific intensity windows, including super-low power density comparable with intensities from base stations/masts [4,7–9]. Some studies have demonstrated different microwave effects depending on wavelength in the range of mm, cm or m [10,11]. Duration of exposure may be as important as power density. Biological effects resulting from electromagnetic field radiation might depend on dose, which indicates long-term accumulative effects [3,9,12]. Modulated and pulsed radiofrequencies seem to be more effective in producing effects [4,9]. Pulsed waves (in blasts), as well as certain low frequency modulations exert greater

E-mail addresses: abalmori@ono.com, balmaral@jcyl.es.

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biological activity [11,13–15]. This observation is important because cell phone radiation is pulsed microwave radiation modulated at low frequencies [8,9].

Most of the attention on possible biological effects of electromagnetic radiation from phone masts has been focused on human health [5,16–21]. The effects of electromagnetic pollution on wildlife, have scarcely been studied [22–25].

The objective of this review is to detail advances in knowledge of radiofrequencies and microwave effects on wildlife. Future research may help provide a better understanding of electromagnetic field (EMF) effects on wildlife and plants and their conservation.

2. Effects on exposed wildlife

2.1. Effects on birds

2.1.1. Effects of phone mast microwaves on white stork

In monitoring a white stork (*Ciconia ciconia*) population in Valladolid (Spain) in vicinity of Cellular Phone Base Stations, the total productivity in nests located within 200 m of antennae, was 0.86 ± 0.16. For those located further than 300 m, the result was practically doubled, with an average of 1.6 ± 0.14. Very significant differences among total productivity were found ($U = 240$; $P = 0.001$, Mann–Whitney test). Twelve nests (40%) located within 200 m of antennae never had chicks, while only one (3.3%) located further than 300 m had no chicks. The electric field intensity was higher on nests within 200 m (2.36 ± 0.82 V/m) than nests further than 300 m (0.53 ± 0.82 V/m). In nesting sites located within 100 m of one or several cellsite antennae with the main beam of radiation impacting directly (Electric field intensity >2 V/m) many young died from unknown causes. Couples frequently fought over nest construction sticks and failed to advance the construction of the nests. Some nests were never completed and the storks remained passively in front of cellsite antennae. These results indicate the possibility that microwaves are interfering with the reproduction of white stork [23]. (Fig. 1)

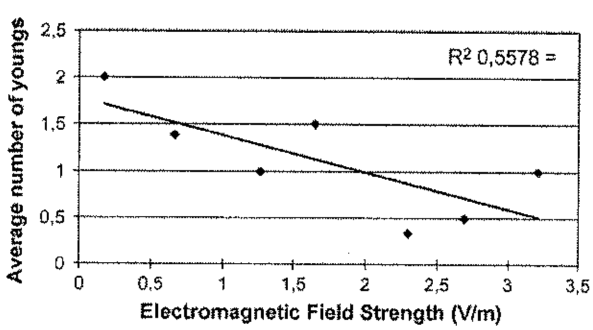

Fig. 1. Average number of youngs and electric field intensity (V/m) in 60 nests of white storks (*Ciconia ciconia*) (Hallberg, Ö with data of Balmori, 2005 [23]).

2.1.2. Effects of phone mast microwaves on house sparrows

A possible effect of long-term exposure to low-intensity electromagnetic radiation from mobile phone (GSM) base stations on the number of house sparrows during the breeding season was studied in Belgium. The study was carried out sampling 150 point locations within six areas to examine small-scale geographic variation in the number of house sparrow males and the strength of electromagnetic radiation from base stations. Spatial variation in the number of house sparrow males was negative and highly significantly related to the strength of electric fields from both the 900 and 1800 MHz downlink frequency bands and from the sum of these bands (Chi-square-tests and AIC-criteria, $P < 0.001$). This negative relationship was highly similar within each of the six study areas, despite differences among areas in both the number of birds and radiation levels. 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 behavior of house sparrows in the wild [24].

In another study with point transect sampling performed at 30 points visited 40 times in Valladolid (Spain) between 2002 and 2006, counting the sparrows and measuring the mean electric field strength (radiofrequencies and microwaves: 1 MHz to 3 GHz range). Significant declines ($P = 0.0037$) were observed in 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 $R = -0.87$; $P = 0.0001$ According to this calculation, no sparrows would be expected to be found in an area with field strength >4 V/m [25]. (Fig. 2)

In the United Kingdom a decline of several species of urban birds, especially sparrows, has recently happened [26]. The sparrow population in England has decreased in the last 30 years from 24 million to less than 14. The more abrupt decline, with 75% descent has taken place from 1994 to 2002. In 2002, the house sparrow was added to the Red List of U.K. endangered species [27]. This coincides with the rollout of mobile telephony and the

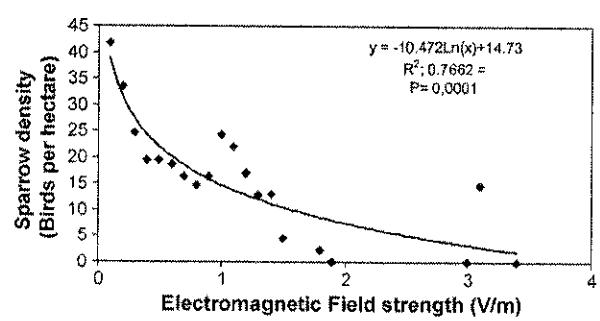

Fig. 2. Mean sparrow density as a function of electric field strength grouped in 0.1 V/m. (Balmori and Hallberg, 2007 [25]).

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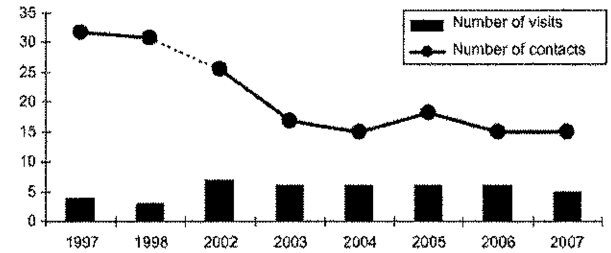

Fig. 3. Annual number of contacts (Mean) for 14 species studied in "Campo Grande" urban park (lack the information of the years 1999–2001).

possible relationship of both circumstances should be investigated.

In Brussels, many sparrows have disappeared recently [28]; similar declines have been reported in Dublin [29]. Van der Poel (cited in Ref. [27]) suggested that sparrows might be declining in Dutch urban centres also.

2.1.3. *Effects on the bird community at an urban park*

Microwaves may be affecting bird populations in places with high electromagnetic pollution. Since several antennas were installed in proximities of "Campo Grande" urban park (Valladolid, Spain) the bird population has decreased and a reduction of the species and breeding couples has occurred. Between 1997 and 2007, of 14 species, 3 species have disappeared, 4 are in decline and 7 stay stable (Balmori, unpublished data) (Fig. 3). In this time the air pollution (SO2, NO2, CO and Benzene) has diminished.

During the research some areas called "silence areas" contaminated with high microwave radiation (>2 V/m), where previously different couples usually bred and later disappeared, have been found. Several anomalies in magpies (*Pica pica*) were detected: plumage deterioration, locomotive problems (limps and deformations in the paws), partial albinism and melanism, especially in flanks [30]. Recently cities have increased cases of partial albinism and melanism in birds (*Passer domesticus*, *Turdus merula* and *P. pica*) (personal observation).

2.1.4. *Possible physiological mechanisms of the effects found in birds*

Current scientific evidence indicates that prolonged exposure to EMFs, at levels that can be encountered in the environment, may affect immune system function by affecting biological processes [3,31,32]. A stressed immune system may increase the susceptibility of a bird to infectious diseases, bacteria, viruses, and parasites [33].

The plumage of the birds exposed to microwaves looked, in general, discolorated and lack of shine. This not only occurred in ornamental birds; such as peacocks, but also in wild birds; such as, tits, great tits, house sparrows, etc (personal observation). We must mention that plumage deterioration is the first sign of weakening or illnesses in birds since damaged feathers are a sure sign of stress.

Physiological conditions during exposure minimize microwave effects. Radical scavengers/antioxidants might be involved in effects of microwaves [4].

Microwaves used in cellphones produce an athermal response in several types of neurons of the birds nervous system [34]. Several studies addressed behavior and teratology in young birds exposed to electromagnetic fields [23,25,35–37]. Most studies indicate that electromagnetic field exposure of birds generally changes, but not always consistently in effect or in direction, their behavior, reproductive success, growth and development, physiology and endocrinology, and oxidative stress [37]. These results can be explained by electromagnetic fields affecting the birds' response to the photoperiod as indicated by altered melatonin levels [38].

Prolonged mobile phone exposure may have negative effects on sperm motility characteristics and male fertility as has been demonstrated in many studies made in man and rats [39–46]. EMF and microwaves can affect reproductive success in birds [23,25,35,36,47]. EMF exposure affected reproductive success of kestrels (*Falco sparverius*), increasing fertility, egg size, embryonic development and fledging success but reducing hatching success [35,36].

The radiofrequency and microwaves from mobile telephony can cause genotoxic effects [48–55]. Increases in cytological abnormalities imply long-term detrimental effects since chromosomal damage is a mechanism relevant to causation of birth defects and cancer [55].

Long-term continuous, or daily repeated EMF exposure can induce cellular stress responses at non-thermal power levels that lead to an accumulation of DNA errors and to inhibition of cell apoptosis and cause increased permeability of blood–brain barrier due to stabilization of endothelial cell stress fibers. Repeated occurrence of these events over a long period of time (years) could become a health hazard due to a possible accumulation of brain tissue damage. These findings have important implications with regards to potential dangers from prolonged and repeated exposure to non-ionizing radiation [56,57].

Pulsed magnetic fields can have a significant influence on the development and incidence of abnormalities in chicken embryos. In five of six laboratories, exposed embryos exhibited more structural anomalies than controls. If the data from all six laboratories are pooled, the difference for the incidence of abnormalities in exposed embryos and controls is highly significant [58]. Malformations in the nervous system and heart, and delayed embryo growth are observed. The embryo is most sensitive to exposure in the first 24 h of incubation [58]. An increase in the mortality [59] and appearance of morphological abnormalities, especially of the neural tube [13,60,61] has been recorded in chicken embryos exposed to pulsed magnetic fields, with different susceptibility among individuals probably for genetic reasons. A statistically significant high mortality rate of chicken embryos subjected to radiation from a cellphone, compared to the control group exists [62,63]. In another study eggs exposed to a magnetic field intensity of 0.07 T showed embryonic mortality during their incubation was higher. The negative effect of the magnetic field was manifested also by a lower weight of the hatched chicken [64]. Bioelectric fields have long been suspected to play a causal role in embryonic development. Alteration of the electrical field may disrupt the chemical gradient and signals received by embryo cells. It appears that in some manner, cells sense their position in an electrical field and respond appropriately. The disruption of this field alters their response. Endogenous current patterns are often correlated with specific morphogenetic events [65].

Available data suggests dependencies of genotype, gender, physiological and individual factors on athermal microwave effects [4,9]. Genomic differences can influence cellular responses to GSM Microwaves. Data analysis has highlighted a wide inter-individual variability in response, which was replicated in further experiments [4]. It is possible that each species and each individual, show different susceptibility to radiation, since vulnerability depends on genetic tendency, and physiologic and neurological state of the irradiated organism [15,35–37,61,66–68]. Different susceptibility of each species has also been proven in wild birds exposed to electromagnetic fields from high-voltage power lines [47].

2.2. *Effects on mammals*

2.2.1. *Alarm and aversion behavior*

Rats spent more time in the halves of shuttle boxes that were shielded from 1.2 GHz. Microwaves irradiation. The average power density was about 0.6 mW/cm^2. Data revealed that rats avoided the pulsed energy, but not the continuous energy, and less than 0.4 mW/cm^2 average power density was needed to produce aversion [69]. Navakatikian & Tomashevskaya [70] described a complex series of experiments in which they observed disruption of rat behavior (active avoidance) from radiofrequency radiation. Behavioral disruption was observed at a power density as low as 0.1 mW/cm^2 (0.027 W/kg). Mice in an experimental group exposed to microwave radiation expressed visible individual panic reaction, disorientation and a greater degree of anxiety. In the sham exposed group these deviations of behavior were not seen and all animals show collective defense reaction [71]. Microwave radiation at 1.5 GHz pulsing 16 ms. At 0.3 mW/cm^2 power density, in sessions of 30 min/day over one month produced anxiety and alarm in rabbits [72].

Electromagnetic radiation can exert an aversive behavioral response in bats. Bat activity is significantly reduced in habitats exposed to an electromagnetic field strength greater than 2 V/m [73]. During a study in a free-tailed bat colony (*Tadarida teniotis*) the number of bats decreased when several phone masts were placed 80 m from the colony [74].

2.2.2. *Deterioration of health*

Animals exposed to electromagnetic fields can suffer a deterioration of health and changes in behavior [75,76].

There was proof of frequent death in domestic animals; such as, hamsters and guinea pigs, living near mobile telecommunication base stations (personal observation).

The mice in an experimental group exposed to microwave radiation showed less weight gain compared to control, after two months. The amount of food used was similar in both groups [71]. A link between electromagnetic field exposure and higher levels of oxidative stress appears to be a major contributor to aging, neurodegenerative diseases, immune system disorders, and cancer in mammals [33].

The effects from GSM base transceiver station (BTS) frequency of 945 MHz on oxidative stress in rats were investigated. When EMF at a power density of 3.67 W/m^2, below current exposure limits, were applied, MDA (malondialdehyde) level was found to increase and GSH (reduced glutathione) concentration was found to decrease significantly ($P < 0.0001$). Additionally, there was a less significant ($P = 0.0190$) increase in SOD (superoxide dismutase) activity under EM exposure [77].

2.2.3. *Problems in reproduction*

In the town of Casavieja (Ávila, Spain) a telephony antenna was installed that had been in operation for about 5 years. Then some farmers began blaming the antenna for miscarriages in many pigs, 50–100 m from the antenna (on the outskirts of the town). Finally the topic became so bad that the town council decided to disassemble the antenna. It was removed in the spring 2005. From this moment onwards the problems stopped (C. Lumbreras personal communication).

A Greek study reports a progressive drop in the number of rodent births exposed to radiofrequencies. The mice exposed to 0.168 μW/cm^2 become sterile after five generations, while those exposed to 1.053 μW/cm^2 became sterile after only three generations [22].

In pregnant rats exposed to 27.12 MHz continuous waves at 100 μW/cm^2 during different periods of pregnancy, half the pregnancies miscarried before the twentieth day of gestation, compared to only a 6% miscarriage rate in unexposed controls, and 38% of the viable foetuses had incomplete cranial ossification, compared to less than 6% of the controls. Findings included a considerable increase in the percentage of total reabsorptions (post-implantation losses consequent to RF radiation exposure in the first post-implantation stage). Reduced body weight in the exposed dams reflected a negative influence on their health. It seems that the irradiation time plays an important role in inducing specific effects consequent to radiofrequency radiation exposure [78]. There was also a change in the sex ratio, with more males born to rats that had been irradiated from the time of conception [2]. Moorhouse and Macdonald [79] find a substantial decline in female Water Vole numbers in the radio-collared population, apparently resulting from a male skew in the sex ratios of offspring born to this population. Recruits to the *radio-tracked* population were skewed heavily in favour of males (43:13). This suggests that radio-collaring of females caused male-skewed sex ratios.

Mobile phone exposure may have negative effects on sperm motility characteristics and male fertility in rats [46]. Other studies find a decrease of fertility, increase of deaths after birth and dystrophic changes in their reproductive organs [11]. Intermittent exposure showed a stronger effect than continuous exposure [4]. Brief, intermittent exposure to low-frequency EM fields during the critical prenatal period for neurobehavioral sex differentiation can demasculinize male scent marking behavior and increase accessory sex organ weights in adulthood [80].

In humans, magnetic field exposures above 2.0 mG were positively associated with miscarriage risk [81]. Exposure of pregnant women to mobile phone significantly increased foetal and neonatal heart rate, and significantly decreased the cardiac output [82].

2.2.4. Nervous system

Microwaves may affect the blood brain barrier which lets toxic substances pass through from the blood to the brain [83]. Adang et al. [84] examined the effect of microwave exposure to a GSM-like frequency of 970 MHz pulsed waves on the memory in rats by means of an object recognition task. The rats that have been exposed for 2 months show normal exploratory behavior. The animals that have been exposed for 15 months show derogatory behavior. They do not make the distinction between a familiar and an unfamiliar object. In the area that received radiation directly from "Location Skrunda Radio Station" (Latvia), exposed children had less developed memory and attention, their reaction time was slower and neuromuscular apparatus endurance was decreased [85]. Exposure to cell phones prenatally and, to a lesser degree, postnatally was associated with behavioral difficulties such as emotional and hyperactivity problems around 7 years of age [86]. Electromagnetic radiation caused modification of sleep and alteration of cerebral electric response (EEG) [87–89]. Microwave radiation from phone masts may cause aggressiveness in people and animals (personal observation).

2.3. Effects on amphibians

Disappearance of amphibians and other organisms is part of the global biodiversity crisis. An associated phenomenon is the appearance of large numbers of deformed amphibians. The problem has become more prevalent, with deformity rates up to 25% in some populations, which is significantly higher than previous decades [90]. Balmori [91] proposed that electromagnetic pollution (in the microwave and radiofrequency range) is a possible cause for deformations and decline of some wild amphibian populations.

Two species of amphibians were exposed to magnetic fields at various stages of development. A brief treatment of early amphibian embryos produced several types of abnormalities [92]. Exposure to a pulsed electromagnetic field produced abnormal limb regeneration in adult Newts [93]. Frog tadpoles (*Rana temporaria*) developed under electromagnetic field (50 Hz, 260 A/m) have increased mortality. Exposed tadpoles developed more slowly and less synchronously than control tadpoles and remain at the early stages for longer. Tadpoles developed allergies and EMF caused changes in blood counts [94].

In a current study exposing eggs and tadpoles ($n = 70$) of common frog (*R. temporaria*) for two months, from the phase of eggs until an advanced phase of tadpole, to four telephone base stations located 140 m away: with GSM system 948.0–959.8 MHz; DCS system: 1830.2–1854.8; 1855.2–1879.8 MHz. and UMTS system: 1905–1910; 1950–1965; 2140–2155 MHz. (electric field intensity: 1.847–2.254 V/m). A low coordination of movements, an asynchronous growth, with big and small tadpoles, and a high mortality (90%) was observed. The control group ($n = 70$), under the same conditions but inside a Faraday cage (metallic shielding component: EMC-reinforcement fabrics 97442 Marburg Technic), the coordination of movements was normal, the development was synchronously and the mortality rate was only 4.2% [95].

2.4. Effects on insects

The microwaves may affect the insects. Insects are the basis and key species of ecosystems and they are especially sensitive to electromagnetic radiation that poses a threat to nature [96].

Carpenter and Livstone [97] irradiated pupae of Tenebrio molitor with 10 GHz microwaves at 80 mW for 20–30 min and 20 mW for 120 min obtained a rise in the proportion of insects with abnormalities or dead. In another study exposing fruit flies (*Drosophila melanogaster*) to mobile phone radiation, elevated stress protein levels (Hsp70) was obtained, which usually means that cells are exposed to adverse environmental conditions ('non-thermal shock') [98]. Panagopoulos et al. [99] exposed fruit flies (*D. melanogaster*) to radiation from a mobile phone (900 MHz) during the 2–5 first days of adulthood. The reproductive capacity of the species reduced by 50–60% in modulated radiation conditions (emission while talking on the phone) and 15–20% with radiation nomodulated (with the phone silent). The results of this study indicate that this radiation affects the gonadal development of insects in an athermal way. The authors concluded that radio frequencies, specifically GSM, are highly bioactive and provoke significant changes in physiological functions of living organisms. Panagopoulos et al. [100] compare the biological activity between the two systems GSM 900 MHz and DCS 1800 MHz in the reproductive capacity of fruit flies. Both types of radiation were found to decrease significantly and non-thermally the insect's reproductive capacity, but GSM 900 MHz seems to be even more bioactive than DCS 1800 MHz. The difference seems to be dependent mostly on field intensity and less on carrier frequency.

A study in South Africa finds a strong correlation between decrease in ant and beetle diversity with the

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electromagnetic radiation exposure (D. MacFadyen, personal communication.). A decrease of insects and arachnids near base stations was detected and corroborated by engineers and antenna's maintenance staff [101]. In houses near antennas an absence of flies, even in summer, was found.

In a recent study carried out with bees in Germany, only a few bees irradiated with DECT radiation returned to the beehive and they needed more time. The honeycomb weight was lower in irradiated bees [102]. In recent years a "colony collapse disorder" is occurring that some authors relate with pesticides and with increasing electromagnetic pollution [96].

The disappearance of insects could have an influence on bird's weakening caused by a lack of food, especially at the first stages in a young bird's life.

2.5. *Effects on trees and plants*

The microwaves may affect vegetables. In the area that received radiation directly from "Location Skrunda Radio Station" (Latvia), pines (*Pinus sylvestris*) experienced a lower growth radio. This did not occur beyond the area of impact of electromagnetic waves. A statistically significant negative correlation between increase tree growth and intensity of electromagnetic field was found, and was confirmed that the beginning of this growth decline coincided in time with the start of radar emissions. Authors evaluated other possible environmental factors which might have intervened, but none had noticeable effects [103]. In another study investigating cell ultrastructure of pine needles irradiated by the same radar, there was an increase of resin production, and was interpreted as an effect of stress caused by radiation, which would explain the aging and declining growth and viability of trees subjected to pulsed microwaves. They also found a low germination of seeds of pine trees more exposed [104]. The effects of Latvian radar was also felt by aquatic plants. *Spirodela polyrrhiza* exposed to a power density between 0.1 and 1.8 $\mu W/cm^2$ had lower longevity, problems in reproduction and morphological and developmental abnormalities compared with a control group who grew up far from the radar [105].

Chlorophylls were quantitatively studied in leaves of black locust (*Robinia pseudoacacia* L.) seedlings exposed to high frequency electromagnetic fields of 400 MHz. It was revealed that the ratio of the two main types of chlorophyll was decreasing logarithmically to the increase of daily exposure time [106].

Exposed tomato plants (*Lycopersicon esculentum*) to low level (900 MHz, 5 V/m) electromagnetic fields for a short period (10 min) measured changes in abundance of three specific mRNA after exposure, strongly suggesting that they are the direct consequence of application of radio-frequency fields and their similarities to wound responses suggests that this radiation is perceived by plants as an injurious stimulus [107]. Non-thermal exposure to radiofrequency fields induced oxidative stress in duckweed (*Lemna minor*) as well as unespecific stress responses, especially of antioxidative enzymes [108].

For some years progressive deterioration of trees near phone masts have been observed in Valladolid (Spain). Trees located inside the main lobe (beam), look sad and feeble, possibly slow growth and a high susceptibility to illnesses and plagues. In places we have measured higher electric field intensity levels of radiation (>2 V/m) the trees show a more notable deterioration [109]. The tops of trees are dried up where the main beams are directed to, and they seem to be most vulnerable if they have their roots close to water. The trees don't grow above the height of the other ones and, those that stand out far above, have dried tops (Hargreaves, personal communication and personal observation). White and black poplars (*Populus sp.*) and willows (*Salix sp.*) are more sensitive. There may be a special sensitivity of this family exists or it could be due to their ecological characteristics forcing them to live near water, and thus electric conductivity. Other species as *Platanus sp.* and *Lygustrum japonicum*, are more resistant (personal observation). Schorpp [110] presents abundant pictures and explanations of what happens to irradiated trees.

3. Conclusions

This literature review shows that pulsed telephony microwave radiation can produce effects especially on nervous, cardiovascular, immune and reproductive systems [111]:

- Damage to the nervous system by altering electroencephalogram, changes in neural response or changes of the blood–brain barrier.
- Disruption of circadian rhythms (sleep–wake) by interfering with the pineal gland and hormonal imbalances.
- Changes in heart rate and blood pressure.
- Impairment of health and immunity towards pathogens, weakness, exhaustion, deterioration of plumage and growth problems.
- Problems in building the nest or impaired fertility, number of eggs, embryonic development, hatching percentage and survival of chickens.
- Genetic and developmental problems: problems of locomotion, partial albinism and melanism or promotion of tumors.

In the light of current knowledge there is enough evidence of serious effects from this technology to wildlife. For this reason precautionary measures should be developed, alongside environmental impact assessments prior to installation, and a ban on installation of phone masts in protected natural areas and in places where endangered species are present. Surveys should take place to objectively assess the severity of effects.

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Seymour Jr., Whitney N.

From: crgr@aol.com
Sent: Saturday, February 05, 2011 1:44 AM
To: Seymour Jr., Whitney N.
Subject: Confidential - ?? from Camilla Rees

Hello Mr. Seymour!
I am helping someone in NYC in a 5th Avenue building where the building has given an option to T-Mobile to put a
tower on the rooftop (just above this woman's penthouse) in exchange for $35,000 a year.

The points T-Mobile has made that most of the Board believes are:
1. They can precisely beam the radiation so that it is not directed into the apartment below.
and
2. It is better to be under the antenna with it beaming outwards (i.e. placed on their building) than have
T-Mobile put it on a neighboring building where it would be beaming at them.

In my limited experience with buildings with antennas on the roof, the people below were very sick despite the antennas beaming outward.
Do you have any idea if perhaps if they placed metal under the antenna on the roof could that *totally* shield the radiation?
Any experience with this??

Have you ever come upon the argument that it is better to be under the antenna than have the antennas on the building next door?

There is some possibility the roof may not hold the intended structure, and that they would use the side of the
building in the center courtyard instead to which to attach antennas. In that case, where antennas are attached to
the side of the building, I wonder if it is it realistic that a metal plate of some sort could shield.

Any thoughts on this would be gratefully appreciated! **Do you know of any research negating these T-Mobile
arguments? Have you ever encountered this sort of situation before and addressed it from a legal
perspective?**

She is a very high potential donor to this cause so I want to help her marshall the forces fast to show her
board these 2 points are invalid if possible! If you have any thoughts on this I would love to hear them!!

Many thanks!!

Camilla
415-992-5093

JOURNAL OF BIOELECTRICITY 5(2), 201-210 (1986)

MODIFICATION OF HEART FUNCTION WITH LOW INTENSITY ELECTROMAGNETIC ENERGY

Allan H. Frey and Edwin S. Eichert
Randomline, Inc.
Huntingdon Valley, PA 19006

ABSTRACT

Three groups of frogs were exposed to pulsed modulated radio frequency electromagnetic (EM) energy. One group was subjected to alternating ten-minute periods of energy exposure and sham exposure, with the exposure pulses synchronized with the rise of the R-wave. A second group was subjected to alternating ten-minute periods of energy exposure and sham exposure, with the exposure pulses synchronized with the T-wave. The third group was sham-exposed controls. The data indicated that rate of change of beat is influenced by exposure to EM energy at incident average power densities of 3 microwatts/cm^2. Synchronization of the energy pulses with the phase of the cardiac cycle is of consequence.

INTRODUCTION

Frey and Seifert (1), using the isolated frog heart, found that when the heart was exposed to pulses of electromagnetic (EM) energy synchronized to occur with the QRS complex, the heart rate increased and sometimes arrhythmia occurred. The increase was statistically significant with average incident power densities of 6 $\mu W/cm^2$. Exposure at the occurrence of the P-wave, during the P-Q interval, and sham exposure did not cause similar effects. Other experimenters also have reported effects on the heart (2-5). Thus, a complementary experiment was under-

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taken to determine if the changes seen by Frey and Seifert in the isolated heart preparation would occur in vivo.

MATERIALS AND METHODS

Leopard frogs (Rana Pipiens) were pithed and placed ventral side up on a polystyrene surface. They were restrained at the arms and legs by plastic clips. The ventral body wall was opened and electrodes placed so as to minimize the possibility of artifacts. Egg-carrying frogs, those with noticeable parasites, and those with non-beating hearts were not used. After pilot experimentation, 24 frogs were used in the data collection reported here. Twelve were subjected to alternating 10-minute periods of energy exposure and sham exposure, with the exposure pulses synchronized with the rise of the R-wave. Six were subjected to alternating 10-minute periods of energy exposure and sham exposure, with the exposure pulses synchronized with the T-wave. Six were used as non-exposure controls, three in each of two non-exposure conditions used. In one condition, the preparation was shielded from the energy with a piece of EM energy absorber (Eccosorb AN77). In the other, EM energy was delivered to a dummy load instead of to the horn antenna.

The heart rate of a typical preparation decreased by 2-3% during each 10-minute period, as is normal. Generally, the heart remained active for ten to twelve 10-minute periods. To control for possible non-linear heart rate decreases, half of the preparations were initially sham exposed and half were initially exposed to synchronized pulse-modulated energy.

The preparation was positioned on a polystyrene sheet (which is essentially transparent to this energy) and placed on a table made of Eccosorb AN77. The table was inside an EM energy anechoic enclosure constructed from Eccosorb AN77. The preparation was located approximately 90 cm below the open end of a standard gain horn antenna. Measurements of the EM field showed that the energy was evenly distributed at the heart's level.

The frog's electrocardiogram (ECG) was monitored with the use of a pair of electrodes. Each electrode was constructed from a 20-gauge, 5-cm long stainless-steel tube connected to the center lead of a 1-m length subminiature coaxial cable (RG 196). These two cables were passed through a 1-cm diameter polystyrene tube. The electrode assembly was fixed to the tube by cooling molten polystyrene on the electrode ends where they projected from the tube. The shields were connectd at the electrode end of the tube. The polystyrene tube passed through a hole in the Eccosorb enclosure and was supported by a micromanipulator outside of the enclosure. For minimal field effects, the tube was positioned perpendicular to the electric field produced by the horn antenna. With the aid of a micromanipulator and a microscope, the tips of these stainless-steel electrodes were placed in connective tissue approximately 3 mm from the heart, one near the top of the heart and the other near the apex.

The subminiature coaxial cables from the electrodes were attached to a differential amplifier in a dual-trace oscilloscope. The time base for each trace was adjusted to trigger on the P-wave of the frog's ECG. The sweep rate was adjusted so only a single ECG cycle occurred during a sweep. The oscilloscope provided a pulse to a jack each time a sweep was triggered. After shaping by a diode clamp differentiator, the pulse was applied simultaneously to the EM energy generation circuitry and to a computer. The computer was used to measure and store the periods of the ECG (time between P-waves).

The EM energy generation circuitry consisted of a pulse generator (AEL Model 104) which delayed the pulse before it was used to modulate an EM energy transmitter. The transmitter was adjusted to deliver one 5-microsecond pulse to the preparation each time the machine received a trigger pulse. The transmitter also concurrently provided a synchronization pulse to a jack. This latter pulse was applied to the oscilloscope's second input amplifier and allowed the monitoring of transmitter pulses on the second trace of the scope. Thus, the experimenter could simultaneously monitor the ECG and the apparent transmitter output. The word apparent is used because the transmitter monitoring pulse would appear on the scope even during the sham exposure condition. This was a control on the experimenter, who was not aware of whether the exposure was actual or sham. The experimenter adjusted the delay time of the pulse generator throughout the experiment to maintain synchronization of the EM energy pulse with the rise of the R-wave or the rise of the T-wave, as required during a particular run by the experimental design. A stepping relay was cycled automatically by the control circuitry. It provided alternating 10-minute periods of exposure and sham exposure. During sham exposure periods, the energy was applied to a dummy load rather than to the horn antenna.

The EM energy carrier frequency of 1.25 GHz was modulated to deliver 5-microsecond pulses of energy to the frog, in synchrony with the rise of the R-wave in one group and at the rise of the T-wave in the other group. The incident power density was measured before and after each experimental run with a quarter-wave dipole connected in series with a Hewlett-Packard Model 477B thermister mount and a Hewlett-Packard Model 430C power meter. With a heart rate of approximately one beat per second, the incident average power during exposure was 3 $\mu W/cm^2$.

For data processing, a train of pulses was inputted to a computer by a pulse generator. The computer counted the number of pulses received and stored the count in a memory location. The pulse generator was operated at 1 KHz; thus, the system was capable of resolving ECG intervals to 0.001 second. As previously noted, a P-wave trigger pulse was directed to the computer. Each such trigger pulse stepped the computer from its present memory location to the next location.

After each 10-minute exposure or sham exposure period, the automatic control circuitry activated a strip chart recorder to first record a current 10-second portion of the frog's ECG and then record the contents of the computer memory. After storing the computer's memory contents, the control circuitry changed the exposure conditions and reset the computer for the next exposure period. The print-out interval was approximately 2 minutes.

All equipment was permitted to warm up and stabilize for 3 hours before each experimental run. The accuracy of the data collection system was checked before and after each run by the power company's 60-Hz powerline frequency. The data from one R-wave synchronized run was discarded because the equipment did not conform to calibration standards after the run.

Alternating periods of exposure and sham exposure were repeated until the heartbeat ceased. Data collected during the last recorded period was rejectd if tne heartbeat ceased during that time. If it stopped during the print-out interval, the data from the last completed period was retained. After each experimental run, the strip chart records were labeled with a code number and delivered to another experimenter for blind analysis.

The evaluation consisted of dividing each 10-minute exposure or sham exposure condition into ten 1-minute periods. The count in the computer memory at the start of a condition and at the end of each of the ten 1-minute periods was obtained. These eleven data points are referred to as period data. In addition to recording period data, the number of discontinuities greater than 0.02 seconds during each 1-minute interval was also recorded as an indicator of arrhythmia.

RESULTS

The mean times between heartbeats for each minute of the 10-minute periods, as well as linear regression lines, are plotted in Figure 1. The data designated as CONTROL (non-exposure Eccosorb and dummy load conditions) were combined because there were no significant differences in the non-exposure data. The average heart rate increased at a rate of 0.4% per minute for the R-ON condition. It decreased at a rate of 0.6% per minute for R-OFF, 0.4% per minute for T-ON, 0.7% per minute for T-OFF, and 0.4% per minute for CONTROL. The use of t tests on the percentage change in heart rate indicate significant differences between R-ON and R-OFF ($P < .005$), between R-ON and CONTROL ($P < .005$), and between T-ON and T-OFF ($P < .05$). The difference between T-ON and CONTROL was not significant, and there were no significant differences in arrhythmia.

The slopes of the regression lines and the correlation coefficients are shown in Table 1.

DISCUSSION

The data indicate that the heart function of an *in vivo* preparation can be influenced by exposure to low-intensity

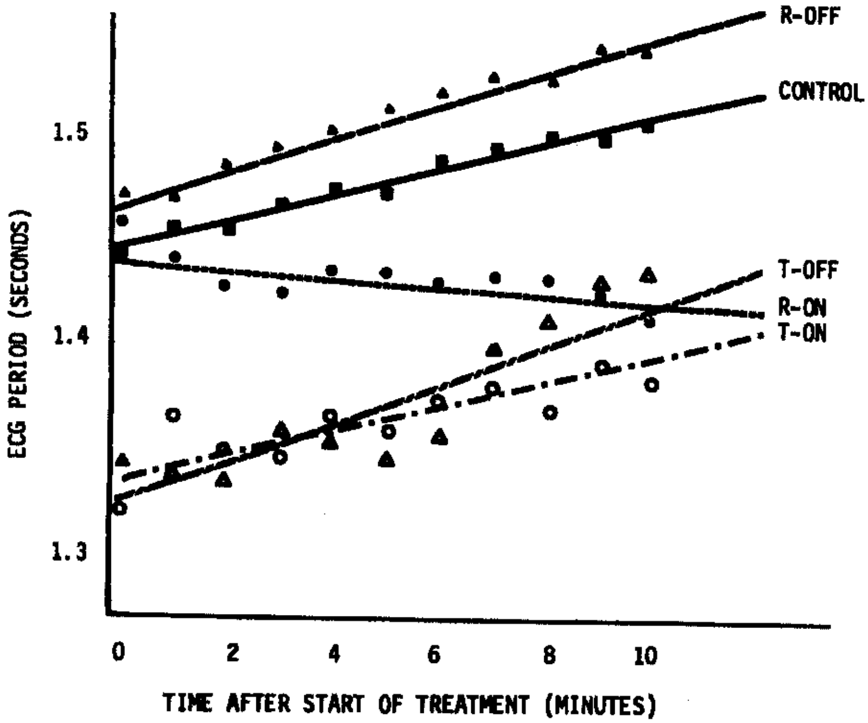

FIGURE 1

The effect of different conditions of electromagnetic energy exposure, as a function of exposure time, is illustrated by a plot of minute-to-minute means and linear regression lines. The data are scaled as obtained, in terms of the time between beats. Thus, slowing of the heart is shown by a rise in the curve. Data obtained when the energy impinged at the R- or T-wave are designated R-ON and T-ON, respectively. Data obtained from preparations that had no exposure to the energy are designated CONTROL, R-OFF, and T-OFF.

TABLE 1

Regression Line Slopes and Correlation Coefficients for Each Condition

CONDITION	SLOPE	r
R-on	-0.33	-.71
R-off	1.08	.98
T-on	0.67	.84
T-off	1.43	.91
Control	0.88	.98

pulsed EM radiation. The rate of change in beat was affected, but the preparation appears to be more resistant to arrhythmia than an isolated preparation. It also appears that the exposure must be for more than one minute for a significant effect to appear.

This finding can be related to the work of Lords et al. (6), who exposed isolated turtle hearts to microwave-frequency fields between capacitor plates. They found they could induce a bradycardia at an absorbed power of 3.3 mW. They suggested that the effect might be due to stimulation of the parasympathetic and sympathetic nerve remnants. In a follow-up experiment, Tinney et al. (7) found that over a narrow power range of approximately 2-10 mW/g absorbed dose, there was apparent stimulation of sympathetic and parasympathetic nerve remnants which could, respectively, increase or decrease the heart rate.

Tigranian (2) also studied the effect of exposure of the frog heart to EM energy. He found that modulated energy exposure occurring at the time of the P, R and T waves disturbed the heart rate. With the modulated energy, he found that sino-atrial block developed. With unmodulated fields, he reported the effect was smaller for the same incident average power and was qualitatively different in nature. Chalker et al. (3), using isolated frog hearts and a helium neon laser sensor, found that the beat rate of the heart changed with exposure to the energy. They report that the onset of the change was fast compared to the thermal time constant.

Schwartz et al. (4) assessed calcium efflux in the heart exposed to EM energy. They found an effect occured only at a modulation of 16 Hz, not with continuous energy or the other modulation frequencies that they used. When Schwartz and Mealing (5) used a different carrier frequency and only atrial strips of the frog heart, they found there was no calcium efflux change. This suggests either that the atrial strips are not sensitive to the energy, or that the carrier frequency is of importance. In sum, a variety of experiments have shown an influence of EM energy on the heart.

Several authors have reported what they thought to be contradictory results, but there were defects in their experiments. Jauchem et al. (8) used a frequency of 5.6 GHz to expose intact rats. They reported they did not find a change in heart rate at their lower power density. However, one would not expect to find an effect on the heart with 5.6 GHz frequency energy. It does not penetrate the skin and thus does not reach the heart. Chou et al. (9) also report no effect on the heart of exposure to EM energy. However, they used as subjects only 3 rabbits with a carrier frequency at 2450 MHz. Aside from the fact that the carrier frequency has peculiar penetration characteristics that might have resulted in little energy reaching the heart, it would be impossible to show a statistically significant effect using only 3 rabbits. In addition, rabbits have a very labile heart rate. Even if they had used reasonable size groups, it would have been unlikely that an effect would appear, since the variance in the data would be quite high. Thus, their experimental design closed out the possibility of finding an effect before they even started. Two other papers from that laboratory, Yee et al. (10,11) were also defective and provide no usable data. Clapman and Cain report finding no effect (12). They used two frequencies of microwave energy and exposed the isolated frog heart at the P-wave, 100 msec after the P-wave, and 200 msec after the P-wave. But the exposures to EM energy were only one minute in length and the data we report here shows that that is too short an exposure to see an effect.

Thus, the data as a whole clearly indicates that the heart responds to EM energy, particularly if it is pulsed and the pulses impinge at the right time in the cardiac cycle. The data available on the heart are not sufficient to draw conclusions about mediators. But a neuro-humoral mechanism may be involved. The neural system is responsive to the energy, as Frey and others have shown (13).

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The incidence of electromagnetic pollution on the amphibian decline: Is this an important piece of the puzzle?

ALFONSO BALMORI

Direccion General del Medio Natural, Consejeria de Medio Ambiente, Junta de Castilla y Leon, C/Rigoberto Cortejoso, 14, 47014 Valladolid, Spain

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Abstract
A bibliographical review on the possible effects of radiofrequency radiation (RFR) from wireless telecommunications on living organisms and its impact on amphibians is presented. The technical characteristics of this new technology and the scientific discoveries that are of interest in the study of their effects on wild fauna and amphibians are described. Electromagnetic pollution (in the microwave and in the radiofrequency range) is a possible cause for deformations and decline of some amphibian populations. Keeping in mind that amphibians are reliable bio-indicators, it is of great importance to carry out studies on the effects of this new type of contamination. Finally, some methodologies that could be useful to determine the adverse health effects are proposed.

Keywords: *Athermal effects, electromagnetic pollution, effects on amphibians, microwaves, phone masts*

Introduction

Amphibians are important components of the ecosystem and reliable bio-indicators; their moist skin, free of flakes, hair or feathers, is highly permeable to water chemicals (particularly larvae) and air pollutants (especially adults). Amphibian eggs are also directly exposed to chemicals and radiation. These characteristics make amphibians especially sensitive to environmental conditions, changes of temperature, precipitation or ultraviolet (UV) radiation and reliable monitors of local conditions [1].

A recent report from the International Union for Conservation of Nature (IUCN), prepared by 500 scientists from 60 countries, analyzed populations of 5743 amphibian

Correspondence: Alfonso Balmori, Direccion General del Medio Natural, Consejeria de Medio Ambiente, Junta de Castilla y Leon, C/Rigoberto Cortejoso, 14, 47014 Valladolid, Spain. Tel.: 983/419439. Fax: 983/419933. E-mail: balmaral@jcyl.es; abalmori@ono.com

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species in the world and concluded that 1856 (32%) of them were considered threatened of extinction. Nine species have become extinct since 1980 and another 113 have not been observed in the recent years, and probably are also extinct [2]. The results demonstrate that amphibians are far more threatened than either birds or mammals, and the factors causing 'enigmatic' declines are driving the species toward extinction particularly rapidly. Unless these declines are quickly understood and reversed, hundreds of amphibian species can be expected to become extinct over the next few decades [3]. The disappearance of amphibians together with other organisms is a part of the global biodiversity crisis [4,5].

An associated phenomenon is the appearance of large numbers of deformed amphibians, with absent or extra limbs [5]. From 1995, at least 60 different species were affected with a high incidence of deformities, with several species affected in one place, in 46 states of United States and in regions of Japan, Canada, and several European countries [5,6]. The problem seems to have become more prevalent, with deformity rates of up to 25% in some populations, which is significantly higher than in previous decades [6].

The problem of deformities is complex because it is related to water quality, physiology, development, anatomy, and ecology [5]. The reduction in populations and the increase in deformities are a warning of serious environmental degradation [5].

Evidence exists that several populational declines are probably the result of complex interactions among several biotic and abiotic factors [1,4,7,8]. The proposed explanations are an increase of ultraviolet radiation (UV-B)[1,5,9–14]; chemical pollutants (pesticides, herbicides, fungicides, fertilizers, etc.) [5,15]; pathogen and parasites [1,6,16], destruction and alteration of habitat, changes in meteorological patterns (climatic change) [4,17], and introduced species [1,5].

The amphibian population declines are also occurring in relatively pristine places such as National Parks, or rural areas far from urban centers [3,14]. Humans and other animals can also be affected by the same environmental factors that damage amphibians [6].

A type of contamination whose effects on amphibians have not been studied up to now, is the electromagnetic pollution, especially microwaves and radiofrequencies from mobile telecommunications and radio station transmitters that will be discussed in this review. Before the 1990s, radiofrequencies were mainly from a few radio and television transmitters, located in remote areas and/or very high places. Since the introduction of wireless telecommunication in the 1990s, the rollout of phone networks has seen a massive increase in the electromagnetic contamination in cities and in the wilderness [18,19]. At the moment, new types of antennas are being investigated to reduce the power needed to establish communication [20,21]. Recently, there has also been an increase of other wireless transmitters (radio or television stations).

The objective of this review is to detail advances in the knowledge of biological mechanisms and effects from radiofrequencies and microwaves on animals, and some considerations are made on its possible relationship with deformations and the population decline of amphibians.

Main causes of populational decline and appearance of deformations in amphibian populations

Ultraviolet radiation

UV-B radiation (1) induces mutations and cellular death, (2) weakens the immune system, (3) reduces growth, and (4) induces several types of damage, like malformations of the limbs, body, and eyes [1,5,12,14]. Not all the species respond in the same way [14]. Embryos with higher photolyase levels (DNA photorepair enzyme) are more resistant to UV-B radiation [11,12].

The eggs of some of the amphibian species experienced high mortality that may contribute to the populational declines [9]. UV acts in conjunction with other agents like pesticides to induce defects in the development [10]. UV also decreases defense mechanisms against illnesses making individuals more susceptible to pathogen and parasites, affecting normal development and increasing mortality that consequently impacts on the decline of some populations [10]. The egg mass protected from UV-B radiation have significantly more hatching, less deformities, and develop more quickly [10].

Synergy between a pathogenic fungus and UV-B radiation increased mortality among amphibian embryos [12]. The synergy may occur when developing amphibians have reduced ability to respond to a stressor in the presence of another stressor. For example, contamination exerts more deleterious effects with UV-B [1]. Animals use molecular and physiologic mechanisms and certain behaviors [22] to limit their exposure to UV-B and repair from UV-B damage [14].

Although cellular repair mechanisms of several species are not effective in the presence of persistent increase in UV-B radiation levels [14], amphibians are relatively resistant to this radiation if they can repair the damage effectively [14]. In some species, photoreactivation is the most important repair mechanism of UV-damaged DNA [9]. Heat shock proteins may also play a role in protecting cells from UV-B damage, since they prevent the denaturation of proteins during exposure to environmental stress [14].

Chemical pollutants

Chemical pollutants appear in areas where pesticides and fertilizers are applied extensively and produce mortality and deformities in amphibians. Although on a broad scale, no correlation between pesticide contamination and amphibian deformities was found, pesticides cannot be completely ruled out as causal agents [5].

Pathogens and parasites

Three pathogens received attention recently for having produced an amphibian populational decline in some areas: *Batrachochytrium denderobatidis*, *Saprolegnia ferax*, and an iridovirus (*Ambystoma tigrinum virus*) [1]. The parasite *Ribeiroia ondatrae* is an important source of malformations of amphibian extremities in western USA [16]. Larvae with malformations experience higher mortality before and during metamorphosis than the normal ones. The relevance of infection by *Ribeiroia* and the influence of habitat alteration on the pathology and biological cycle of this trematode, requires further investigation [16]. In relative pristine environments, the incidence of snails infected with *Ribeiroia* is low, but the habitat alteration can increase the rate of infestation [16]. Infection of amphibian larvae by the trematode *R. ondatrae* may represent a threat to amphibians or species in decline. Although deformities can be the cause of declines in some places, numerous populations of amphibians have greatly declined in the absence of any deformity, for which there must be other factors [6].

Climatic change

Climatic change influences breeding patterns of certain organisms which affect their populational structure and may be reflected in the populational declines of very sensitive species such as amphibians. The pattern found up to now in the published studies is that some anurans of temperate areas show an early reproduction tendency [17]. Climate-induced reductions in water depth at egg-laying sites produced high embryo mortality by increasing their exposure to UV-B radiation which is more worrying than the reduction in ozone layer. Climate also increases their vulnerability to *S. ferax* [4].

Physical and technological characteristics of mobile telephone

Electromagnetic radiation (EMR) transmits small packages of energy denominated photons [23]. The radiofrequencies occupy the range from 10 MHz to 300 GHz. Cellsite antennae emit a frequency of 900 or 1800 MHz, pulsed at low frequencies, generally known as microwaves (300 MHz–300 GHz). Microwaves carry sound information by blasts or pulses of short duration, with small modulations of their frequency, that are transferred between wireless phones and base stations over dozens of kilometres.

The main variable that measures these radiations is 'power density' (measured in $W\,m^{-2}$, or $\mu W\,cm^{-2}$) expressing radiant power that impacts perpendicularly to a surface, divided by the surface area; and 'electric field intensity' (measured in $V\,m^{-1}$), a vectorial magnitude to the force exercised on a electric loaded particle, independent of their position in space.

For a concrete address with relationship to an antenna, the power density at a point varies inversely proportional to the square of the distance to the source. Though EMR have many and varied outputs, at a distance of 50 m the power density is about $10\,\mu W\,cm^{-2}$ [24], while at distances of 100 m at ground level it measures above $1\,\mu W\,cm^{-2}$ (pers. obs.). Between 150 and 200 m, the power density of the main lobe near the ground is typically some tenth of $1\,\mu W\,cm^{-2}$ [25].

Experimental difficulties

Experiments that study the effects of EMR on living organisms are complex, since a high number of variables exist that need to be controlled. Microwave radiation produces different effects depending on certain methodological positions such as frequency, power, modulation, pulses, time of exposure, etc. [26–28]. Some studies demonstrated different microwave effects depending on the wavelength in the range of mm, cm or m [28,29]. The dose–response relationships (of non-thermal effects), are not simple to establish since they present a non-linear relationship [30–32].

Pulsed waves (in blasts), as well as certain low frequency modulations exert greater biological activity [26,28,31,33]. These radiations also have accumulative effects that depend on the duration of exposure [19,34,35]. It is possible that each species and each individual, show different susceptibility to radiations, since the vulnerability depends on the genetic tendency, and the physiologic and the neurological state of the irradiated organism [31,36–41].

Effects and action mechanisms on biological systems

One of the well known effects of microwaves is their capacity to excite water molecules and other components in food, elevating their temperature. The resulting heating level depends on the radiation intensity and the exposure time. At a power density above $500\,\mu W\,cm^{-2}$

(microwave ovens) heating effects take place, below that level the effects are 'athermal non-heating'.

Animals are sensitive complex electrochemical systems that communicate with their environment through electrical impulses. In cellular membranes and body fluids, ionic currents and electrical potential exist [42]. Electromagnetic fields (EMFs) generated in biological structures, are characterized by certain specific frequencies. It is possible a frequency-specific, non-thermal electromagnetic influence, of an informational nature exists [25,31,43]. Some organs or systems like the brain, heart, and nervous system are especially vulnerable.

The wave systems have properties such as the frequency, which affect resonance capacity of living organisms to absorb the energy of an electromagnetic field [25]. Electromagnetic fields induce biological effects at "windows of frequency" (window effect) [44]. Living organisms are exposed to variable levels of radiofrequency electromagnetic fields, according to (1) distance to phone masts, (2) presence of metallic structures which are able to reflect or obstruct the waves (buildings or other obstacles), (3) number of phone masts, and (4) orientation and position [24].

Microwaves emitted by phone antennae affect organisms living in their vicinities, like vertebrate [45–47], insects [48–55], vegetables [56–58], and humans [25,31,59–63]. Small organisms are especially vulnerable: size approach to resonance frequency and thinner skull, facilitates an elevated penetration of radiation into the brain [24,31,64]. In a recent study carried out with bees in Germany, only few irradiated bees returned to the beehive and required more time to reach the hive. The weight of honeycombs is also smaller in the bees that were irradiated [54].

The microwave effects were investigated in a variety of living organisms, but the results found in vertebrates have special interest to amphibians. For more than 30 years, there is growing evidence on the existence of athermal effects on birds [65,66]. The exposed animals suffer a deterioration of health in the vicinity of phone masts [67,68]. Rats spent more time in the halves of shuttle boxes that were shielded from illumination by 1.2 GHz microwaves. The average power density was about $0.6\,mW\,cm^{-2}$. Data revealed that rats avoided the pulsed energy, but not the continuous energy, and less than $0.4\,mW\,cm^{-2}$ average power density was needed to produce aversion [69]. Navakatikian and Tomashevskaya [70] described a complex series of experiments in which they observed disruption of a rat behavior (active avoidance) by radiofrequency radiation (RFR). Behavioral disruption was observed at $0.1\,mW\,cm^{-2}$ ($0.027\,W\,kg^{-1}$) power density.

It has been documented that the radiofrequencies induce biological effects on biomolecules [27,51,71] that include changes in intracellular ionic concentration [72,73], cellular proliferation [74], interferences with immune system [19,75,76], effects on animals reproductive capacity [77,78], effects on stress hormones [79], in intrauterine development [80], genotoxic effects [81–87], effects on the nervous system [32,88–92], the circulatory system [93,94], and a decline in the number of births [47,95]. Firstenberg [18] proposed a connection between EMR, deformations, and the worldwide decline and extinction of amphibians.

Evidence that electromagnetic contamination may be responsible for the appearance of deformities and decline of amphibians

Some athermal effects of EMR on amphibians have been well known for more than 35 years [96,97]. The radiation of frogs with $30–60\,\mu W\,cm^{-2}$ produced a change in the heart rhythm, probably due to the nervous system activation (Levitina, 1966 cited in [96]). When toad hearts were irradiated with pulses of 1425 MHz at a power density of $0.6\,\mu W\,cm^{-2}$, an increase in the heart rate and arrhythmia were observed [96]. Radiofrequency burst-type dilated arterioles were observed on the web of the anaesthetized frog (*Xenopus laevis*) by a athermal non-heating mechanism [93].

The exposure to magnetic fields on two species of amphibians induced deformities [48].

Frog tadpoles (*Rana temporaria*) developed under electromagnetic field (50 Hz, $260\,A\,m^{-1}$) have increased mortality. Experimental tadpoles developed more slowly and less synchronously than control tadpoles, remain at the early stages for a longer time. Tadpoles developed allergies and EMF causes changes in the blood counts [98].

Amphibians can be specially sensitive: thresholds of an overt avoidance response to weak electrical field stimuli down to $0.01\,V\,m^{-1}$ were found in *Proteus anguinus* and $0.2\,V\,m^{-1}$ in *Euproctus asper* at 20–30 Hz, but sensitivity covered a total frequency range of below 0.1 Hz to 1–2 kHz [99].

Deformities in nature

Ultraviolet radiation, UV-B. UV-B radiations produce deformities in amphibian embryos that go from lateral flexure of the tail to abnormal skin, eye damage, and lower survival rate [6,10]. However, numerous experiments carried out did not provide evidence that this exposure induces all types of deformities observed in nature, nor the appearance of extra limbs, one of the most frequent deformities noted [5,6]. On the other hand, most of the deformations for UV-B radiation occur in the legs or in reduction of the number of bilateral fingers. However, in the wild, amphibians exhibit a wide diversity of aberrations that are limited to only one side of the body, including problems in the skin, loss of legs, and twisted internal organs, reasons for which it was considered that this radiation is not the only source [5]. Similar abnormalities found in the wild and not induced by UV-B radiation have been obtained in laboratory studies, by exposing amphibian larvae to magnetic fields [48]. A similarity exists in the deformations of amphibians observed by Levengood [48] and Blaustein and Johnson [5]. Several studies addressed behavior and teratology in young birds exposed to electromagnetic fields [39,41]. Typical abnormalities include malformation of the neural tube and abnormal twisting of the chicken embryo. The electric currents are believed to have a significant role in the control of development and it is also possible that external EMR could influence these control systems [100]. The appearance of morphological abnormalities influenced by pulsed electromagnetic fields during embryogenesis in chickens [33,101] are similar to those produced by ultraviolet radiation [36]. The pulses are in fact a characteristic of mobile telephone radiations that have increased from 1995, when a marked rise in deformations started. Several experimental studies point out that the exposure to UV-B produced deferred effects (early exposure causes delayed effects in later stages) [1]. The exposure to electromagnetic fields also induces delayed effects and the tadpoles are the same as the control until the beginning of metamorphosis. The extra limbs and blistering were induced during the gastrula stage of the development which appeared to be the most sensitive stage [48]. The early *Rana pipiens* embryonic development was also inhibited by magnetic fields [97]. In rats, brief intermittent exposure to low-frequency EMFs during the critical prenatal period for neurobehavioral sex differentiation can demasculinize male scent marking behavior and increase accessory sex organ weights in adulthood [102]. Biological effects resulting from EMR field exposures might depend on the dose (e.g. duration of exposure). Short-term exposures up-regulate cell repair mechanisms, whereas long-term exposures appear to down-regulate protective responses to UV radiation [103].

Parasites. The parasite *R. ondatrae* is an important and extensive cause of malformations in amphibian extremities in western USA [16]. Tadpoles with malformations experience higher mortality than the normal ones before and during metamorphosis. The *Ribeiroia* infection represents a threat for amphibian populations that are in decline. However, with a growing volume of data based on the experimental evidence, the infection from parasites does not seem to be the cause of all the malformations on limbs, since in some places with the presence of deformations, the parasite *R. ondatrae* was absent [5]. Further certain deformities like the absence of eyes, limbs, and twisted internal organs was not induced by the parasite [5].

In a laboratory study, eggs and embryos of *Rana sylvatica* and *Ambystoma maculatum* were exposed to magnetic fields at several development stages. A brief treatment of the early embryo produced several types of abnormalities: microcephalia, scoliosis, edema, and retarded growth [48]. Several of the treated tadpoles developed severe leg malformations and extra legs, as well as a pronounced alteration of histogenesis which took the form of subepidermal blistering and edema [48]. In chick embryos exposed to pulsed EMR a potent teratogenic effect was observed: microphthalmia, abnormal trunkal torsion, and malformations on the neural tube [33,36,101,104]. One of the possible reasons for these deformities appearing more often [5], may be due to wireless telecommunications and exponential increase of electromagnetic contamination.

Bioelectric fields have long been suspected to play a causal role in embryonic development. The electrical field may directly affect the differentiation of some tail structures, in particular those derived from the tail bud. Alteration of the electrical field may disrupt the chemical gradient and signals received by embryo cells. It appears that in some manner, cells sense their position in an electrical field and respond appropriately. The disruption of this field alters their response. Endogenous current patterns are often correlated with a specific morphogenetic events such a limb bud formation. The most common defect in chick embryos experimental group was in tail development. Internally, tail structures (neural tube, notochord, and somites) were frequently absent or malformed. Defects in limb bud and head development were also found in experimentally treated chick embryos, but less often than the tail defects [105]. Amphibians can be especially sensitive because their skin is always moist, and they live close to, or in water, which conducts electricity easily.

Populations' decline

Deformities found in nature can directly affect embryonic mortality and survival after hatching [10]. It seems interactions that exist among UV-B radiation and additional factors contribute to embryo mortality [9]. Water pollution and excessive ultraviolet radiation act jointly, producing specific problems and alter the immune system, making amphibians more vulnerable to parasitic invasions and pathogen infections [6,8,12,14]. It is proposed that there exists a possible relationship between the decline of amphibians and exponential increase of electromagnetic pollution. Several experiments with bird eggs showed a high mortality of embryos exposed to EMR from mobile phones [36,106,107]. EMFs increases mortality of tadpoles [98]. The EMR alters the immune, nervous, and endocrine systems, and operates independent or together with other factors like UV-B radiation or chemical pollutants. Death of embryos in nature is not due to UV radiation as the capacity of DNA repair mechanisms like photolyase (photoreactivating enzyme) is effective [9]. EMR produces stress on the immune system [76,98] that obstructs DNA repair [42,108,109]. Heat shock proteins may play a role in protecting amphibians from UV-B damage [14] and animals exposed to EMR [27,51,71,110,111]. Different susceptibility to UV among species and even among populations exists [112], as seen with EMR [31,40].

Hallberg and Johansson [108,109] proposed that radiofrequencies increase the effects of UV radiation. A study on the causes of melanoma in humans conclude that the incidence increases and the mortality associated with this skin tumor cannot only be explained by the elevation in UV sun radiation, but rather by the continuous alterations on mechanisms of cellular repair, produced by EMR (radiofrequencies) resonant with the body, that amplify the carcinogenic effects of the cellular damage induced by the UV-B radiation. The cases of melanoma experienced a significant increase from the 1960–70s [108] that continues today, and also asthma and several types of cancer associated with deterioration of immune system. Data suggest there is an increase of electromagnetic pollution [108,113]. The public health situation in Sweden has become worse since the autumn of 1997. There is a correlation between the massive roll-out of GSM mobile phone antennae and adverse health effects [109].

Enigmatic decline of amphibian species are positively associated with streams at high elevations in the tropics and negatively associated with still water and low elevations [3]. In high places, the electromagnetic contamination is usually higher [47]. Microwave measurements of power density as low as $0.0006\,\mu W\,cm^{-2}$ show strong correlation with symptoms like depressive tendency, fatigue, and insomnia in humans [63].

Proposed research

To demonstrate the conclusive effect of microwave radiation on amphibians it is necessary to approach research with a control (non-exposed) and an experimental group. This methodological position is complicated at present due to the ubiquity of these radiations [98]. Studies that try to correlate populational evolution, appearance of deformities, or the presence or absence of amphibians with measurements of electromagnetic fields from radiofrequencies will be of great interest. Field investigations of urban park populations and phone masts surrounding territories need to be high-priority. A radius of $1\,km^2$ laid out in concentric circumferences at intermediate distances may be useful to investigate the differential results among areas, depending on their vicinity and corresponding levels of EMR. Laboratory studies on amphibians exposed to pulsated and modulated microwaves would also be of great interest.

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A Possible Effect of Electromagnetic Radiation from Mobile Phone Base Stations on the Number of Breeding House Sparrows (Passer domesticus)

JORIS EVERAERT AND DIRK BAUWENS

Research Institute for Nature and Forest, Brussels, Belgium

A possible effect of long-term exposure to low-intensity electromagnetic radiation from mobile phone (GSM) base stations on the number of House Sparrows during the breeding season was studied in six residential districts in Belgium. We sampled 150 point locations within the 6 areas to examine small-scale geographic variation in the number of House Sparrow males and the strength of electromagnetic radiation from base stations. Spatial variation in the number of House Sparrow males was negatively and highly significantly related to the strength of electric fields from both the 900 and 1800MHz downlink frequency bands and from the sum of these bands (Chi^2-tests and AIC-criteria, $P < 0.001$). This negative relationship was highly similar within each of the six study areas, despite differences among areas in both the number of birds and radiation levels. Thus, 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 behavior of House Sparrows in the wild.

Keywords Antenna; Bird; Electromagnetic radiation; GSM base station; Non thermal effect.

Address correspondence to Joris Everaert, Research Institute for Nature and Forest, Kliniekstraat 25, B-1070 Brussels, Belgium; E-mail: joris.everaert@inbo.be

Introduction

Mobile phones, also called cellular phones or handies, are now an integral part of modern life. The widespread use of mobile phones has been accompanied by the installation of an increasing number of base station antennas on masts and buildings. GSM base stations emit electromagnetic fields at high frequencies in the 900 and 1800 MHz range (= downlink frequency bands), pulse modulated in low frequencies (Hyland, 2000). In recent years, increased public awareness and scientific research have questioned to what extent the non thermal exposure to low-intensity electromagnetic fields may affect the health, reproduction, well-being and behaviour of humans and other organisms. There is an active and, as yet, unsettled controversy about current safety standards. Some researchers and national committees advised more stringent safety standards, based on experimental data with reported biological effects from (chronic) non thermal exposures (Hyland, 2000; Belyaev, 2005a, b).

There are studies showing frequency-specific biological effects, and studies demonstrating that a high frequency signal modulated at certain low frequencies, or a signal that is pulsed, has more harmful effects than an unmodulated, steady carrier. These so-called 'window effects' greatly complicate any attempt to understand the relationship between electromagnetic radiation and health (Adey, 1981; Hyland, 2000; Lai, 2005; Belyaev, 2005a).

Public and scientific concern were also raised by results of some epidemiologic studies that examined the effects of long-term exposure on humans living near mobile phone base stations. A growing number of studies point to the existence of effects, ranging from changes in cognitive performance and sleep disturbances to serious illness and disablement, with even higher cancer rates (Santini et al., 2002; Navarro et al., 2003; Bortkiewicz et al., 2004; Eger et al., 2004; Wolf and Wolf, 2004; Hutter et al., 2006; Abdel-Rassoul et al., 2006).

Short-term laboratory experiments used mice, rats, chickens and other birds as study models to better understand the possible implications of electromagnetic fields on organismal functioning. In many studies however, 'mobile communication-like' signals were investigated that in fact were different from the real exposures in such aspects as intensity, carrier frequency, modulation, polarisation, duration and intermittence (Belyaev, 2005a, b; Lai, 2005).

Studies of the effects of exposure to electromagnetic fields on populations of wild birds can provide further insights into the potential impacts on animal and human health (Fernie and Reynolds, 2005). Birds are candidates for being good 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, they are very mobile and possible psychosomatic effects are absent (Bigu-del-Blanco and Romero-Sierra, 1975; Balmori, 2005). Field studies of wild populations can also reveal possible effects of long-term exposure to radiation from GSM base stations. In addition, species like the House Sparrow (*Passer domesticus*) are especially of interest because a large proportion of the birds use higher breeding height locations like roof spaces (Wotton et al., 2002) where potentially higher levels of base station radiation are present.

Here we report results of a preliminary study that explored putative effects of electromagnetic radiation emitted by mobile phone base stations on the number of House Sparrows during the breeding season. Specifically, we examined small-scale geographic variation within each of six study areas in both the number of birds and the strength of electromagnetic radiation. If electromagnetic fields from GSM base stations have adverse effects on bird populations, this should result in a decreasing number of House Sparrows with increasing levels of radiation.

Materials and Methods

Data collection

We determined, during the spring of 2006, the number of House Sparrow males and the strength of electromagnetic radiation from mobile phone (GSM) base stations at 150 locations that were distributed over six residential areas in the region of Gent – Sint-Niklaas (province of East Flanders, Belgium). The study areas were similar in overall appearance, with abundant hedges, bushes and other vegetation between the houses, and with one or more GSM base stations nearby.

The 150 study locations were selected in advance as points on a map (ArcGIS). All locations were situated along small roads within the residential areas and were at variable distances from the nearest GSM base station (mean = 352 m, range = 91 - 903 m, about 90% at 100 - 600 m). The number of locations, and study dates, within each area were: Lokeren - Eksaarde (N = 19; April 9), Lokeren - Spoele (N = 27, April 15), Lokeren - Bergendries (N = 17, April 17), Sint Niklaas - Clementwijk (N = 25, April 20), Gent- Wondelgem (N = 38, April 25) and Gent - Mariakerke (N = 24, April 26).

At each location, a point count of five minutes (see 'point transect count' in Bibby et al., 2000; Hustings et al., 1985) was made of the number House Sparrow males that were singing or otherwise visible within a distance of ca. 30 m. Sightings of birds were done with binoculars (Swarovski EL 10x42). Counts were restricted to the morning hours (7-11h), when male House Sparrows are most active (Hustings et al., 1985; Van Dijk, 2004), on days with favourable weather conditions (no rain, little wind, sunny, normal temperatures).

Simultaneously, we measured the maximum value (peak hold) of the electric field strength (in V/m) from the downlink frequencies of GSM 900 MHz (925-960 MHz) and GSM 1800 MHz (1805-1880 MHz) base station antennas. Measurements at each location were made during two minutes for each frequency band. The electric field strength was measured using a portable calibrated high-frequency spectrum analyser (Aaronia Spectran HF-6080; typ. accuracy ± 3 dB) with calibrated EMC directional antenna (HyperLOG 6080; logarithmic-periodic). To measure the maximum radiation values, the EMC antenna was turned around in all directions.

Additional antennas for the new UMTS-system are now being installed on several existing base stations in Belgium. Therefore, at several locations within each study area, the electric field strength from the downlink frequencies of UMTS antennas (2110-2170 MHz) was also checked, but no significant signals were found. Consequently, the UMTS variable was not taken into account for further analysis.

Data analyses

The sum (Egsm) of the measured GSM 900 MHz (Egsm900) and 1800 MHz (Egsm1800) electric field strength values was calculated using the formula: $Egsm = \sqrt{Egsm900^2 + Egsm1800^2}$ (Electronic Communications Committee, 2003). Prior to all analyses, the electric field strength variables were logarithmically transformed to achieve normality of their frequency distributions.

We explored relations between the number of House Sparrow males (dependent variable) and each of the three electric field strength variables. As the dependent variable consists of count data and is hence discontinuous, standard regression (or correlation) techniques are inappropriate. Instead, we used Poisson regressions (i.e., generalized linear models) with a log link function to examine putative relationships. Preliminary analyses indicated that significant variation among the six study areas was present for all variables (ANOVA, $P < 0.001$). Therefore we included "area" as a categorical factor in all models and considered it to be a proxy for all unknown, and hence unmeasured variables causing among area variation in the number of House Sparrows (e.g., habitat characteristics, food availability, temporal differences among censuses). Statistical analyses were done with S-PLUS v. 6.2.

Results

The number of House Sparrow males varied between zero and four at the different locations. The measured electric field strengths were seldom higher than 1 V/m, and most often well below that value (Table 1).

To explore the putative effects of area, electric field strength and their interaction on the number of House Sparrows, we performed separate analyses for each of the three radiation variables. As no significant interaction effect between area and electric field strength was detected in any of the three analyses (Chi^2-tests and AIC-criteria, $P > 0.20$), we excluded the interaction term from further treatments. The final regression models were highly similar for the three electric strength variables. They revealed significant variation among study areas (Chi^2-tests, $P < 0.001$), and a highly significant negative effect of electric field strength on the number of House Sparrow males (Chi^2-tests and AIC-criteria, $P < 0.001$; Figure 1). Estimates of the scaled deviance (1.06 – 1.14) were very close to 1, and examination of the regression residuals revealed no clear patterns or deviations from normality. These observations indicate an adequate fit of the models to the data.

Table 1

Summary statistics (mean, 95% confidence interval, range) of the number of House Sparrow males and electric field strength variables in the six study areas. Means and confidence limits of the radiation variables were calculated after back-transformation of the logarithmically transformed data; the confidence intervals are therefore asymmetrical around the mean

Study area		Number of House Sparrow males	E_{gsm900} (V/m)	$E_{gsm1800}$ (V/m)	E_{gsm} (V/m)
1: Lokeren - Eksaarde	mean	1.5	0.153	0.075	0.193
	95% CI	0.8 – 2.2	0.108 - 0.216	0.046 - 0.123	0.139 - 0.270
	Min - Max	0 – 4	0.036 - 0.494	0.015 - 0.333	0.052 - 0.505
2: Lokeren - Spoele	mean	1.9	0.084	0.083	0.130
	95% CI	1.5 – 2.3	0.059 - 0.120	0.058 - 0.120	0.091 - 0.183
	Min - Max	0 – 4	0.008 - 0.327	0.013 - 0.394	0.016 - 0.412
3: Lokeren - Bergendries	mean	0.8	0.245	0.017	0.247
	95% CI	0.3 - 1.3	0.186 - 0.323	0.009 - 0.031	0.187 - 0.327
	Min - Max	0 - 3	0.052 - 0.537	0.004 - 0.125	0.052 - 0.551
4: Sint Niklaas - Clementwijk	mean	1.0	0.130	0.056	0.148
	95% CI	0.6 - 1.4	0.098 - 0.173	0.039 - 0.082	0.111 - 0.197
	Min - Max	0 - 3	0.019 - 0.412	0.009 - 0.231	0.021 - 0.469
5: Gent - Wondelgem	mean	1.3	0.109	0.040	0.121
	95% CI	0.9 - 1.6	0.079 - 0.151	0.030 - 0.054	0.089 - 0.165
	Min - Max	0 - 4	0.016 - 1.006	0.009 - 0.321	0.022 - 1.056
6: Gent - Mariakerke	mean	0.8	0.043	0.080	0.160
	95% CI	0.3 - 1.2	0.024 - 0.078	0.049 - 0.130	0.107 - 0.240
	Min - Max	0 - 4	0.006 - 1.022	0.017 - 0.824	0.040 - 1.023

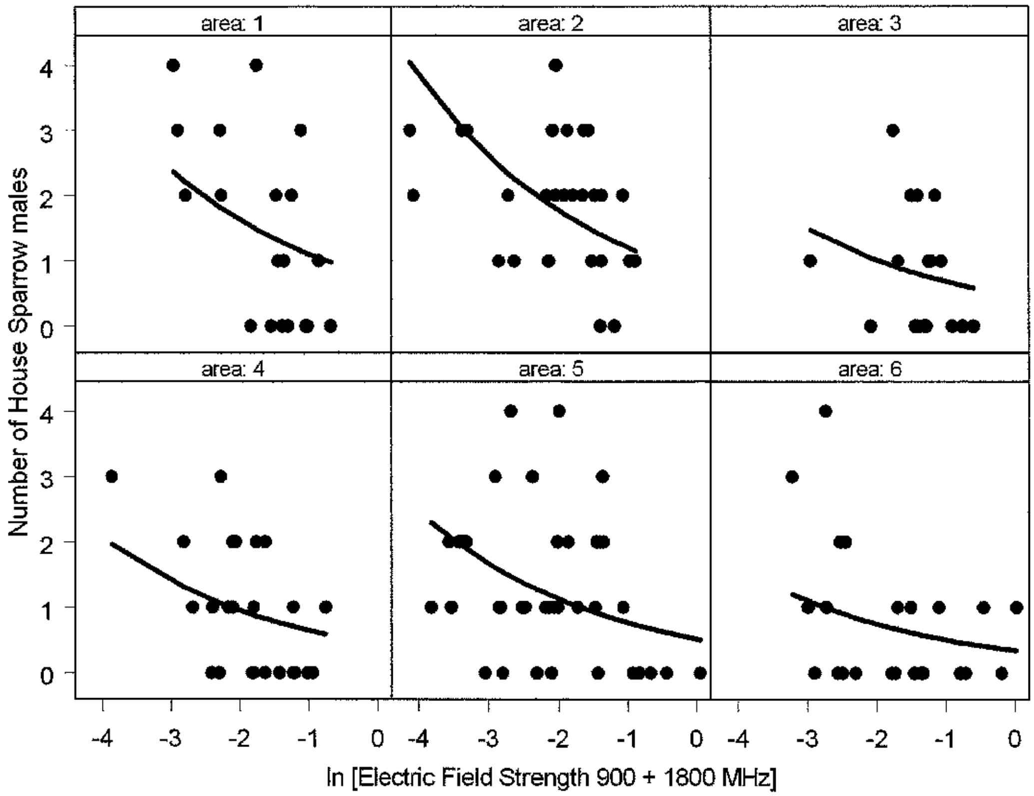

Figure 1. Scatterplots of the observed number of House Sparrow males as a function of the sum (Egsm) of GSM 900 MHz and GSM 1800 MHz electric field strength values (logarithmic scale) at the different locations within each of the six study areas. Regression lines were obtained by Poisson regressions and incorporated the effects of area and radiation intensity (see text).

We further explored the separate effects of electromagnetic radiation at the two frequencies by modelling the number of House Sparrow males as a function of area, electric field strength at 900 MHz, electric field strength at 1800 MHz, and their interactions. The final model retained included highly significant effects of area and the two electric field strengths (Chi^2-tests and AIC-criteria, $P < 0.001$) and a marginally significant interaction effect between both field strengths (Chi^2-test, $P = 0.02$). This strongly suggests that the electromagnetic radiations at both frequencies have complex additive effects on the number of House Sparrow males.

Overall, analyses indicated that the strength of all three radiation variables decreased with increasing distance to the nearest base station (F-tests, $P < 0.001$). We therefore examined whether the negative relation between the number of birds and strength of radiation was induced by variation among sampling locations in the distance to GSM base stations. Upon adding distance to the nearest base station as an additional factor to the regression models that included area and electric field strength, distance did not account for a significant portion of the residual variation (Chi^2-tests and AIC-criteria, $P > 0.50$). Conversely, when we forced distance as the first factor into the regression equations, both area and radiation strength were subsequently selected as highly significant factors (Chi^2-tests and AIC-criteria, $P < 0.001$).

Discussion

Our results indicate that spatial variation among sampling locations in the number of House Sparrow males was negatively related to the strength of electric fields emitted by GSM base stations. Importantly, this relation was highly similar among the six study areas, as evidenced by the non-significant interaction effects between area and electric field strength, despite differences among areas in both the number of birds and radiation levels. Moreover, the negative association was detected for electric field strengths from both the 900 and 1800 MHz frequency bands and from the sum of these frequency bands. Our analyses also revealed that the negative relation between the number of birds and strength of radiation was not a simple consequence of differences among sampling locations in distances to the nearest GSM base station. This can probably be attributed to variations in the orientation, position and number of antennas and to the shielding effects and multiple reflections from structures like buildings and trees, which affect local levels of exposure to electromagnetic radiation. Thus, 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.

Nevertheless, our study should be considered as preliminary for several reasons. First, sampling locations were each visited only once, such that counts of the number of House Sparrow males and measurements of electric field strength are subject to some variation and estimation error. However, it is most likely that these errors are randomly distributed among locations. We also note that a single visit during the peak of the breeding season (April – May) is considered to be adequate to locate House Sparrow breeding territories (Hustings et al., 1985; Van Dijk, 2004). Second, because of the short study period, we ignore whether differences in bird counts reflect variation in abundance of breeding birds or in short-term behavioural responses like the tendency to sing. However, a decrease in singing intensity will result in a decrease of reproductive success and ultimately a decline of population size. Third, only the radiation from GSM base station antennas was measured. Probably, the distribution of possible other significant electromagnetic signals will be random, but due to the lack of measurements in other frequency bands (except for UMTS), this remains an object of further study. Fourth, as with all descriptive field studies, we cannot provide evidence for a causal relationship between radiation levels and the number of birds. Nevertheless, the fact that we found a highly similar pattern in each of the six study areas strengthens the possibility that the relationship is not a spurious one.

There are several unpublished and anecdotal reports about birds and mobile phone base stations, but we know of only one other published study that examined the effects of electromagnetic radiation from mobile phone base stations on wild bird populations. Balmori (2005) found a significantly lower number of White Stork (*Ciconia ciconia*) fledglings in nests exposed to relatively high electromagnetic radiation (2.36 ± 0.82 V/m) than in nests receiving lower levels of radiation (0.53 ± 0.82 V/m). Together with observations on aberrant behaviours of the adult birds, these results suggest that electromagnetic radiation interferes with reproduction in this wild population.

What could be the underlying mechanisms of the (putative) negative effects of radiation from GSM base stations on wild bird populations? Because all measured electric field strength values were far below what is required to produce heating as low as 0.5 °C (i.e., 10 mW/cm² or ca. 194 V/m; Bernhardt, 1992), the effects should be considered as non thermal at very low intensities.

Non thermal effects of microwaves on birds were reported already 40 years ago (Tanner, 1966; Tanner et al., 1967). Most studies indicate that exposure of birds to electromagnetic fields generally changes, but not always consistently in effect or in direction, their behaviour, reproductive success, growth, development, physiology, endocrinology, and oxidative stress (Wasserman et al., 1984; Grigor'ev et al., 2003; Fernie and Reynolds, 2005). Of special relevance within the context of our research are laboratory studies that demonstrate negative effects of electromagnetic radiation from mobile phones on the development and survival of bird embryo's (Farrel et al., 1997; Youbicier-Simo and Bastide, 1999; Grigoriew, 2003).

Bird feathers are known to act as dielectric receptors of high frequency electromagnetic fields and some experiments indicate that audiofrequency pulse-modulated high frequency fields may induce piezoelectric effects in the feathers (Bigu-del-Blanco and Romero-Sierra, 1975a, b). These results are important in view of the fundamental role that feathers play in the life of birds and in the influence of environmental factors on bird behaviour. Experiments also indicated that microwave radiation can have the same averse effects on birds in flight as those observed in caged birds (Romero-Sierra et al., 1969).

Several bird species also use magnetic navigation (Liboff and Jenrow, 2000; Muheim et al., 2006) and can become disorientated when exposed to weak (< 1/50 of geomagnetic field strength) high frequency magnetic fields (Ritz et al., 2004; Thalau et al., 2005). The available evidence concerning magnetoreception suggests that birds use a radical pair mechanism for a chemical compass, and a mechanism based on magnetite particles (Wiltschko and Wiltschko, 2005; Mouritsen and Ritz, 2005). Magnetite is an excellent absorber of microwave radiation at frequencies between 0.5 and 10.0 GHz through the process of ferromagnetic resonance (Kirschvink, 1996), so that interaction with electromagnetic fields from mobile phone base stations might be possible.

In an experiment with Zebra Finches (*Taenopygia guttata*) that were temporary (10 minutes) stimulated with a pulsed electromagnetic field similar to the signal produced by mobile phones with carrier frequency 900 MHz, significant non thermal changes in the amount of neural activity by more than half of the brain cells were detected (Beason and Semm, 2002). The effect did not appear tot be limited to magnetic sensory cells, but occurred in any part of the brain. The authors postulate that similar neural responses to different frequencies point toward a common mechanism of low frequency modulation, perhaps at the cell membrane. Such a stimulus might mimic a natural mechanism involved in cell communication. Although the peak electric field strength used in that experiment (0.1 mW/cm^2 = approx. 19 V/m; Beason and Semm, 2002) was higher than the values measured in our study, results from other studies indicate that a long-term exposure at low intensities can produce the same effects as a short-term exposure at higher intensity (D'Andrea et al., 1986a, b; Lai, 2005; Belyaev, 2005a). This suggests that the non thermal effects of relatively weak electromagnetic radiation from mobile phone base stations can accumulate over time and have significant implications, as detected by several pilot epidemiological studies on humans (see Introduction).

Radiation from GSM base stations may also affect the local abundance of insects or other invertebrates and thereby indirectly influence the number of House Sparrows. Although adult House Sparrows are mainly seed-eaters, they need insects and other invertebrates to feed their young, such that it is likely that they will prefer areas with high abundance of invertebrates at the beginning of the breeding period. Several researchers have postulated that the lack of invertebrates might be an important factor in the reported decline of House Sparrow populations in urban areas (Wotton et al., 2002; Summers-Smith, 2003). Short-term exposure of pulsed mobile phone radiation with carrier frequency 900 MHz resulted in a 50-60 % decrease of the reproductive capacity of insects (Panagopoulos et al., 2004). Similar results were also found with microwave radiation at other frequencies (Bol'shakov et al., 2001; Atli and Unlu, 2006).

The results of our study suggest that long-term exposure to low-intensity (pulsed) electromagnetic radiation from GSM base stations may have significant effects on populations of wild birds. The exact mechanisms of these effects are as yet poorly understood. Given the potential importance that such effects may have on aspects of biodiversity and human health, more detailed studies in both the laboratory and the field are urgently needed to corroborate our results and to uncover the underpinning mechanistic relationships.

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Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stork (*Ciconia ciconia*)

ALFONSO BALMORI

Consejería de Medio Ambiente, Junta de Castilla y León, Valladolid, Spain

Monitoring of a white stork population in Valladolid (Spain) in the vicinity of Cellular Phone Base Stations was carried out, with the objective of detecting possible effects. The total productivity, in the nests located within 200 meters of antennae, was 0.86 ± 0.16. *For those located further than 300 m, the result was practically doubled, with an average of* 1.6 ± 0.14. *Very significant differences among the total productivity were found* ($U = 240$; $p = 0.001$, *Mann-Whitney test). In partial productivity, an average of* 1.44 ± 0.16 *was obtained for the first group (within 200 m of antennae) and of* 1.65 ± 0.13 *for the second (further than 300 m of antennae), respectively. The difference between both groups of nests in this case were not statistically significant* ($U = 216$; $P = 0.26$, *Mann-Whitney Test U). Twelve nests (40%) located within than 200 m of antennae never had chicks, while only one (3.3%) located further than 300 m had no chicks. The electric field intensity was higher on nests within 200 m* (2.36 ± 0.82 *V/m) than on nests further than 300 m* (0.53 ± 0.82 *V/m). Interesting behavioral observations of the white stork nesting sites located within 100 m of one or several cellsite antennae were carried out. These results are compatible with the possibility that microwaves are interfering with the reproduction of white storks and would corroborate the results of laboratory research by other authors.*

Keywords Cellsites; Cellular phone masts; *Ciconia ciconia*; Electromagnetic fields; Microwaves; Nonthermal effects; Reproduction; White stork.

Introduction

Most of the attention on the possible biological effects of electromagnetic fields (EMF) has been focused on human health. People frequently use wildlife as biological indicators to detect the alterations in the ecosystems and in an urban

Address correspondence to Alfonso Balmori, Consejería de Medio Ambiente, Junta de Castilla y León, C/Rigoberto Cortejoso, 14 47071 Valladolid, Spain; E-mail: balmaral@jcyl.es

habitat. The numeric tendency of the populations of birds is of particular interest in the conservation of nature [1].

The cellsite antennae emit a frequency of 900 or 1800 MHz, pulsed in very low frequencies, generally known as microwaves (300 MHz–300 GHz), similar to the radar spectrum. The cellsite ordinarily have 3 sectors, with 3 antennae that cover an angle of 120 degrees each [2–5]. Though they have many and varied outputs, at a distance of 50 m, the power density is about $10\,\mu W/cm^2$ [2], while at distances of 100 m at ground level it measures above $1\,\mu W/cm^2$ (personal observation). Between 150 and 200 m, the power density of the main lobe near the ground is typically of some tenth of $1\,\mu W/cm^2$ [3].

In real life, living organisms are exposed to variable levels of electromagnetic fields (radiofrequencies), according to the distance from the cellular bases stations, the presence of passive structures to either amplify the waves (e.g., the metallic structures) or to shield them (buildings or other obstacles), the number of transmission calls within the transmitters and their position with relationship to the orientation of the antenna [2].

Animals are very sensitive electrochemical complexes that communicate with their environment through electrical impulses. Ionic currents and electric potential differences exist through the cellular membranes and corporal fluids [6]. The intrinsic electromagnetic fields from the biological structures are characterized by certain specific frequencies that can be interfered with by the electromagnetic radiation, through induction and causing modification in their biological responses [3]. Animals exposed to the EMF can suffer a deterioration of health, changes in behavior [7, 8], and changes in reproductive success [9, 10].

The low intensity pulsed microwave radiation from cellsites produces subtle athermal influences in the living organisms, because this radiation is able to produce biological responses by the microwave carrier and by the low frequency of pulses from GSM system. "Windows" exist in whereby EMFs produce biological effects at specific frequencies (window effect) [11]. Some effects are manifested exclusively with a certain power density [12], while others are manifested after a certain duration of the irradiation, which indicates long-term cumulative effects [13]. During lingering exposure, the effects can change from stimulant to inhibition, depending on the pulse shape [14, 15], the duration, development, and differentiation and the physiologic condition or health of the receiving organism [16], and their genetic predisposition [17]. These waves seem to cause different, and even contrary effects, depending on their frequency, intensity, modulation, pulses or time of exposure [12, 16, 18]. The pulsed waves (in bursts) and certain low frequency modulations, produce great biological activity [14, 15, 18]. The dose-response relationships (athermal) are nonlinear [19].

Research has shown such effects on the living organisms at molecular [12] and cellular levels [20] on immune processes [21], in DNA [22], on the nervous, cardiac, endocrine, immune, and reproductive systems [16, 23–28], modification of sleep and alteration of the cerebral electric response (EEG) [29], increase of the arterial pressure and changes in the heart rhythm [30], and an increase in the permeability of the blood brain barrier [31].

The objective of this study was to investigate if the phone mast cellsites caused effects in wild birds similar to the laboratory studies, and studies carried out on people exposed to this radiation [3, 5, 32–35].

Materials and Methods

For monitoring the breeding success of the white stork population, nests ($n = 60$) were selected and visited from May to June of 2003. The difficulty of the investigation in the field, (and when studying wild species) does not allow one to control all variables as in the laboratory; however, the selected nests had similar characteristics. They were located in the roof of churches and buildings inside urban nuclei in Valladolid (Spain). (The nests on trees and other natural supports or outside the urban nuclei were never studied.) Since the cellsite radiations are omnipresent, very few places exist with an intensity of 0 V/m near inhabited nuclei. For that reason, nests were chosen that were exposed at very high or very low levels of electromagnetic radiation, depending on the distance from the nests to the antennas.

The nests were selected and separated in two categories:

a) Nests ($n = 30$) located within 200 m of one or several cellsite antennae (GSM-900 MHz and DCS-1800 MHz), placed in masts and in the roof of the buildings at 15–30 m high.
b) Nests ($n = 30$) located further than 300 m of any cellsites.

The nest were observed using a prismatic Zeiss 8 × 30 and a "Leika" 20-60 X telescope. The number of young were counted.

For the analysis of the results of the reproduction, two indexes were used:

1) the total productivity (number of young flown by each couple, including nests with zero chicks).
2) the partial productivity (number of young flown by couples with some chicks, excluding nests with zero chicks).

To compare the breeding success of both groups of nests a nonparametric test was applied (Mann-Whitney test U).

Also, we measured the electric field intensity (radiofrequencies and microwaves) in V/m, using a "Nuova Elettronica" device Model LX 1435 with 10% sensitivity, from a unidirectional antenna (range: 1 MHz–3 GHz). Keeping in mind the inaccessibility of the nests, the measurements were made in their vacinity under similar conditions, recording the reproducible values obtained when directing the antenna of the device toward the cellsite antenna in line of sight.

Between February 2003 and June 2004, we carried out 15 and 10 visits, respectively, to 20 nests located within 100 m of one or several cellsite antennae to observe the behavior of the species. The visits covered all the phases of breeding, from construction of the nest, until the appearance of young storks exercising their wings and practicing flight.

Results

Table 1 presents the number of young and electric field intensity (V/m) of each studied nest.

The total productivity, in the nests located within 200 m of antennae was 0.86 ± 0.16. For those located further than 300 m, the result was practically doubled, with an average of 1.6 ± 0.14 (Table 1). Both groups showed very significant differences in the breeding success ($U = 240$; $P = 0.001$, Mann-Whitney Test U).

Table 1
Intensity of electric field, total and partial productivity in the nests within 200 m and further than 300 m to the phone mast

Nests within 200 m			Nests further than 300 m		
Nest	Number of young	EMF (V/m)	Nest	Number of young	EMF (V/m)
1	2	0.8	1	1	0.4
2	2	0.6	2	2	0.7
3	0	0.8	3	1	1.3
4	3	1.5	4	1	1.1
5	1	1.7	5	1	0.6
6	2	2.9	6	3	0.4
7	1	3.1	7	2	0.6
8	1	1.3	8	2	0.7
9	1	1.3	9	3	0.6
10	1	2.8	10	1	0.7
11	1	1.8	11	2	0.8
12	3	3.2	12	2	0.3
13	1	1.6	13	3	0.1
14	0	2.7	14	1	0.6
15	0	2.3	15	2	0.5
16	0	2.7	16	3	0
17	0	2.5	17	2	0.3
18	0	3.5	18	1	0.8
19	0	3.5	19	2	0.2
20	0	2.7	20	0	0.8
21	0	2.9	21	2	0.2
22	2	3.2	22	1	0.6
23	0	2.5	23	1	0.5
24	1	2.6	24	1	0.7
25	1	2.4	25	1	1.4
26	0	2.2	26	2	0.1
27	1	2.6	27	1	0.1
28	1	3.1	28	2	0.2
29	1	3.1	29	1	0
30	0	3.0	30	1	0.6
Mean EMF		2.36			0.53
Total productivity		0.86		1.6	
Partial productivity		1.44		1.65	
Nests without young		12 (40%)		1 (3.3%)	

In partial productivity in average of 1.44 ± 0.16 was obtained for the first group (within 200 m of antennae) and 1.65 ± 0.13 for the second (further than 300 m of antennae) respectively. The difference between both groups of nests in this case was not statistically significant ($U = 216$; $P = 0.26$, Mann-Whitney Test U).

Twelve nests (40%) located within 200m of the antennae never had any chicks, while only one (3.3%), located further than 300m, never had chicks.

The electric field intensity was higher on nests within 200m (2.36 ± 0.82 V/m) that on nests further 300m (0.53 ± 0.82 V/m) (Table 1).

The results of the findings and interesting behavioral observations of the white stork nesting sites located within 100m of one or several cellsite antennae and on those that the main beam impacted directly (EFI > 2 V/m) included young that died from unknown causes. Also, within this distance, couples frequently fought over the nest construction sticks and failed to advance the construction of the nests. (Sticks fell to the ground while the couple tried to build the nest.) Some nests were never completed and the storks remained passively in front of cellsite antennae.

Discussion

The effects of athermal microwaves on birds have been well known for more than 35 years [36, 37]. Some authors obtained beneficial effects in the production of insect eggs and exposed birds, but found that the mortality was doubled [38]. In hen experiments, problems of health and a deterioration of the plumage arose, while in the autopsies, leucosis and tumors of the central nervous system appears [39]. Giarola and Krueger [40] obtained a large reduction of the rate of growth and also a reduction of the adrenal glands, in exposed chickens. Kondra et al. [41] obtained an increase in the frequency of ovulation of exposed birds, and a bigger production of eggs but with less weight, proposing that the pituitary gland was stimulated. Other authors also have obtained effects reducing the rate of growth in chickens and rats, reduction in the production of eggs in hens exposed to microwaves of different frequencies and intensities, increase of fertility, and a deterioration of the quality of the eggshell at certain frequencies [42]. An increase in the embryonic mortality of chickens also has been found [15, 17, 43, 44]. These microwave effects are athermal [45]. Recently, it also has been demonstrated that the microwaves used in cellphones produce an athermal response in several types of neurons of the nervous system in birds [46] and that they can affect the blood brain barrier as has been observed in rats [47].

Birds are especially sensitive to the magnetic fields [48]. The white stork (*Ciconia ciconia*) build their nests on pinnacles and other very high places with high electromagnetic contamination (exposed to the microwaves). Also, they usually live inside the urban environment, where the electromagnetic contamination is higher, and remain in the nest a lot of the time, for this reason the decrease on the brood can be a good biological indicator to detect the effects of these radiations.

The results indicate a difference in total productivity but not in partial productivity between the near nests and those far from the antennae. This indicate the existence of nests without chicks, or the death of young in their first stages in the nests near cellsites (40% of nest without young, compared to 3.3% in nests further 300m). Also, in the monitoring of the nests near to cellsite antennae, some dead young were observed and several couples never built the nest.

In previous studies in Valladolid, the results of productivity were generally higher than those obtained in this study and less nests appeared without young (Table 2).

Consistent with these results, the microwaves could be affecting one or several reproductive stages: the construction of the nest, the number of eggs, the embryonic

Table 2
Results of censuses carried out in Valladolid (Spain).

Year	Number of visited nests	Total productivity	Partial productivity	Couples without young(%)	References
1984	113	1.69	2.13	7	[65]
1992	115		1.93	5.2	[62]
1994	24	1.84		7.6	[63]
2001	35		2.43		[64]
2003 (<200 m)	30	0.83	1.44	40	This study
2003 (>300 m)	30	1.6	1.65	3.3	This study

development, the hatching or the mortality of chicks in their first stages. The faithfulness of the white stork to nest sites can increase the effects of the microwaves. A Greek study [49] relates to a progressive drop in the number of births of rodents. The mice exposed to 0.168 $\mu W/cm^2$ become sterile after 5 generations, while those exposed to 1.053 $\mu W/cm^2$ became sterile after only 3 generations. The interaction seems to take place through the central nervous system more than on the reproductive gland directly. Other studies find a decrease of fertility, increase of deaths after the birth in rats and dystrophic changes in their reproductive organs [16]. A recent study shows a statistically significant high mortality rate of chicken embryos subjected to the radiation from a cellphone, compared to the control group [43]. EMF exposure affected the reproductive success of kestrels (*Falco sparverius*), increasing fertility, egg size, embryonic development and fledging success but reduced hatching success [10]. An increase in the mortality [50] and the appearance of morphological abnormalities, especially of the neural tube [14, 15, 17] has been recorded in chicken embryos exposed to pulsed magnetic fields, with different susceptibility among individuals probably for genetic reasons. It is probable that each species, even each individual, shows different susceptibility to the radiation, since the susceptibility depends on the genetic bias, and of the irradiated living organisms physiologic and neurological state [4, 51]. Different susceptibility of each species also has been proven in wild birds exposed to CEM from high-voltage powerlines [9]. When the experimental conditions (power density, frequency, duration, composition of the tissue irradiated, etc.) change, their biological effects also change [25, 52]. Microwaves have the potential to induce adverse reactions in the health of people [2–5, 34, 35, 47]. Although the power output differs per site and type of transmitter, at more than 300 m distance from the antennas, most of the symptoms recorded in people diminish or disappear [34, 35]. It also has been pointed out that below 0.6 V/m the effects on the people disappear (Salzburg resolution).

Since, we cannot see symptoms for white storks, it is necessary to use objective variables such as the Total and Partial Productivity, and other characteristics of behavior (nonconstruction of nest, sticks fall, etc.). We recommend electromagnetic contamination in the microwave range be considered a risk factor in the decline of some populations, especially urban birds, especially when exposed to higher radiation levels. Because of their thinner skull, their great mobility and the fact that they use areas with high levels of microwave electromagnetic radiation, birds are very good biological indicators. The freedom of movement of birds and their habit of settling in the proximity and even on the cellsites, makes them potentially susceptible to such effects. Small organisms (children, birds, small mammals, etc.) are especially vulnerable, as absorption of microwaves of the frequency used in mobile telephones is greater as a consequence of the thinner skull of a bird, the penetration of the radiation into the brain is greater [2, 49, 53, 54].

Several million birds of 230 species die annually from collisions with the masts of telecommunication facilities in United States during migration [55]. The cause of the accidents has yet to be proven, although one knows that they mainly take place during the night, in fog, or bad weather. The birds use several orientation systems: the stars, the sun, the site-specific recognition and the geomagnetic field [48]. The illumination of the towers probably attracts the birds in the darkness, but it is possible that the accidents take place in circumstances of little visibility, because at the time, other navigational tools are not available. The perception to the terrestrial magnetic field can be altered by the electromagnetic radiation from the antennae. The reports of carrier pigeons losing direction in the vicinity of cellsites are numerous, and more investigation is necessary.

In the United Kingdom, where the allowed radiation levels are 20 times higher than those of Spain, a decline of several species of urban birds has recently taken place [56], coinciding with the increasing installations of cellsites. Although this type of contamination is considered at the present time by some experts as the most serious [4], inspection systems and controls have never been developed to avoid their pernicious effects on living organisms. Some of the biological mechanisms of the effects of these waves are still ignored [12], although the athermal effects on organisms have been sufficiently documented. The telephone industry could be taking advantage of the complexity of the biological and physical processes implied, to create an innocuous atmosphere, repeatedly denying the existence of harmful effects in living organisms. For this reason the reports related to animals are of special value, since in this case it can never be alleged that the effects are psychosomatic [3].

Future investigation should be carried out with long-term monitoring of the breeding success, of the sleeping places and of the uses of the habitat for species more vulnerable to the microwaves. Of special interest should be investigations that try to make correlations with the radiofrequency electromagnetic field measurements. Field studies investigating populations of urban parks and territories surrounding cellsites should be a high-priority. A radius of 1 sq K and the layout of concentric lines at intermediate distances can be useful to investigate differential results among areas depending on their vicinity and the radiation levels. We consider that the birds most affected from the microwave electromagnetic contamination could be:

1) those bound to urban environments with more sedentary customs, in general those that spend more time in the vicinity of the base stations;
2) those that live or breed in high places, more exposed to the radiation and at higher power density levels;
3) those that breed on open structures where the radiation impacts directly on adults and chicks in the nest;
4) those that spend the night outside of holes or structures that attenuate the radiation.

In far away areas, where the radiation decreases progressively, the chronic exposure can also have long term effects [13, 49]. Effects from antennas on the habitat of birds are difficult to quantify, but they can cause a serious deterioration, generating silent areas without male singers or reproductive couples. The deterioration of the ecosystem can also take place from the impact of the radiation on the populations of invertebrate prey [54, 57, 58] and on the plants [59].

Bioelectromagnetics is historically a frontier discipline. Controversy is frequent when the scientists recognize serious effects on health and on the environment that cause high economic losses. Independent investigators state the necessity of a drastic reduction of the emmitted power levels on people and the ecosystems and that it is technically viable although more expensive for the industry [4, 22, 60]. Our opinion is that areas of continuous use should never exist at the height of the antennas either inside the beam or within a radius of several hundreds meters. The restriction to exposure to fauna presents special complexity; the main reason for the drastic reduction in the emission power of the antennae is presented as the only viable and effective solution to prevent these effects. Some authors have already propose that we are withessing a paradigm change in biology [61].

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RF Radiation–Induced Changes in the Prenatal Development of Mice

Ioannis N. Magras[1]* and Thomas D. Xenos[2]

[1]Department of Anatomy, Histology, and Embryology, School of Veterinary Medicine, Aristotle University of Thessaloniki, Thessalonike, Greece
[2]Department of Telecommunications, School of Electrical Engineering and Computer Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece

The possible effects of radiofrequency (RF) radiation on prenatal development has been investigated in mice. This study consisted of RF level measurements and in vivo experiments at several places around an "antenna park." At these locations RF power densities between 168 nW/cm^2 and 1053 nW/cm^2 were measured. Twelve pairs of mice, divided in two groups, were placed in locations of different power densities and were repeatedly mated five times. One hundred eighteen newborns were collected. They were measured, weighed, and examined macro- and microscopically. A progressive decrease in the number of newborns per dam was observed, which ended in irreversible infertility. The prenatal development of the newborns, however, evaluated by the crown-rump length, the body weight, and the number of the lumbar, sacral, and coccygeal vertebrae, was improved. *Bioelectromagnetics 18:455–461, 1997.* © 1997 Wiley-Liss, Inc.

Key words: RF radiation effects; prenatal development; mice development

Five years ago the "antenna-park of Thessaloniki" progressively developed on the top of the nearby mountain Chortiatis, 1.5 km away from a small village of the same name. Today, almost 100 commercial TV and FM-radio broadcasting transmitters in the VHF and the UHF bands are situated there. The antennas are installed on towers well visible from a large part of the village. Living so close to the antennae and the vast amount of RF power they transmit, which is of the order of 300 kW, the people of the village Chortiatis, anxious for their health, encouraged the author to undertake a research program.

The hypothesis that RF radiation may adversely affect the health of the animal organism is still under consideration in public and scientific forums. One of the critical issues seems to be the RF effects on the reproductive process [Chernoff et al., 1992]. Numerous studies dealing with this subject ended up with seemingly contradictory results. Therefore, an "in vivo" study on experimental animals sensitive to RF radiation, was chosen. Based on the relevant literature, this research investigated RF radiation effects on the reproductive system, particularly on prenatal development. The mouse was selected as the experimental animal, because it is easily manipulated in the environment in which the experiments had to take place. Of course, experimenting at the mountain sites, far from the easily controlled laboratory conditions, might add a certain amount of uncertainty; therefore, these experiments should be considered preliminary.

MATERIALS AND METHODS

We used a total of 36 mice (18 females and 18 males), 2 months old and sexually mature (BALB/c/f breed colony). Breeding colony virgin males and females were obtained from the "Theageneion Anticancer Institute of Thessaloniki." The use of these experimental animals was approved by the Veterinary Service of the Municipality of Thessaloniki, according to the provisions of the laws 1197/81 and 2015/92 and the Presidential Decree 160/91 of the Greek Democracy. Upon arrival, all experimental animals were quarantined for 2 weeks to discover and to allow them to acclimatise the mountain environment, an altitude ranging between 570 (position h) and 730 m (position d) above sea level. All the mice were healthy at the end of this period and showed no signs of illness during

*Correspondence to: Ioannis N. Magras, Department of Anatomy, Histology, and Embryology, School of Veterinary Medicine, Aristotle University of Thessaloniki, 540-06 Thessaloniki, Greece.

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TABLE 1. Light–Dark Cycle during the Experimental Matings

Gestation	Date	Day		Night	
		Min	Max	Min	Max
1st	25.5–16.6	14.28	14.47	09.13	09.32
2nd	21.6–12.7	14.37	14.48	09.12	09.23
3rd	6.9–29.9	11.54	12.45	11.15	12.06
4th	7.10–28.10	10.45	11.35	12.25	13.15
5th	23.11–13.12	09.34	09.55	14.05	14.26

the course of the study. Tap water and certified feed (Greek Sugar Factory) were freely available.

The mice were maintained under natural lighting, both during the daytime and at the night (Table 1). Twelve Plexiglas cages transparent to RF radiation, were placed at several locations with one female in each cage. Each female was caged with one male for 12 h. Vaginal smears were taken the next morning and successful mating was identified by the presence of sperm. The day on which evidence of mating was observed was considered to be the first day of gestation. The litters were collected in the first 2 h after delivery and were moved to the laboratory for examination. After a period of recovery, the same mating procedure was repeated for each dam. Five experimental pregnancies were carried out in a period of almost 6 months.

The first pregnancy of the experimental animals took place in eight selected positions (a–h, Fig. 1), some close to the "antenna-park" and some near the village of Chortiatis. Then the experimental animals were moved to two positions, because these positions presented almost the same RF radiation levels with those initially selected and the experiment could be managed more effectively. Six dams (labelled as group A), initially placed at positions a, b, c, and d, with their males, were moved to the position d (Refuge of Hypaithrios Life). The other six dams (labelled group B), with their males, initially placed at positions e, f, g, and h were moved to position h (Public Primary School of Chortiatis). These two positions were selected because the most important living conditions, i.e., light, temperature, ventilation, food, etc., were the same.

Finally, all the experimental animals were moved to position i (Laboratory of Anatomy, School of Veterinary Medicine, University of Thessaloniki) about 10 km away from the Mountain Chortiatis, in the city of Thessaloniki, for the fifth pregnancy. This relocation was done to seek an indication of a possible reversibility of the observed phenomena. In fact, we wanted to repeat the experiment in an environment almost free of RF. An extra group of six couples of mice were mated once and used as controls in the laboratory (posi-

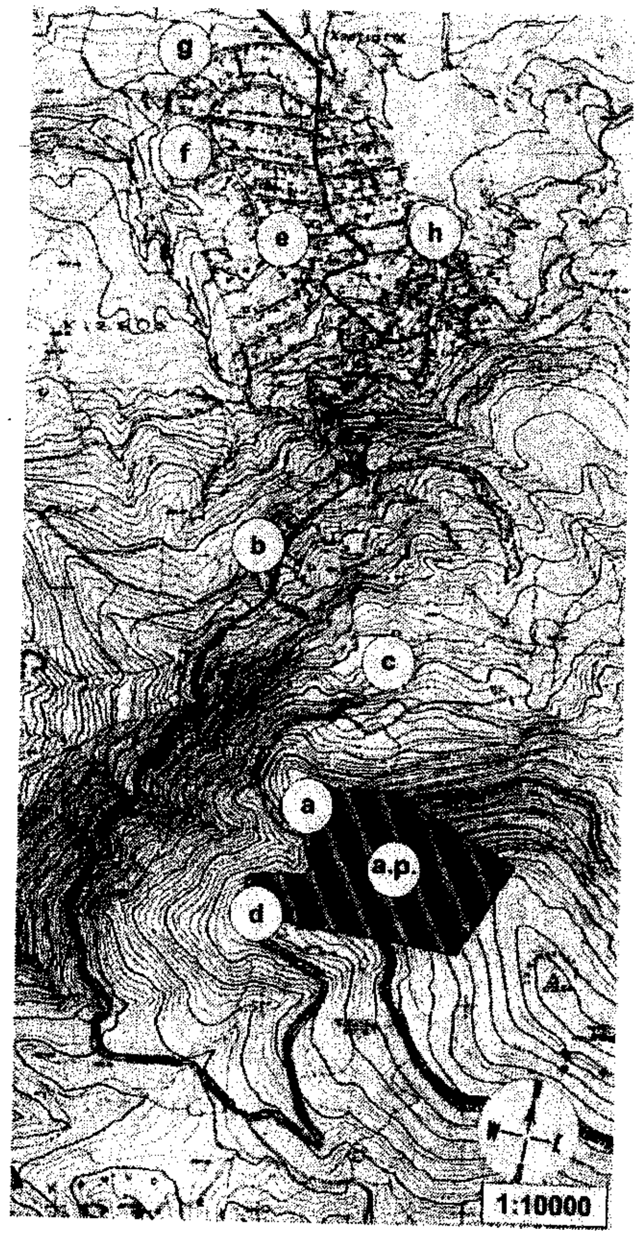

Fig. 1. Wide area of Chortiatis, where the fist four matings took place.

tion i), far from the "antenna park" in a more or less free-of-RF radiation environment.

It was extremely difficult to use RF-free controls at the mountain sites, because it was almost impossible to make "electromagnetically screened cages." Such a cage should ideally provide high (of the order of 30 dB) screening at the frequency range between 88.5 and 950 MHz (Commercial Radio FM band, UHF TV band, and Mobile Communication band), and therefore would require a very dense and well-grounded, highly conductive external metal grid. Obviously, mice could hardly survive in such cages for about 5 months.

The litter was considered to be the experimental unit for the analysis of data. We measured the crown-rump length, the body weight, the number of the posterior (lumbar, sacral, and coccygeal) vertebrae, the congenital malformations, and the ossification of the skeleton.

The RF power was measured in each position, using an electric field meter and a low gain (4 dB) wide-band (80–900 MHz) log-periodic antenna and spectrum analyser. To obtain comparable results the "IEEE std. C95.3.1991" was used. On the third floor of the public school, where the mice were situated, a 360 degree integration was also performed, due to the directivity of the measuring antenna together with the close proximity of the walls and metal furniture. Wherever iron bars or metal screens existed in front of the windows, two series of measurements were carried out; one on each side of the screen.

The collected newborns were killed for examination. Their crown-rump length was measured, and they were weighed and inspected under the dissecting microscope for external congenital malformations. Then they were fixed and subsequently cleared and stained in toto by a double staining of their skeleton [Peters, 1977]. The procedure was lightly modified as follows:

The newborns were fixed with alcohol 86% for 3 days; their skin, eyes, and viscera were removed; then they were immersed for 3 days in alcohol 100% and for 4 days in a mixture of alcohol 100% and ether 1:1. They were stained for 1–2 days with blue alcyan coloration [alcohol 86% 80 ml, acetic acid 20 ml, alcyan blue 20 mg] until the nonmineralised cartilagenous parts of the bones became blue. They were immersed in alcohol 100% for 4 days. Then they were stained for 12–24 days with red alizarin coloration [KOH 1 g, H_2O 100 ml, alizarin solution (alcohol 86% saturated with alizarin red S) 0.1 ml] until the ossified parts of the bones became red. They were immersed in solution Mall I (KOH 1 g, distilled water 80 ml, glycerine 20 ml) until the transparency of their body was completed. Finally, they were stored in a conservation solution (distilled water and glycerine 1:1, with some thymol crystals as contamination prevention). The stained newborns were inspected for skeletal defects as well as for the degree of ossification of their bones. The ossification of the skeleton and particularly of the vertebrae is an excellent and creditable indicator of the prenatal exposure to noxious agents and can be a measure of development delay.

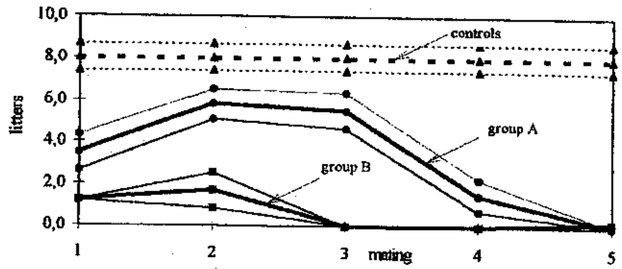

Fig. 2. Comparison of the mean values ± standard deviation of number of newborns per dam and mating from all experimental groups.

RESULTS

The RF power levels measured, although below the limits proposed by the "ENV50166-2" and the "IEEE C95.1.1991" standards, are high and well above the power levels that are likely to be measured in other European or U.S. residential areas. In fact, on the third floor of the public primary school (position h), an average power density of 1.053 $\mu W/cm^2$ was found, equivalent to a specific absorption rate of 1.935 mW/kg. In the Hypaithrios Life Refuge (position d) the average power density in which the mice were located was of the order of 168 nW/cm^2. This reduced level was due to the screening effect of the iron bars in front of the windows, which gave an 8–10 dB RF-power decrease. The average power density levels in position i (Laboratory of Anatomy, School of Veterinary Medicine, University of Thessaloniki), where the controls were placed and the fifth experimental matings were performed, was 40 dB weaker.

The number of the littered newborns by the experimental dams of groups A and B were, compared with those littered by the controls, progressively reduced from the first to the fifth pregnancy. This reduction is more evident in group B and is clearly shown in Table 2 and in Figure 2.

On the other hand, the rest of the four measured parameters, i.e., the crown rump length and the weight and the number of the lumbar, sacral, and coccygeal vertebrae increased in the newborns from groups A and B compared with the controls. This was more evident in group A than in group B (Table 2 and Fig. 3). A

TABLE 2. Statistical Characteristics of All Four Measurable Parameters per Dam, per Group, and per Gestation

Mating	Litters per dam mean ± s.d. median	Length (cm)	Weight (gr)	Vertebrae
Group A (6 dams)				
1st (25.05.1995)	3.5 ± 0.9	1.47 ± 0.13	2.71 ± 0.09	31.48 ± 1.43
	4.0	1.44	2.69	32.07
2nd (21.06.1995)	5.8 ± 0.7	1.25 ± 0.06	2.55 ± 0.05	24.28 ± 0.97
	7.0	1.22	2.50	24.29
3rd (08.09.1995)	5.5 ± 0.9	1.72 ± 0.25	2.71 ± 0.13	28.72 ± 1.92
	6.5	1.72	2.60	28.71
4th (07.10.1995)[a]	1.5	1.10	2.47	23.22
	0.0	1.10	2.47	23.22
5th (23.11.1995)[a]	0.0			
	0.0			
Mean value	3.3	1.39	2.61	26.93
Group B (6 dams)				
1st (25.05.1995)[a]	1.2	1.19	2.53	28.57
	0.0	1.19	2.53	28.57
2nd (21.06.1995)	1.7 ± 0.9	1.25 ± 0.04	2.60 ± 0.06	28.55 ± 1.14
	1.5	1.26	2.58	27.26
3rd (08.09.1995)[a]	0.0			
	0.0			
4th (07.10.1995)[a]	0.0			
	0.0			
5th (23.11.1995)	0.2	1.05	2.50	30.00
	0.0	1.05	2.50	30.00
Mean value	0.6	1.16	2.54	29.04
Controls (6 dams)				
1st (23.11.1995)	8.0 ± 0.07	0.96 ± 0.15	2.38 ± 0.02	19.59 ± 0.47
	7.5	0.97	2.37	19.52
Mean value	8.0	0.96	2.38	19.59

[a]Single or no gestation.

thorough external and internal examination under the dissecting microscope revealed only one case of extensive and two cases of limited malformation. No retardation of skeletal ossification worth mentioning was observed; only five cases out of 116 showed limited retardation. It has to be noted here, that the evaluation of the skeleton ossification was focused in the bones of the forelimbs and hindlimbs and in the lumbar, sacral, and coccygeal vertebrae.

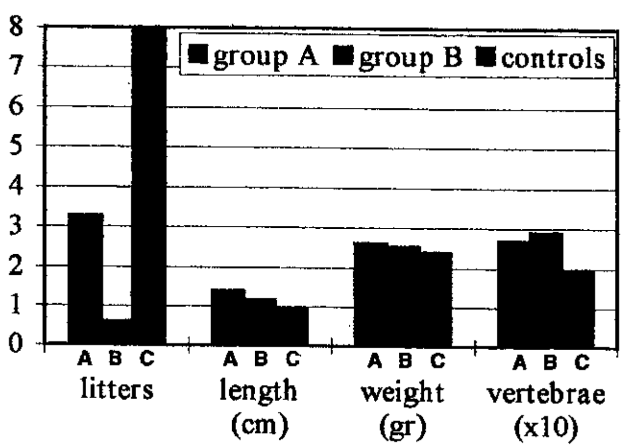

Fig. 3. Comparison of the mean values of all four measurable parameters for all gestations. Controls (C).

DISCUSSION

To study effects of a possibly noxious agent on a mammalian embryo, three groups should be considered: the embryos, the dams, and the males. In this work, all three have been studied: the infertility for dams and males, the lethality for embryos, the teratogenicity or the reduction in deformity for foetuses, or any combinations of them. They all have been considered by exposing male and female mice (before and during pregnancy) to an RF-radiation environment close to the "antenna park."

Infertility and lethality were assessed by counting the number of their newborns, whereas the possible teratogenicity and the reduction deformity by autopsy was considered by the study of the embryonic skeletons. An important stage in this study was the examination of the skeletons, since the ossification of the bones is considered an excellent and creditable indicator of the prenatal exposure to noxious agents and can be a measure of development delay. In the beginning of organogenesis, the neural tube functions as a precursor of the cartilages and bones of the developing skeleton [Noden and Delahunta, 1985]. Teratogenic factors of any kind, that affect the embryonic nervous system, result in structural defects of the skeletal components. Therefore, to detect the teratogenic action of a factor on the embryonic nervous system, it is technically convenient to study the foetal skeleton rather than the embryonic nervous system itself.

A very important result of this experimental study (Table 2 and Fig. 2) is a progressive decrease of the number of the size of the litters of the dams of group A (position d) and group B (position h), compared with the controls (position i) and with the breeding history of these mice. Mice from the BALB/c/f breeding colony obtained from the "Theageneion Anticancer Institute of Thessaloniki" have been used for years in our laboratory for reproduction. Repeated pregnancies with a recovery period of 1–4 weeks for over a year, had never affected the fertility of the dams or any morphological parameters of the offspring, a fact that to our knowledge has not been questioned in the available literature.

It is worth noting that the RF power density levels, although very different from place to place, were very low and well below the CENELEC and IEEE relevant standards. Yet, it should be pointed out that:

(a) the experimental animals lived in this environment for 6 months, which is a long period of time,

(b) there was a considerable difference in power density levels of the order of 10 dB between the two main positions d and h and almost of 40 dB between d and i,

(c) there is a considerable difference between the volumes and consequently the body mass of the adult mouse and other experimental animals used as models in the international standards applied to humans.

The interpretation of our observations could follow various directions. The most popular view in numerous studies of the relevant literature, that this is a consequence of the overheating of the irradiated testis [Lary et al., 1986, 1987; O'Connor, 1980)] could be considered. On the other hand, the assumption that RF and microwave radiation effects are limited to heating has been questioned in a series of studies [Cleary, 1988, 1990]. The exposure conditions in these "in vivo" studies may suggest a thermal component of RF-induced testicular damage. However, interpretation of these data with respect to damage thresholds or interaction mechanisms is difficult. This difficulty is due to a number of factors, including the time, intensity, or both, the variations in species sensitivities, and the frequency-dependent non-uniform microwave energy absorption in tissue. Consequently, although these findings seem to be consistent with a hypothesis that the RF-induced heating is associated with testicular damages, the borderline between the "direct" effects of radiation and the effects that are indirectly associated with the tissue heating is not very clear.

Our observations could also be attributed to an intra-uterus death of the irradiated embryos in the early stages of the prenatal development, a speculation that could not be investigated in our experimental design because it required a postmortem autopsy of the dam. On the other hand, the prerequisite to these scenarios is a large RF power density, whereas the power densities we measured were of the order of $\mu W/cm^2$ or nW/cm^2, rather than mW/cm^2, or in terms of specific absorption rate (SAR), mW/kg rather than W/kg. Therefore, we cannot exclude the possibility of an indirect nonthermal mechanism focused on the endocrinological axon hypophysis-gonads that causes infertility to the males or the females [Thuery, 1991].

It should be noted here that the male experimental animals progressively developed a very bad physiological condition (rough hair, emaciation, etc.), not correlated to any other sickness symptoms, during their stay at the experimental positions a–g. Therefore, despite of the limited amount of data, the duration of the exposure to low intensity RF electromagnetic fields seems to be a repression parameter. In fact, chronic or long-term exposure to low intensity electromagnetic fields is generally associated with adverse results [Lary et al., 1983]. The most peculiar findings of this study were the increases in the crown-rump length, the body weight, and the number of the posterior vertebrae (lumbar, sacral, and coccygeal) of the experimental offsprings compared with the controls (Table 2, Fig. 3).

It must be noted that a study of mice [Jensh et al., 1977; 1978a; 1978b] under low levels of irradiation during the whole period of a single gestation (10 and 20 mW/cm^2) had no effect on maternal, foetal, or placental masses and no effect on the frequency of resorption, foetal death rate, size of litter, sex of the newly born, and their ability to perform. Other studies [Michaelson et al., 1976] reported a faster development of rat foetuses. This finding agrees with another report [Johnson et al., 1977] that noted an increase in the weight of newly born rats and a premature opening of the eyes after prenatal irradiation (5 mW/cm^2 at 918 MHz, for 380 h), as well as an impaired ability to learn. On the other hand, other studies found lower average weight at birth. At medium power density levels (10, 20, and 50 mW/cm^2, at 2375 MHz), which are above the limits imposed by CENELEC and the relevant IEEE standard, the reproductive capacity of mice was somewhat impaired, with smaller litter size and a rise in neonatal mortality, which is a direct function of the power flux density [Il'Cevic and Gordodeckaja, 1976; McRee, 1980].

Although it is difficult to explain this foetal development increase, we believe that it could be due to a favourable placental nourishment of the foetuses during the pregnancy. In fact, this finding could be associated with:

(a) reproductive causes, i.e., blood-flow to a smaller number of foetuses, because of the reduction of the fertility of the irradiated males or females,

(b) thermal causes, i.e., possible increase of the blood flow of the dams, directly due to the RF irradiation,

(c) endocrinological causes, i.e., increase of the somatotrophic hormone because of the RF irradiation and

(d) environmental causes, i.e., the vasodilatation and partial increase of the blood pressure of the experimental dams because of the mountain altitude.

Of course combinations of these possibilities cannot be excluded.

According to various references [Tell and Harlen, 1979; Lu et al., 1980; Deschaux et al., 1983] discrepancies between the results of experiments may be due to different experimental conditions, random formation of hot spots in the glands and the hypothalamus, or a variety of other factors, as the cicardian rhythm and differences between species. With the exception of the high power effects on testicles, that do not belong to the endocrine ensemble, the interaction seems to involve the pituitary gland or even the central nervous system rather than the terminal glands.

We would close this discussion with what Jacques Thuery wrote (1991), that the true state of affairs is probably far more complex, but the available data are not sufficient to allow us to outline it more clearly, and that all attempts to extrapolate these results to humans lead to very high power densities, partly because geometric resonance effects are very significant in small animals. Consequently, taking into account the constant exposure of the human population living close to the "antenna park" to low intensity RF radiation, these adverse health effects in mice resulting from chronic or prolonged exposure may prove of importance in the near future. Indeed, there is evidence that chronic exposure to low-intensity RF radiation may be associated with health effects different to embryo-toxicity [Salford et al., 1992; Cleary, in press].

The findings of this preliminary experimental study have led to several conclusions. Of course, the final word to the problem in question has not been said as yet. Therefore, more work is called for; laboratory-based simulation might provide valuable information.

ACKNOWLEDGMENTS

The authors thank I. Grivas, G. Marangos, and V. Oiconomou, students of the Faculty of Veterinary Medicine of Thessaloniki, and Mr. I. Milarakis of the Department of Telecommunications of the School of Electrical Engineering and Computer Engineering, who followed this experimental study and offered their technical assistance.

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IW77

STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Bureau of Natural Resources/Wildlife Division
79 Elm Street, Sixth Floor
Hartford, CT 06106
Natural Diversity Data Base

February 8, 2011

Mr. Ellery W. Sinclair
Canaan Inland Wetland/Conservation Commission
201 Under Mountain Road
Falls Village, CT 06031

Re: State Listed Species Records within an approximately Two Mile Radius Circle centering on Proposed Cobble Hill Telecommunications Tower located at 8 Barnes Hill Road in Canaan, Connecticut

Dear Mr. Sinclair:

I have reviewed Natural Diversity Data Base maps and files regarding the area delineated on the map you provided for all state-listed species records and significant natural community records within an approximately two mile radius circle that centered on the proposed Cobble Hill Telecommunications Facility to be located at 8 Barnes Hill Road in Canaan, Connecticut. As we discussed on the phone, our program had reviewed this telecommunications facility in the fall of 2010 and determined that there were no Federal or State Listed species that occurred within the project boundaries as presented by Mr. Dean Gustafson of Vanasse Hangen Brustlin Inc. I have attached that letter for your records.

Your recent request to our program provided a map with a much wider radius around the Cobble Hill Telecommunications Facility and you asked us to provide the Canaan Inland Wetlands Conservation Commission with a list of species and significant natural communities in this larger radius. I have attached a list of these records for your Commission. Please be aware, however, that this list is just that, a list. We have made no assessment on impacts or effects that this facility may or may not have on these species. This list is for informational purposes only.

Natural Diversity Data Base information includes all information regarding critical biological resources available to us at the time of the request. This information is a compilation of data collected over the years by the Department of Environmental Protection's Natural History Survey and cooperating units of DEP, private conservation groups and the scientific community. This information is not necessarily the result of comprehensive or site-specific field investigations. Consultations with the Data Base should not be substitutes for on-site surveys required for environmental assessments. Current research projects and new contributors continue to identify additional populations of species and locations of habitats of concern, as well as, enhance existing data. Such new information is incorporated into the Data Base as it becomes available.

Please contact me if you have further questions at 860-424-3592 or dawn.mckay@ct.gov. Thank you for consulting the Natural Diversity Data Base. Also be advised that this is a preliminary review and not a final determination. A more detailed review may be conducted as part of any subsequent environmental permit applications submitted to DEP for the proposed site.

Sincerely,

Dawn M. McKay

Dawn M. McKay
Biologist/Environmental Analyst 3

Cc: SIMS NDDB #201100523

Species List for Request Number R201100523

2/4/2011

Scientific Name	Common Name	State Protection Status
Animals		
Aegolius acadicus	Northern saw-whet owl	SC
Agrotis stigmosa	Spotted dart moth	SC
Ambystoma jeffersonianum	Jefferson salamander "complex"	SC
Ambystoma laterale	Blue-spotted salamander	E/SC
Apodrepanulatrix liberaria	New Jersey tea inchworm	T
Atylotus ohioensis	Tabanid fly	SC
Botaurus lentiginosus	American bittern	E
Calephelis borealis	Northern metalmark	E
Catocala herodias gerhardi	Herodias underwing	E
Crotalus horridus	Timber rattlesnake	E
Empidonax alnorum	Alder flycatcher	SC
Erynnis lucilius	Columbine duskywing	E
Euphyes bimacula	Two-spotted skipper	T
Euphyes dion	Sedge skipper	SC
Glyptemys insculpta	Wood turtle	SC
Gomphus ventricosus	Skillet clubtail	SC
Hemaris gracilis	Slender clearwing	T
Hybomitra luridus	Horse fly	SC
Lota lota	Burbot	E
Lycaena hyllus	Bronze copper	SC
Notropis bifrenatus	Bridle shiner	SC
Papaipema leucostigma	Columbine borer	T
Passerculus sandwichensis	Savannah sparrow	SC
Rana pipiens	Northern leopard frog	SC
Sargus fasciatus	Soldier fly	SC
Satyrodes eurydice	Eyed brown	SC
Speranza exornata	Barrens itame	T
Sturnella magna	Eastern meadowlark	SC
Natural Communities		
Acidic rocky summit/outcrop		
Circumneutral maple/ash basin swamp		
Circumneutral northern white cedar basin swamp		
Circumneutral rocky summit/outcrop		
Circumneutral seepage swamp		
Dry circumneutral forest		
Dry subacidic forest		
Floodplain forest		
Rich fen		
Subacidic rocky summit/outcrop		
Plants		
Agastache nepetoides	Yellow giant hyssop	E

E = Endangered, T = Threatened, SC = Special Concern, SC* = Special Concern, Presumed Extirpated

Species List for Request Number R201100523

2/4/2011

Scientific Name	Common Name	State Protection Status
Alopecurus aequalis	Orange foxtail	T
Anemone canadensis	Canada anemone	T
Asplenium ruta-muraria	Wallrue spleenwort	T
Calamagrostis stricta ssp. inexpansa	Reed bentgrass	SC
Cardamine douglassii	Purple cress	SC
Carex alopecoidea	Foxtail sedge	T
Carex aquatilis var. aquatilis	Sedge	SC
Carex castanea	Chestnut-colored sedge	E
Carex cumulata	Clustered sedge	T
Carex formosa	Handsome sedge	SC
Carex hitchcockiana	Hitchcock's sedge	SC
Carex oligocarpa	Eastern few-fruit sedge	SC
Carex prairea	Prairie sedge	SC
Carex sterilis	Dioecious sedge	SC
Carex trichocarpa	Sedge	SC
Carex tuckermanii	Tuckerman's sedge	SC
Cryptogramma stelleri	Slender cliff-brake	E
Cypripedium parviflorum	Yellow lady's-slipper	SC
Cypripedium reginae	Showy lady's-slipper	E
Draba reptans	Whitlow-grass	SC
Dryopteris goldiana	Goldie's fern	SC
Equisetum scirpoides	Dwarf scouring rush	E
Gentianella quinquefolia	Stiff gentian	E
Hepatica nobilis var. acuta	Sharp-lobed hepatica	SC
Linnaea borealis ssp. americana	Twinflower	E
Lythrum alatum	Winged loosestrife	E
Malaxis brachypoda	White adder's-mouth	E
Mitella nuda	Naked miterwort	SC
Petasites frigidus var. palmatus	Sweet coltsfoot	T
Pinus resinosa	Red pine	E
Plantago virginica	Hoary plantain	SC
Platanthera orbiculata	Large round-leaf orchid	SC*
Potamogeton hillii	Hill's pondweed	E
Quercus macrocarpa	Bur oak	SC
Ribes triste	Swamp red currant	E
Salix serissima	Autumn willow	SC
Schizachne purpurascens	Purple oat	SC
Schoenoplectus acutus	Hard-stemmed bulrush	T
Sibbaldiopsis tridentata	Three-toothed cinquefoil	T
Thuja occidentalis	Northern white cedar	T
Trisetum spicatum	Narrow false oats	SC
Trollius laxus	Spreading globe flower	T
Uvularia grandiflora	Large-flowered bellwort	E
Viola nephrophylla	Northern bog violet	SC

E = Endangered, T = Threatened, SC = Special Concern, SC* = Special Concern, Presumed Extirpated

17984

STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Inland Fisheries Division-Natural History Survey
Natural Diversity Data Base
79 Elm Street, 6th floor
Hartford, CT 06106-5127

September 2, 2010

Mr. Dean Gustafson
Vanasse Hangen Brustlin, Inc.
54 Tuttle Place
Middletown, CT 06457-1847

Subject: Proposed AT&T Cingular Wireless Telecommunications Facility, Canaan, CT
State/Federal Listed Species

Dear Mr. Gustafson:

I have reviewed Natural Diversity Data Base maps and files regarding the area delineated on the map you provided and listed above. According to our information, there are no known extant populations of Federal or State Endangered, Threatened or Special Concern Species that occur at the site in question.

Natural Diversity Data Base information includes all information regarding critical biological resources available to us at the time of the request. This information is a compilation of data collected over the years by the Geological and Natural History Survey and cooperating units of the DEP, private conservation groups and the scientific community. This information is not necessarily the result of comprehensive or site-specific field investigations. Consultations with the Data Base should not be substituted for on-site surveys required for environmental assessments. Current research projects and new contributors continue to identify additional populations of species and locations of habitats of concern, as well as, enhance existing data. Such new information is incorporated into the Data Base as it becomes available.

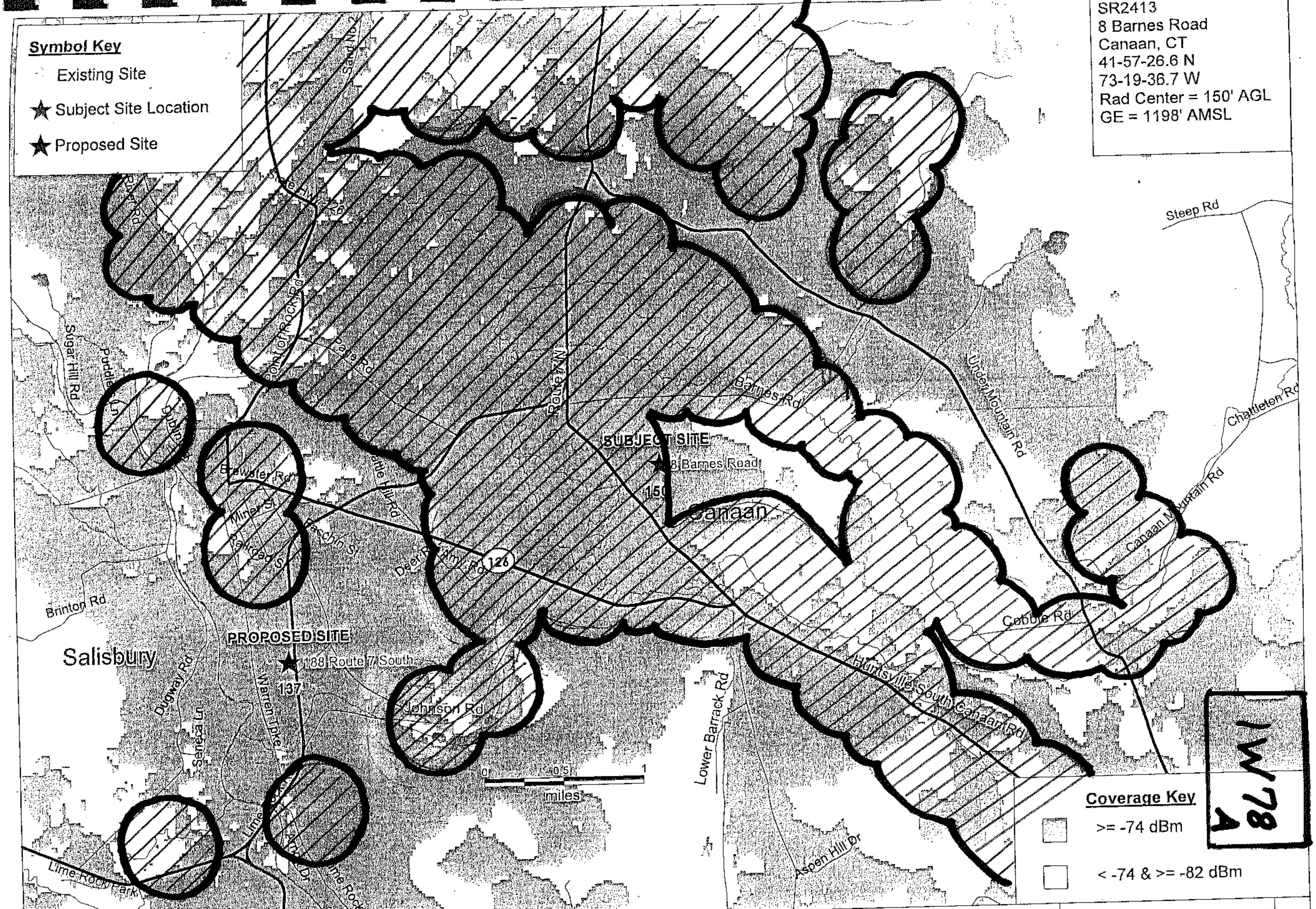
Please contact me if you have further questions (nancy.murray@ct.gov; 860-424-3589). Thank you for consulting the Natural Diversity Data Base and continuing to work with us to protect State listed species.

Sincerely,

Nancy M. Murray
Biologist/Senior Environmental Analyst
NDDB Program Coordinator

cc: NDDB File # 17984

NM:hw



Existing & Proposed Site & Subject Site Coverage | Falls Village | Canaan, CT | at&t | PREPARED ON DATE: 08/23/2010 | REV 0

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