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Experiment on the Anomalous Animal Behaviors by Electric Field Effects for Detecting Earthquake Precursors

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Abstract: The anomalous behaviour of animals prior to a large earthquake has been frequently reported from many places throughout the world since ancient times. This study is to experimentally testify what relations exist between the anomalous animal behavior and electric field effect, which is reported due to the piezo-electric effects in a basement rock before earthquake occurrences. We investigated the electric field effects on behaviors of two kinds of rats and birds. Rats show more sensitive anomalous behavior than birds. Even though the current applied to the experimental birds and rats is just a few μA, they show various abnormal behaviors. The anomalous animal behaviors under the small ground electric field may have some relations to the actual phenomena before great earthquake.

Key words: Anomalous behaviors, animal, electric field effects, great earthquake

INTRODUCTION

The level of seismicity in the Korean peninsula is lower than that in China and Japan. However, some large earthquakes occurred through the historical time and triggered destructive damages. Some earthquakes caused great damages such as destruction of houses, many deaths, ground fissures, liquefaction, surface depression, and earthquake lightening in several places (Kyung, 1977; Kyung and Okada, 1995).

It has long been reported that people sometimes observe anomalies premonitory to a large earthquake. Such anomalies can be sensed by humans without relying on precise instruments. They include sea-level changes at the coastline, strange detonation, unusual lights in the sky, changes in underground water and hot spring, and anomolous animal behaviour (Rikitake et al., 1993).

We couldn't find any detail records about animal behaviors related to great earthquakes in Korea at present. However, there are many reports of animal behavior before great earthquakes in other countries (Biophysics Institute, 1977; Oike, 1978; Tributsch, 1978; Rikitake, 1986, 1987; Ikeya *et al.*, 1996a, b). Some animals evacuated their normal habitats or were seen to move in large numbers as if migrating, in order to avoid the major earthquake. Sometimes they become nervous, excited and panicked before the earthquake. Although the mechanisms have not yet been clarified, these anomalous animal behaviors seem to indicate that animals are in fact detecting some precursor signal of major earthquakes. It seems that many aquatic animals have electro-sensory systems which are used to acquire information for orientation and to communicate with others. The electro-sensing organs of animals may be perturbed by seismic current prior to an earthquake.

Some model (Ikeya *et al.*, 1996a, b) suggests that the current induced by the disappearance of piezo-electric effects due to the seismic stress release might be detected by sensitive animals as to cause electric shocks in water or in wet soil.

In this experiment electric fields are applied to rats and birds in order to investigate its effect. This study is to testify the critical body current and what kind of anomalous animal behaviors can be possible as a responses to electric shocks.

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MODEL OF SEISMIC CURRENT

Electromagnetic fault model (Ikeya *et al.*, 1996a, b) to calculate current can be summarized as follows: The piezo-compensating bound densities, +q and −q appear at the fault zone due to the disappearence of the piezo-electric polarization caused by the release of the seismic stress, σ. The charge density is described by

$$dq/dt = -\alpha(d\sigma/dt) - q/\varepsilon\rho \quad (1)$$

where α is the piezo-electric coefficient and ε, the dielectric constant and ρ, the resistivity.

A mathematical fault model based on dynamical theory gives the stress $\sigma(t) = \mu[D - D(t)]/2a$ where μ is the rigidity of rocks, D and D(t), the final and time dependent displacements, respectively, of a fault having the length, 2a. According to the mathematical model, D(t) is expressed by the initial displacement velocity D' and the displacement time or the rise time of seismic wave, τ as

$$D(t) = D(1 - e^{-D't/D}) = D(1 - e^{-t/\tau}) \quad (2)$$

$$\tau = D/D' = (\Delta\sigma/\sigma_0)/(\beta/a) \quad (3)$$

$\Delta\sigma/\sigma_0$ is the rate of stress drop, i.e., the drop, $\Delta\sigma$, divided by the stress parallel to a fault σ_0, and β, is the velocity of the secondary seismic waves.

The initial condition, $q(0) = 0$ gives a solution q(t) as

$$q(t) = \alpha\Delta\sigma[\varepsilon\rho/(\tau - \varepsilon\rho)](e^{-t/\tau} - e^{-t/\varepsilon\rho}) \quad (4)$$

which is rewritten symmetric to τ and $\varepsilon\rho$ as

$$q(t) = \alpha\sigma_0[\varepsilon\rho\tau/(\tau - \varepsilon\rho)](\beta/a)(e^{-t/\tau} - e^{-t/\varepsilon\rho}) \quad (5)$$

A pulse is time dependent with the rise time $\varepsilon\rho$ and the decay time τ. The pulsed electric intensity, $F(t) = q(t)/\varepsilon$, is estimated as

$$F(t) = \alpha\sigma_0[\varepsilon\rho\tau/(\tau - \varepsilon\rho)](\beta/a)(e^{-t/\tau} - e^{-t/\varepsilon\rho}) \quad (6)$$

and the current density to the ground sediment, $J(t) = F(t)/\rho'$ is expressed as

$$J(t) = \alpha(\rho/\rho')\sigma_0(\beta/a)(e^{-t/\tau} - e^{-t/\varepsilon\rho})/(1 - \varepsilon\rho/\tau) \quad (7)$$

where ρ' is the resistivity of ground sediment or valley channel ($1 \sim 10^2\ \Omega \cdot m$) leading to $\rho/\rho' = 10^4 \sim 10^6$.

According to Ikeya (1996b), $J = 1A/m^2$ is sufficient to shock animals sensitive to electric field under the granite bed rock containig quartz more than 50%. An electromagnetic fault model based on piezo-compensating bound charges is used to explain the pulsed field and the current causing abnormal animal behaviors.

EXPERIMENT

The response of animals were tested on the wet towel which were placed on the floor of the plastic cage. Electric voltage was applied to copper plate electrodes with a separation of 25 cm in both ends of the wet floor. We could observe the anomalous bahaviors of animal, especially two kinds of rats and birds, when DC voltage ranged from 0 to 250 V was applied to the electrode. The animal behaviors were photographed using a commercial video recorder.

A. Rats

We carried out the experiment with two kinds of rats; first, the Korean wild rat, so called Ta-jui, which was raised outside, second, the white coloured rat which was raised in a small indoor space. The characteristics of animals are described in Table 1. In case of rats, the distance between two legs indicates that between foreleg and hind legs. Rats were placed on the wet towel in a plastic cage. They showed grooming and nervous bahaviors under low electric field as small as 2 ~ 6 V/m as shown in Fig. 1. They stand on two legs using the nails and are cramped in the leg about 70 V/m. They began crying and moving around here and there, and being cramped about 300 V/m. They stand on the copper electrode to avoid field effects at 1000 V/m.

In the second experiment, the white coloured rats were placed on the same wet towel in a plastic cage. They showed almost the same response as the Korean wild rat when DC voltage from 0 to 1000 V/m was applied. Table 2 describes the animal behaviors of

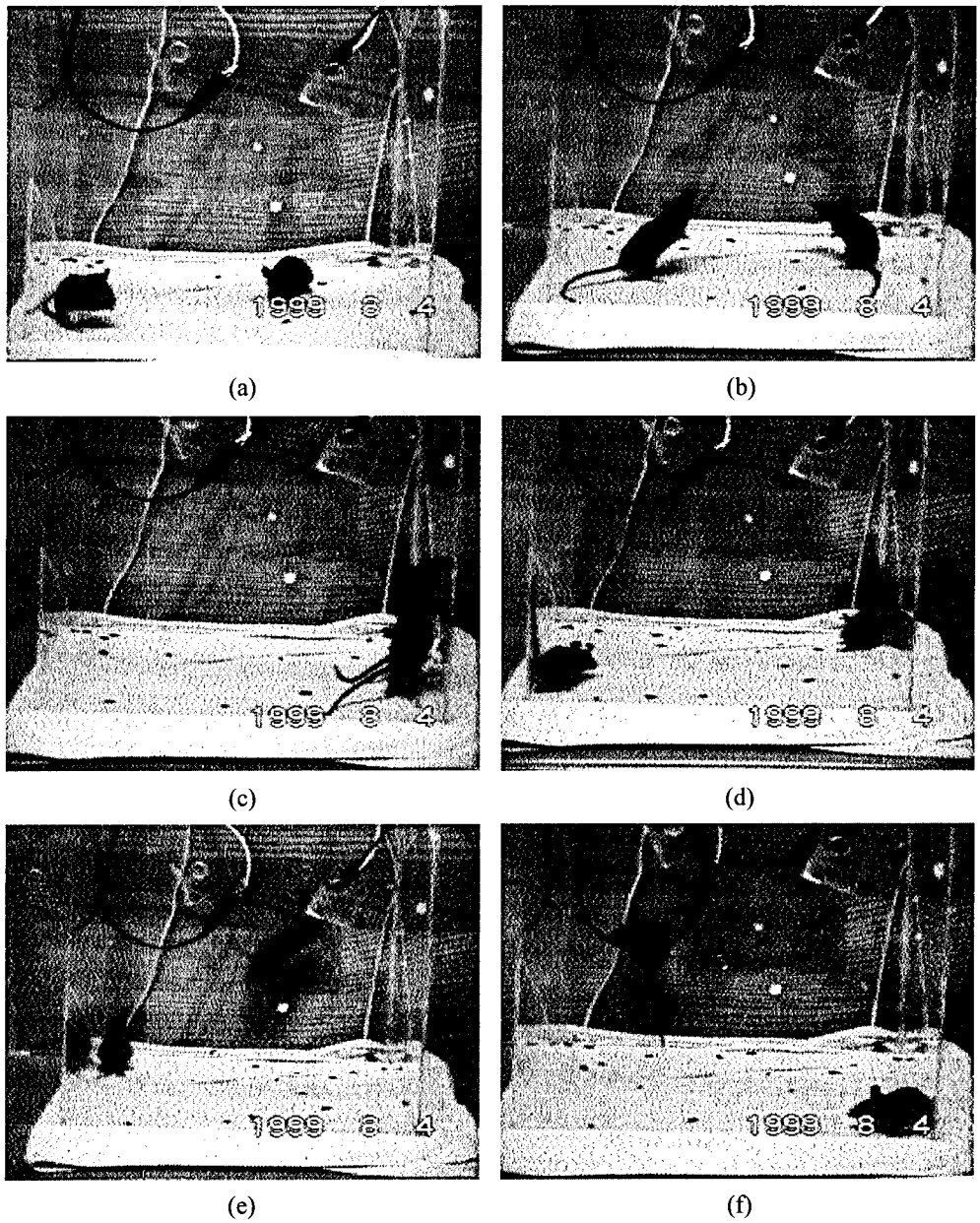


Fig. 1. Photographs of Korean wild rats when electric current was applied to the wet floor. a) Nervous behaviors at 2 V/m, b) grooming with legs and standing at 6 V/m, c) Standing on the nails at 70 V/m, d) Severely cramped at 300 V/m, e) screaming and running around at 1000 V/m, f) Standing on the electric wire at 1000 V/m.

two kinds of rats by the electric field effects.

B. Birds

This time we performed the same experiment with two kinds of birds; sparrow and common finch. Sparrows were placed on the wet towel in a plastic cage. They showed almost normal habitats, sometimes looking around with curiosity and leaping lightly under low electric field as small as 2 ~ 6 V/m as shown in Fig. 2.

They move around in a hurry, jump and try to fly up about 25 V/m. They are embarassed, some-

Table 1. The characteristics of animals used to the experiment.

animal	weight (g)	length of body (cm)	distance between two legs (cm)	resistivity between two legs (MΩ)
Korean wild rat	32	7.5	3.5	0.5
white rat	45	9.7	4.3	0.5
sparrow	21	7.2	1.6	0.5
common finch	17	7.0	1.6	0.5

Table 2. Effects of electric field on rats.

F (V/m)	animals	$V_{l\text{-}l}$ (V)	$I_{l\text{-}l}$ (μA)	responses
2	A	0.07	0.14	going around here and there, nervous behaviors
	B	0.08	0.17	going around here and there, looking afraid
6	A	0.21	0.42	grooming with legs
	B	0.26	0.52	standing on the legs, digging the corner, being cramped
70	A	2.52	5.04	being cramped in the leg, standing on the nails
	B	3.10	6.20	being cramped in the leg, standing on the nails
300	A	10.50	21.00	screaming and running around in a hurry
	B	12.90	25.80	screaming and running around in a hurry
1,000	A	35.00	70.00	running and screaming, standing on the electric wire
	B	43.00	86.00	running and screaming, standing on the electric wire

*A : Korean wild rat, B : white rat, $V_{l\text{-}l}$: voltage between two legs, $I_{l\text{-}l}$: current between two legs.

times groom, move fast, and jump at 70 V/m. They move quite fast and fly up when the voltage increases to about 300 ~ 400 V/m. They fly up and perch on the electric wire to avoid field effects at 600 V/m.

In the second experiment, common finch were placed on the same wet towel in a plastic cage. They showed almost the same response as the sparrows when DC voltage from 0 to 600 V/m was applied. Table 3 describes the animal behaviors of two kinds of birds by the electric field effects.

C. Application of electric field to one side

Electric field is formed only in one side when one copper plate electrode move from the end of the plastic cage to the center. This means that DC voltage is applied to only half of the bottom in the same cage. Two kinds of rats were placed together on the wet towel. We could observe the effects of electric field on the Korean wild and white rats. In this case, all of the rats move from one side to the other side where electric field is not applied, even though the voltage is quite small as 2 V/m. Fig. 3 shows that the rats move from electric field space to non-electric field space to avoid the electric field.

CONCLUSION

In order to understand the anomalous animal behabiors before major earthquakes, an experiment giving electric field was applied to some animals such as Korean wild rat, white coloured rats, sparrows, and common finches.

When electric field is applied to the whole wet floor of the cage, they show nervous behaviors such as grooming, washing their faces, standing on legs or running around in panic to avoid the electric field. When more strong electric field is applied, they jump with shrieking and mount on the electric line. The rat shows more sensitive anomalous behavior than the bird. Even though the current to the experimental birds and rats is just a few μA, they respond in various ways. Most of the rats move from one side to the other side where electric field is not applied, even though the voltage is quite small as 2 V/m.

The anomalous animal behaviors under the small

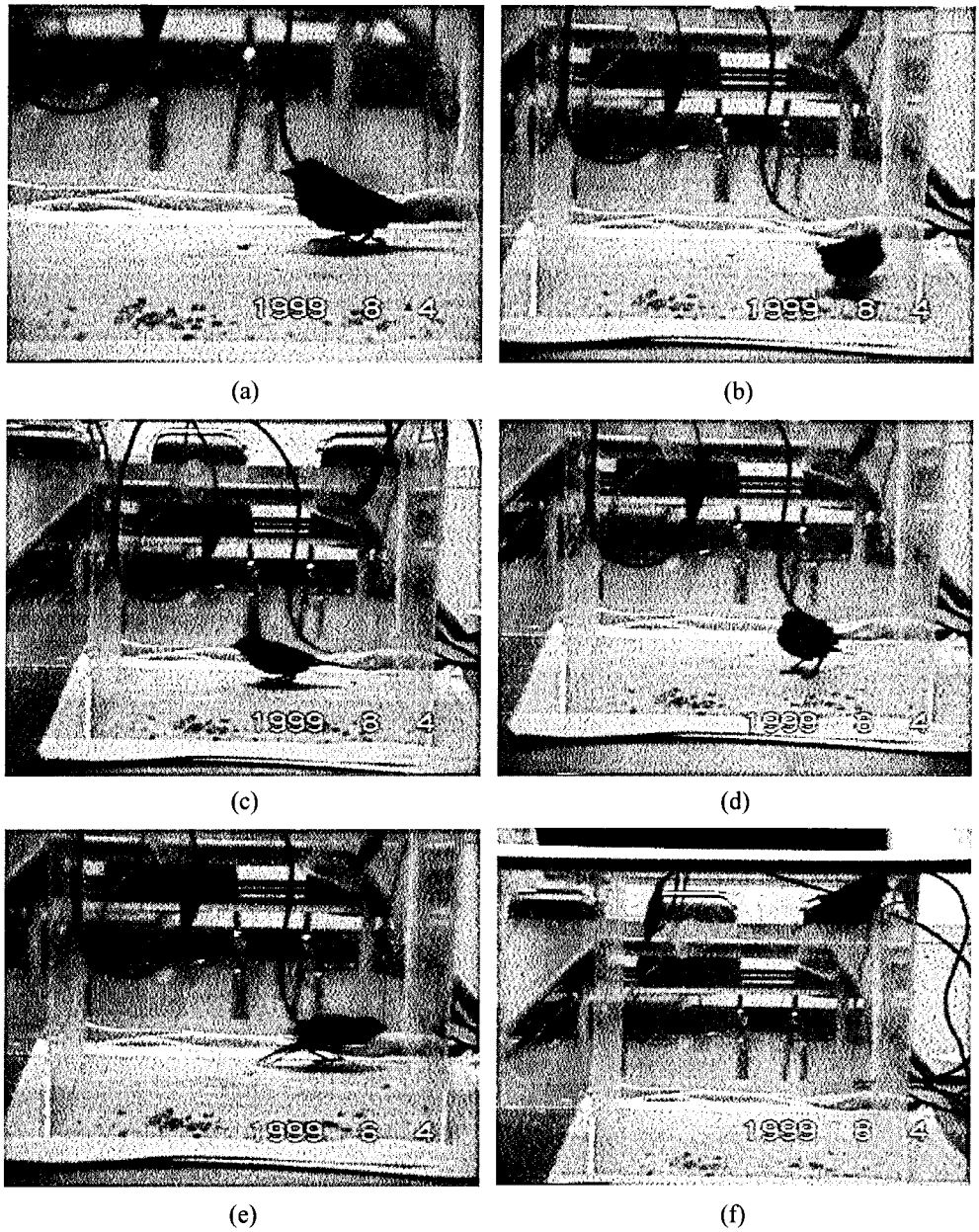


Fig. 2. Photographs of sparrow and fitch when electric current was applied to the wet floor. a) Almost no response, but inflating at 2 V/m, b) Sometimes hopping and grooming at 25 V/m, c) Moving around and hopping at 70 V/m, d) Grooming and flying up to avoid landing at 70 V/m, e) Embarassed and moving fast at 400 V/m, f) Standing on the electric wire to avoid ground current at 600 V/m.

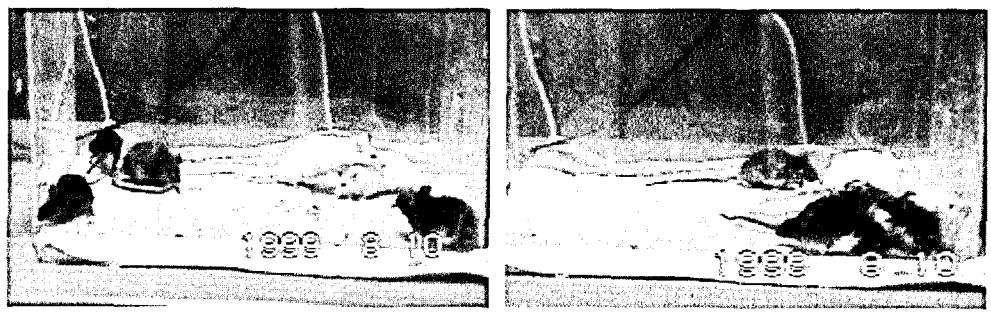
ground electric field may have some relations to the actual phenomena premonitory to a large earthquake.

There are many reports about animal behaviors related to great earthquakes in China and Japan. However, we couldn't find any historical records about animal behaviors before earthquake in Korea. The main reason may be the size of earthquake occurrence. The results of our experiment are quite similar with those by Ikeya (1996a) even though

Table 3. Effects of electric field on birds.

F (V/m)	animals	$V_{I\text{-}I}$ (V)	$I_{I\text{-}I}$ (mA)	response
2	A	0.03	0.064	almost no response, inflating
	B	0.03	0.064	almost no response
6	A	0.10	0.192	look around with curiosity
	B	0.10	0.192	look around with curiosity, sometimes hopping
25	A	0.38	0.768	sometimes hopping and grooming
	B	0.38	0.768	moving around in a hurry, jumping and trying to fly up
70	A	1.15	2.304	moving fast, jumping
		1.15	2.304	embarrassed, jumping, and grooming.
400	A	6.40	12.80	embarrassed and sometimes flying up
300	B	4.80	9.60	moving fast and flying up
600	A	9.60	19.20	flying up on the electric wire to avoid field
	B	9.60	19.20	flying up on the electric wire to avoid field

*A : sparrow, B : common finch.



(a) (b)

Fig. 3. Photographs of Korean wild rat and white rat. (a) Electric field was not applied to the bottom of the plastic cage. (b) Electric field about 2 V/m was applied only to the left half side of the floor.

the species of animals are a little different. We think that the ground conditions in Korea are not quite different from those in China or Japan. The anomalous animal behaviors may be possible if some great earthquake occur in Korea.

Some systematic experiments can be applied to several kinds of animals, birds and reptiles, and compared to actual phenomena. We believe that this kind of experiment is quite worthy for the further understanding of earthquake precursors.

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