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PROPOSAL

for a

STUDY OF THE SENSITIVITY AND RESPONSE OF WEAKLY ELECTRIC FISH TO STATIC AND PULSED MAGNETIC FIELDS

submitted by the

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STUDY OF THE SENSITIVITY AND RESPONSE
OF WEAKLY ELECTRIC FISH
TO STATIC AND PULSED MAGNETIC FIELDS

I. Background.

The study of bioelectrogenesis, particularly in the various species of electric fish, has been of increasing scientific concern in recent years. This interest stems primarily from the potential usefulness of research in this area in contributing to our understanding of a number of fundamental and significant problems. By defining the electric fish's unique sensitivity to electric and magnetic fields, and how it codes and utilizes such sensory information in its detection and navigation behavior, current evidence is providing a more complete concept of such basic questions as migration and territoriality, and is leading toward the development of various bionic devices in the form of underwater sensors and power sources. In addition, knowledge of the effects of magnetic and electric fields on physiological and behavioral processes has assumed great importance in view of man's exposure to drastic changes in such stimuli during space travel.

Living things produce a changing electric field at and near the surface of their bodies; all fish, being sheathed in a conductive substance and living in a conductive medium, produce an electric field that may be detected at relatively great distances. However, there are certain fish which produce electric fields exceeding the norm by hundreds or thousands of degrees of magnitude. The electric eels of the Amazon can produce bursts in excess of 600 volts. Other electric fish, i.e., weakly electric fish, produce continuous fields measured only in millivolts, but by means of interpreting distortions in these fields are able to sense and navigate through their environment to a degree comparable to that of other species in which vision is used for these purposes. The weakly electric fish, having very poorly developed visual abilities, must depend on information acquired through their electric fields in order to survive.

The magnetic field is a form of energy to which all plants and animals are exposed. Its influence on living systems, however, is subtle and not well understood. One approach to studying the effects of magnetic fields upon behavior is through the use of an organism which produces an electric field and uses it as a detection and navigation mechanism. The electric fish is just such an organism, and a one-year study,

of Sternarchus albifrons and S. leptorhynchus,

has demonstrated the feasibility of such work. In these species, impulses are discharged from the tail and received by the head, which becomes positive in regard to the tail. This potential difference creates an electric field about the fish's body, permitting it to detect objects through distortions in the field. Several studies have shown that these fish can perceive a static (constant strength) magnetic field, but only when either the organism or the field is in motion,

therby generating a current in the fish. It was thought that the fish was responding to the current generated in itself by the magnet. However, in these experiments the magnetic field was presented as a static field, and the sensitivity of the fish to a pulsed field presented at various frequencies, praticularly the frequency at which the fish discharges its own electric field (500-1500 cps), was not investigated. Other investigators have shown drastic increase in sensitivity to applied A.C. approximating the frequency of the fish's discharge. In addition, the strength of the field was not systematically varied in terms of the gauss level in the fish's proximity. Therefore, there are considerable gaps in our knowledge of the degree of sensitivity of the fish to magnetic fields at various frequencies and strengths.

I. Completed and Proposed Research.

In order to more clearly define the weakly electric fish's sensitivity and responses to different types of magnetic fields, a study was undertaken on June 1, 1969, in which several individuals of S. albifrons and S. leptorhynchus were obtained, life-support techniques developed, and test and recording equipment purchased and constructed. The fish were tested in a Y maze, T maze, and restraining chamber, and oscilloscope recordings were made of their discharge patterns over time, through variations in temperature, and in response to various drugs including levodopa in a base-line study.

Thier sensitivity to static and pulsed magnetic fields exceeding variations in the earth's magnetic fields was observed over the following ranges of values: between 1 and 10 gauss with a static field; from 0.29 to 82 gauss at 60 cps; and from 10 to 20 Ganss at frequencies of 685-1220 cps. depending on the fish's own frequency. Apparent negative results were obtained with the static field; but the subjects were clearly responsive to the pulsed field at all gauss and frequency levels. In addition, a method was devised to administer the drug levodopa to the fish in order to determine the effects of this agent on their behavior. Two specimens were tested, and the influence of the drug on their electrical and overt behavior noted. However, the data are not complete enough to draw any firm conclusions. Since this study is currently coming to a close, and the positive results which are emerging indicate that further study should provide very meaningful results, it is hoped that the work can be continued. It is proposed that the following lines of investigation be followed:

A. To determine the final absolute and terminal thresholds of the fish's perception of a static magnetic field.
B. To determine the final absolute and terminal thresholds of the fish's perception of a pulsed magnetic field by varying its frequency and strength over a wide range of values.
C. To determine the fish's sensitivity to electric current, as a basis of comparison with his perception of magnetic fields. In addition, to calculate the current generated in the fish by magnetic fields, duplicate these values with an audio signal generator, and compare the results with his performance under the other conditions.

III. Capabilities

staff consisting of 42 full-time and 21 part-time employees and four students working for the Ph.D. degree in information science. Of this number of employees, two have M.D.'s, three have Ph.D.'s and nine have the M.A. or M.S. degree or are otherwise qualified to work at the professional level. The proposed project would be under the irection of

is a doctoral candidate in psychology and is a graduate biologist working for the M.S. degree in ecology.

Laboratory facilities are available

IV. Plan of Procedure.

The work will be accomplished within six months from the effective date of the contract. Five copies of a final report will be prepared and submitted to the contracting agency.

V. Budget - 6 Months.

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A. Personnel.	
Secretary (3%)	
Total Personnel	
B. Fringe benefits* (16.5% S&W)	
Indirect costs (40.00 S&W provisional)	
C. Consultant fees	
D. Travel - local	
E. Reproduction & duplication	
F. Supplies and expendible equipment	
G. Equipment	
Total budget	

* The total salary and wage amount shown herein provides for direct labor effort in the percentages for hours expressed herein for the budget period. The fringe benefit rate is a package rate which provides for several benefits including vacation and sick leave earned