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

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*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.

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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).

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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

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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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