ACTIVITY OF CENTRAL NEURONS OF THE ELECTRORECEPTOR SYSTEM OF
Glyptosternum reticulatum


Two types of electroreceptive neurons — tonic and phasic — were found in acute experiments with extracellular recording of unit activity from the lateral lobes of the medulla in the Turkestan catfish Glyptosternum reticulatum. Tonic neurons were more sensitive to the potential gradient in water (the threshold for most neurons was 1-6 μV/cm) than phasic neurons, they possessed spontaneous activity (mean frequency 4-10 spikes/sec), and their response characteristics depended significantly on the intensity and duration of stimulation. Phasic neurons had no spontaneous activity; their sensitivity was about one order of magnitude lower than that of the tonic neurons, and the response was independent of the parameters of the stimuli. The probable mechanisms of differentiation of neurons into two types, with a possible link with the characteristics of the receptor formations or with the functional organization of the corresponding brain centers, are discussed.

INTRODUCTION

The phenomenon of electrorception, which initially was known to occur only in some electric fishes [10, 11], has more recently been found in a considerable number of species of bony fishes and in practically all nonbony fishes [1, 8, 9, 13, 16]. Quite recently the presence of freshwater fish endemic for the USSR known to have an electroreceptor apparatus [3, 4]. The functional characteristics of the electroreceptors of this fish are to a large degree similar to those of the ampullary electroreceptors of other freshwater fishes. This applies to their sensitivity to electrical stimulation (a threshold of the order of units of microvolts per centimeter), the phasic-tonic structure of the response, anodal type of excitation, and high values of response latencies. The properties of the central structures involved in the transformation of electroreceptor information have not previously been investigated in the Turkestan catfish.

Some functional characteristics of neurons in the lateral lobes (the level of the second neuron) of the medulla of the Turkestan catfish in response to stimulation of the electroreceptor system by a uniform electric field of varied intensity, duration, and direction, were analyzed.

METHOD

Experiments were carried out on Turkestan catfish Glyptosternum reticulatum caught in the River Kara-Dar'ya above Andizhan Reservoir. The fish was immobilized with pentobarbital sodium (1 mg/kg) and fixed to a special frame; aerated cold water (t = 12-14°C) was passed continuously through the gills. After craniotomy, the cerebrospinal fluid was removed under binocular microscopic control. The cranial cavity was filled with mineral oil to prevent drying and to minimize brain pulsations. Unit activity was derived extracellularly from the lateral lobes of the medulla by means of glass microelectrodes (diameter of tip 1-2 μ) with a resistance of 2-10 MΩ, filled with sodium chloride (3M). The reference electrode was placed on the cranial bones near the edge of the burr-hole. Potentials were led to an ac amplifier, monitored visually on the screen of a cathode-ray oscilloscope, and photographed on film. Electrical stimulation was carried out by means of square pulses through a pair of silver...
Fig. 1. Distribution of tonic (a) and phasic (b) neurons according to spontaneous activity. Abscissa, mean spontaneous discharge frequency, spikes/sec; ordinate, number of neurons, n. Black columns indicate neurons without spontaneous activity.

Fig. 2. Responses of a tonic neuron to application of a uniform electric field of varied intensity. a) Poststimulus histograms of unit activity during excitatory response. Bin 10 msec, calibration 5 spikes. b, c) Separate responses of neuron to excitatory and inhibitory stimuli, respectively. Intensity of electric field, in \( \mu V/cm \), indicated between traces. Bottom beam – marker of stimulation. Downward deflection of beam – stimulation by positive current, upward – by negative current (relative to fish's head).

Plates located at the ends of the experimental bath, so that a uniform electric field could be obtained in the space occupied by the fish. The intensity of the field could be controlled in the course of the experiment and varied from 1 to 2000 \( \mu V/cm \).

The quantitative results published in this paper were obtained by averaging responses to 10 identical presentations of the stimulus. Threshold intensity for tonic neurons was taken to be the minimal intensity of the stimulus to which a visible response appeared in 50% of cases; threshold intensity for phasic neurons was taken to be the intensity of stimulation to which a spike response appeared.

With respect to their external morphological features the lateral lobes of the medulla of the Turkestan catfish are very similar to those of the brown bullhead (Ictalurus nebulosus). Just as in the latter, this region is clearly bounded on its lateral side by the wall of the medulla, medially it adjoins the lobes of the facial nerve, while rostrally it is bounded by the cerebellum. Because of the distinct boundaries of the zone the electrode could be introduced directly into the required region under binocular microscopic control.