

EFFECTS OF 50 HZ MAGNETIC FIELD EXPOSURE ON THE BODY COLOR AND THE URINE QUANTITY OF GOLDFISH

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Abstract: We have studied the biological effect of the extremely low frequency (ELF) magnetic fields by using goldfish. The body color changes in the goldfish and changes in the urine quantity were examined. As a result, it found that the urine quantity of goldfish increased when 50 Hz 62 mT magnetic field was exposed continuously for more than 20 hours and at this time flecks in the scale were observed with light microscope. Furthermore, it found that one of causes which these phenomena appeared was an induced current.

Key words: Body color, ELF magnetic field, goldfish, induced current, urine quantity

1. Introduction

The opportunity exposed in the extremely low frequency (ELF) magnetic field increases. Therefore, the interest about the biological effects of the magnetic field is rising. Studies on the effects of the ELF magnetic field have already carried out on small animals and cultured cells. There are many reports which admitted the effect of the magnetic field or denied the influence [1, 2]. However, because the results which were unified about the magnetic field influence were gotten, it needs further studies on the biological effect of the ELF magnetic field.

We have examined the biological effect of the ELF magnetic field by using goldfish which was cheap and easy to handle and the foundation of the organ was similar to the mammals.

When a 50 Hz 62 mT magnetic field was exposed to the goldfish, a swimming movement distance became short, behavior was restrained [3] and it noticed that the body color of the goldfish faded away.

In this report, it was ascertained whether a body color changed due to the exposure of the 50 Hz magnetic field. Next, as for the observation of the body color change the subject of the experimentalist is contained, it was aimed at the urine quantity that is closely to the stress of fish to get an objective result. There is an advantage to measure a physiological change due to the magnetic field exposure in the quantitative appraisal method which made the urine quantity index without collecting scales directly and hurting a goldfish in comparison with the usual way of observing a body color changes. Furthermore,

because an induced current was one of main factors, alternating electric current equal to the induced current which is produced by the 50 Hz magnetic field was applied to the goldfish, and then the influence of the magnetic field was studied on the body color changes and the changes in the urine quantity.

2. Materials and methods

2.1 Experimental systems

The magnetic field exposure equipment was shown in the Figure 1. Electromagnet was used to expose a magnetic field. The electromagnet consists of coils that cores made of the metal are in the center. The magnetic field was made by supplying electric current from a stabilized AC power supply to those coils.

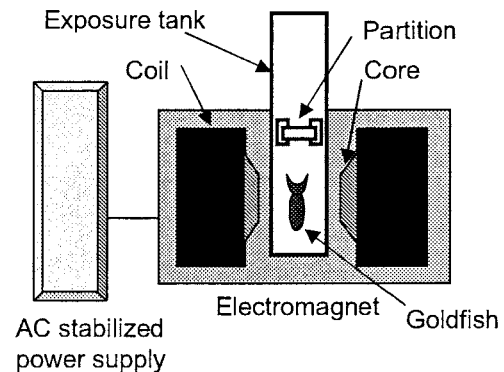


Fig.1 Exposure system

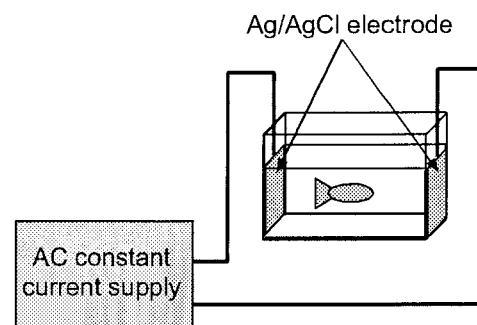


Fig.2 Equipment to apply an electric current to the goldfish

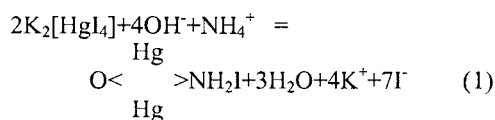
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The water tank used to expose the magnetic field at a goldfish is in the long and narrow tank of vertical 300 mm, the side 40 mm and the height 125 mm. It gained a partition together in the size of the core of the electromagnet to make the goldfish swum in the magnetic field. Furthermore, air was put in the space which the goldfish didn't exist in to make up for the shortage of the dissolved oxygen inside the water tank. Temperature in the water tank was also kept warm in 24 ± 1 degrees which was the temperature that a goldfish was easily active.

The equipment to supply alternating electric current is shown in Figure 2. The Ag/AgCl flat board electrodes were installed on both ends of the water tank. The lead wires were connected to the AC power supply.

2.2 Measurement of the urine quantity (Nessler's method)

The urine of the fish contains undissociation ammonia (NH_3) and ammonia-nitrogen ($\text{NH}_4^+\text{-N}$). The $\text{NH}_4^+\text{-N}$ was specially contained 90 % and more of the insides of the urine. The $\text{NH}_4^+\text{-N}$ is also the material which is suitable to measure the urine quantity because it is never absorbed by skin on to the mucous membrane once it goes to the outside of the body unlike NH_3 . The Nessler's method which can detect ammonia was used to measure the urine quantity of goldfish. That process is shown in the following.



Nessler's reagent (alkaline mercury iodide) is made to react to ammonia-nitrogen contained water like a (1)-type, and produces the material made to have color. This formed material colors lemon yellow, light brown and reddish brown by the concentration of ammonia-nitrogen. Next, absorbance in the wavelength 400 nm was measured. Ammonia concentration was calculated from that value. The measuring range of ammonia concentration of this method is 0 - 2.0 ppm (mg/l). The resolution is 0.01 ppm. In this experiment, it assumes that the urine quantity of goldfish is the ammonia dose inside the water tank.

2.3 Experimental methods

1) Confirmation of the body color changes: Two goldfish of the about same size with less than 1 year old were chosen. Then they were sent to the water tank for the 50 Hz magnetic field exposure and their body color was observed. Two the same water tanks were prepared and one of them was placed between magnetic poles within the 50 Hz 62 mT magnetic field as shown in Figure 1. Goldfish were exposed

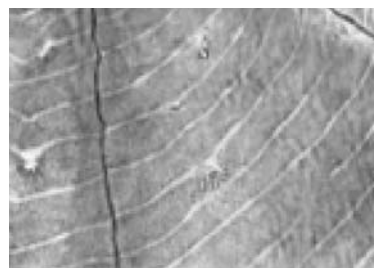
50 Hz 62 mT magnetic field for 24 hours (this is called an exposure group). The others water tank was also set on the same electromagnet with no AC current for three days to compare it with a group of exposure (a group of sham exposure). After that, the scales of the goldfish of both groups were collected. It was put in slide glass and the color state of the scale was observed by a light microscope.

2) Confirmation of changes in the urine quantity:

The following experiment was done to expose a magnetic field to the goldfish and ascertained the urine quantity. Two goldfish of the same size in the same way were sent to the water tank for the magnetic field exposure. Two water tanks were prepared as the sham exposure group and the exposure group respectively. These were put in the inside or outside of the magnetic field for 24 hours. Water was collected from the water tank of both groups in every 4 hours. Ammonia dose was measured by Nessler's method.

Next, the following two experiments were done to be more detailed and to investigate relationship between the urine quantity and the magnetic field. The first: A sham exposure and an exposure were done with the same goldfish to get the urine quantity of both groups from the same goldfish. The goldfish were made to take a rest between the sham exposure and the magnetic field exposure for one night. The second: Some magnetic field strength was chosen from 62 mT to 5 mT and exposed to each of the goldfish to confirm the magnetic field strength characteristic of the urine quantity.

3) Application of alternating electric current to goldfish: It is thought that an induced current is the main cause of the biological influence of the



(a) Sham exposure



(b) 50 Hz 62 mT magnetic field exposure

Fig.3 Photograph of the goldfish's scale

magnetic field because the current occurs in that object when a magnetic field is exposed.

The induced current which occurred in the goldfish by the 50 Hz 62 mT magnetic field was calculated and the same alternating electric current equal to that was applied to the goldfish by using the system of Figure 2.

A spheroid model [4] was used for the computation of the induced current. Induced current value which occurred in the head of the goldfish in the 50 Hz 62 mT magnetic field was 8mA/m².

Terms of passing current are the same as the time of the observation of the body color changes and the observation of changes in the urine quantity.

3. Result and discussion

The microphotograph of the scale of the goldfish exposed in 50 Hz 62 mT magnetic field was shown in Figure 3. The photograph (a) is a group of shame exposure and the photograph (b) was a group of exposure. When both were compared, it found that obviously a scale changed. It also found that the body color changes of the goldfish due to the magnetic field exposure happened on about an average 5 hours. The change was seen by a scale as

well as the case that a magnetic field was exposed when alternating electric current equal to the induced current which occurs in the head of the goldfish by this magnetic field was supplied. The body color changes of the goldfish may be the influence of the induced current from this result.

A body color is maintained by the melanocyte-stimulating hormone secreted from the pituitary gland which acts on the organ with the pigment cell which exists in the scale.

There were reports [5, 6] in the past that the melatonin which maintained the body rhythm was decreased by the magnetic field exposure. When a magnetic field is exposed to goldfish, the brain of the goldfish is stimulated directly and the secretion of the hormone is restrained. As a result, there is possible that an induced current makes cohesion to have the pigment granule in the pigment cell like the photograph.

The ammonia dose of the goldfish which was made to swim in the inside and outside of the magnetic field was measured in every 4 hours as shown in the Figure 4. It found that the urine quantity increased by exposing the magnetic field after 12 hours from this figure. The difference was also recognized clearly in case of the continuous magnetic field

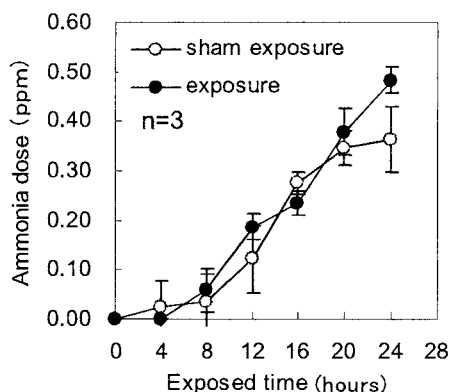
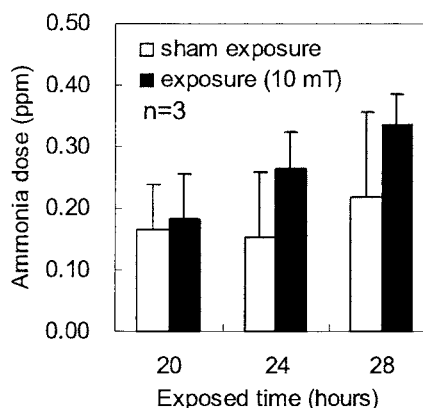


Fig.4 Change in time of the urine quantity on every 4 fours



(a) 10 mT exposure

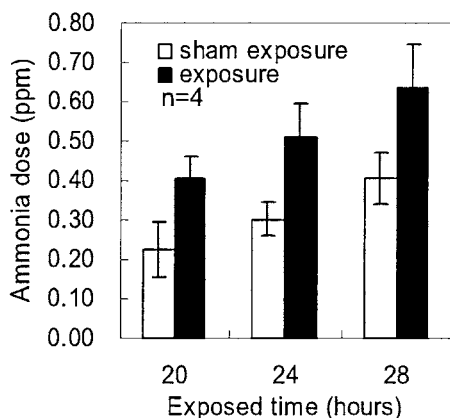
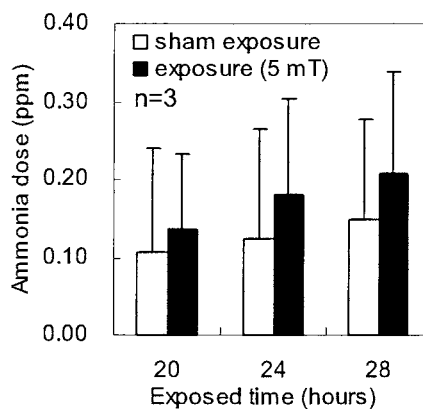


Fig.5 28 hour exposure



(b) 5 mT exposure

Fig.6 Characteristics 50 Hz magnetic field strength on the urine quantity

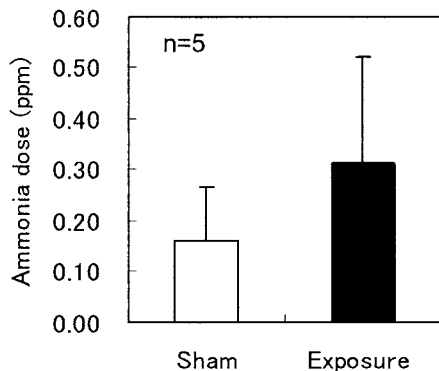


Fig.7 Alternating electric current to goldfish for 24 hours

exposure of 24 hours more as shown in Figure 5. It found that it was the influence of the continuous exposure of 20 hours and more.

A change in the urine quantity to the magnetic field strength is shown in Figure 6. Ammonia dose increased when 10 mT magnetic field was exposed continuously. On the other hand, for 5 mT magnetic field, the difference in ammonia dose in the exposure could not be recognized. The threshold of the magnetic field influence against the changes in the urine quantity can be thought to exist between 5 mT and 10 mT.

As the induced current is generally proportional to magnetic field strength, the urine quantity has the possibility to depend on the magnetic field strength. The urine quantity increased in the result of supplying alternating electric current to the goldfish to investigate relationship between the induced current and the urine quantity as well as the case that a magnetic field was exposed. The result is shown in Fig.7.

It became clear from this result that the factor that the urine quantity increased was the influence of the induced current. However, the body color changes were not observed at this time (in 10 mT). In other words, it is supposed that the repression of the hormone is not caused by the exposure for about 10 mT 28 hours. Therefore, the urine quantity may be increased with another mechanism with the body color changes. Ammonia in the urine of the fish is a final proteinaceous metabolic change formation thing. When strong stress is given a fish, it generally makes a protein stored up in the inside of the body burned besides the intake protein.

A kind of outside stimulus is conveyed from the brain to the hypothalamus through receptors in the viewpoint of physiology and the response of the body pulled up by stress occurs through the internal organs of the whole body. Furthermore, this hypothalamus is well known as a place to administer the adjustment of the endocrine system.

When a magnetic field is exposed to the goldfish, the stimulus of the induced current which occurred by

the magnetic field is conveyed from the sense organ to the brain and it was connected with the protein metabolism in the inside of the body that was unusual by the thing pulled up by the internal secretion adjustment of the hypothalamus. As a report which relates this, there is a paper that the secretion of the stress protein increases when a magnetic field is exposed to the worm [7].

The stimulus of the induced current was involved in the influence of the ELF magnetic field which exerts on the goldfish. In other words, increase in the protein metabolism produced by the indirect stimulus like stress to the brain; it connects with increase in the urine quantity and the body color change for the repression of the hormone secretion by the direct stimulus to the brain.

The exposure of the ELF magnetic field influences a living body in the various forms, and it can have the possibility to disturb the balance of the inside of the body.

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