Effect of 60 Hz Ambient Magnetic Fields on the Development of Axolotl Embryos

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Abstract

This work documents investigations into the possible teratogenic effect of extra low frequency magnetic fields on the development of axolotl (*Ambystoma mexicanum*) embryos. The investigation was done by exposing a group embryos to power frequency magnetic fields and comparing the number of healthy developed ones to those of a control group.

The results indicate that ambient and above ambient levels of low frequency magnetic fields have no adverse effect on the development of the axolotl embryos as measured by the parameters used.

Background on Ambient Magnetic Fields

The naturally occurring magnetic field of the Earth is essentially static. Its vertical component has a magnetic flux density that averages about 50 microTesla (μT) or 500 milliGauss (mG) at middle latitudes. The field peaks at the magnetic poles to about 67 μT, and has a value of zero at the magnetic equator. The horizontal component is 33 μT at the magnetic equator and zero at the magnetic poles.

The peak value of magnetic flux density underneath a double circuit, 500 kiloVolts (kV) transmission line carrying a total of 5000 MegaWatts (MW) is less than 3.5 μT. This value drops to about 0.5 μT at the edge of the right-of-way.

Hypothesis

Review of literature (Chacon et al., 1990; Martin, 1992; Nagai and Ota, 1994; Pafkova and Jerabek, 1994; Santini, et al., 1994; Veicsteinas et al., 1996) indicates that adverse effects of electromagnetic fields appear to be caused by high levels of field strength or high frequencies.

It is expected that ambient levels of 60 Hz magnetic fields (given in Table 1), should have no adverse morphological or behavioral effects

Appliance	Magnetic Flux Density, μT		
	3 cm	30 cm	1m
Can openers	1000-2000	3.5-30	0.07-1
Hair dryers	2-2000	0.01-7	< 0.01-0.3
Electric shavers	15-1500	0.08-9	< 0.01-0.3
Drills	400-800	2-3.5	0.08-0.2
Mixers	60-700	0.6-10	0.02-0.25
Portable heaters	10-180	0.15-5	0.01-0.25
Blenders	25-130	0.6-2	0.03-0.12
Television	2.5-50	0.04-2	0.01-0.15
Irons	8-30	0.12-0.3	0.01-0.025
Coffee makers	1.8-25	0.08-0.15	< 0.01
Refrigerator	0.7-0.7	0.01-0.25	< 0.01

Table 1. Magnetic field level at 60 Hz near various home appliances in a typical U.S. home (Electric Power Research Institute, 1989).

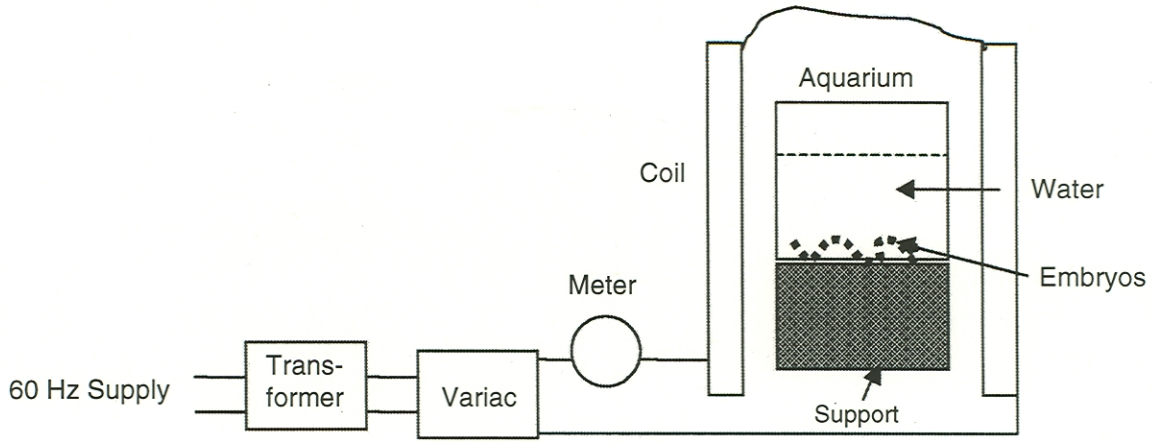

Figure 1. Experiment Setup

on the developing axolotl embryos. The following set of experiments were design to test the validity of this hypothesis.

Materials and Methods

The experiments involved subjecting a group of fertilized eggs to a 60 Hz electromagnetic field from the early stages of development until they hatched. Various field strengths were used from slightly below to as much as triple the ambient values. Various orientations of the exposed eggs with respect to the direction of the field were observed. The hatched embryos were scored and compared to a control group for mortality rate and morphological abnormality.

Experiment Setup

The present work (Abdel-Hadi, 1997) comprises a number of experiments in which axolotl embryos were subjected to 60 Hz electromagnetic fields. The embryos were placed in two identical glass aquaria, sealed with non-conducting aquarium silicone: one was exposed to fields generated by a Helmholtz coil, the other was shielded by placing it inside a box-like metal mesh and grounded through a connection to the laboratory's water pipes.

A Helmholtz coil is made up of a pair of identical coils, placed parallel to each other. When the distance between the coils is equal to their radius, the magnetic field in the space between them is essentially uniform. The magnetic flux density between the coils is a function of their diameters, number of turns and the current flowing through them.

The setup, including the circuit connection is shown in Figure 1. Figure 2 shows the aquarium, the pair of Helmholtz coils and the control aquarium.

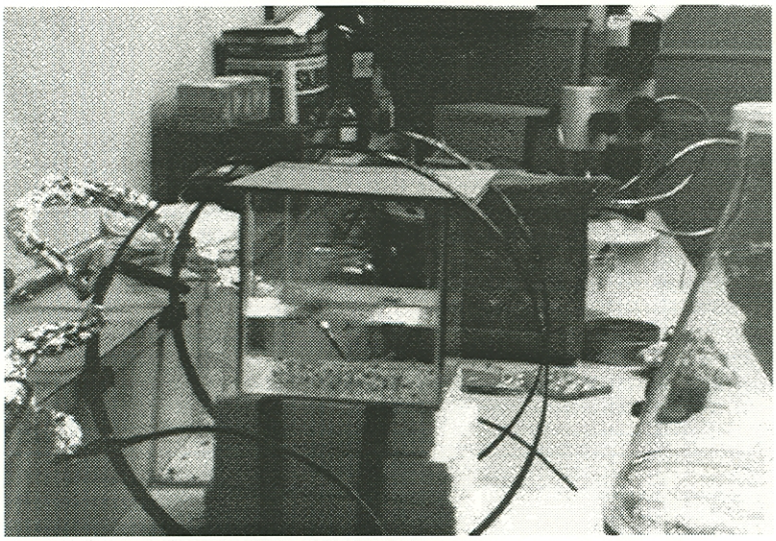

Figure 2. The Aquaria and Helmholtz Coil

Experiments and results

The experiment was repeated four times between February 1994 and May 1996. The following are the particulars of each experiment and the results. In all of the experiments, the embryos were in stages of development numbers 4 to 7 during exposure.

Experiment 1. Each aquarium contained fifty-five eggs. The exposed group was subjected to a 1500 mG magnetic field. Only one egg in each aquarium did not develop. It was noticed that before hatching, all the embryos had a curl shape and were oriented in a vertical plane.

Experiment 2. Forty-eight embryos were placed in each aquarium. The field strength was 15 μT. Six embryos did not develop in the exposed aquarium and four of the control ones failed to develop. The orientation of the embryos was random.

Experiment 3. Sixty-two embryos were placed in each aquarium. Again the field strength was set at 15 μT. Twelve embryos failed to develop in the exposed aquarium and thirteen in the control aquaruium. The orientation was random.

Experiment 4. Seventy-three embryos were placed in each aquarium. The field strength was doubled to 30 μT. Five of the control group and seven of the exposed group did not develop. The orientation was again random.

Table 2 summarizes the results of the six experiments.

In all of the above experiments, the embryos that developed were free from morphological abnormalities. In order to test behavior, the embryos were fed brine shrimp after hatching, and there was no evidence of any behavioral abnormalities, since they showed orange abdomens. The variability in the number of developed embryos could be due to the parents being different.

The 'p values' for all of the above experiments, as measured by the chi-square test, is greater than 0.05 and hence the difference between the control and exposed embryos is not significant.

Experiment	Field Strength mGauss	Number Of Embryos						P value
		Control			Exposed			
		in group	developed	%	in group	developed	%	
1	1500	55	54	98	55	54	98	0.5173
2	1500	48	44	92	48	42	88	0.7379
3	1500	62	49	79	62	50	81	0.8177
4	3000	73	68	93	73	66	90	0.7611
Total		238	215	90	238	212	89	

Table 2. Summary of Experimental Results

Conclusions

This work investigated the possible effects of ambient and above ambient levels of North America power frequency magnetic fields on the axolotl embryos. The results of the study clearly indicate that exposure of axolotl embryos to 1500 and 3000 mG, 60 Hz sinusoidal magnetic field; from the early cleavage stages until hatching (9 to 10 days), do not adversely affect the developing embryo. The scoring was based on:

1. Failure to develop.
2. Morphological abnormalities.
3. Post hatching abnormal behavior.

The fact that a relatively large number of the embryos were aligned with the field in experiment #3 cannot be attributed to the magnetic field since these results could not be reproduced.

Most of the adverse effects reported in the literature resulted from exposing embryos to high frequency, or to low frequency pulsed magnetic fields containing high frequency components. This, together with the results of the present study, indicates the need to establish a relationship between possible adverse effects on organisms and the field frequency. Pure fundamental power frequency sinusoidal waves that are free of harmonic contents appeared to have no effect on axolotl embryos. These results are in agreement with those reported by other researchers such as Chacon et al. (1990), Martin (1992), Santini et al. (1994) , Pafkova and Jerabek (1994), Nagai et al. (1994) and Veicsteinas et al. (1996).

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