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BIOCHEMISTRY, BIOPHYSICS, AND MOLECULAR BIOLOGY

Electrical Discharges in Chinese Salamander *Andrias davidianus*

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Abstract—In 2-year-old Chinese giant salamanders *Andrias davidianus,* occasional electric discharges with a characteristic pattern similar to the electric discharges of weakly electric catfish, *Polypterus* and *Protopterus*, were recorded for the first time. The discharges markedly differ in shape from the myograms accompanying abrupt movements of the salamander or exceeded them in amplitude by more than an order of magnitude. The discharges were recorded both in the autonomous experiment in the absence of experimenters and at a weak tactile stimulation.

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Life activity of any organism is accompanied by electrical manifestations. However, the ability to specialized electrical emission has been recognized so far only in fish belonging to certain taxonomic groups.

The criterion was the presence of specific morphological structures (electric organs) and species-specific electrical discharges. The electric organs of the representatives of six groups of fishes—Torpedinidae, Raijdae, Gymnotiformes (including the electric eel *Electrophorus electricus*), Mormyriformes, electric catfish Malapteruridae, and strongly electric *Astroscopus* sp. of the family Uranoscopidae—were described in [1]. In recent years, the list of electric fish has been expanded due to inclusion of the weakly electric stargazers [2, 3]; weakly electric catfish of the families Mochokidae, Clariidae, Claroteidae, Siluridae, and Plotosidae [4–10]; as well as lobe-finned fishes (Sarcopterygii: Protopteridae) [11] and polypterous Polypteriformes [12]. Specialized electrical discharges of these fishes exceed in amplitude the conventional electromyograms and differ from them in the pattern stability. We found no data on the possibility of specialized electrical emission in animals do not belonging to fish (in particular, in the evolutionarily close Amphibia) in the available scientific literature.

This paper describes the results of the first attempt to record specialized electrical discharges in the Chinese giant salamander *Andrias davidianus.* This amphibian draws attention primarily by the fact that, similarly to the well-known weakly electric fishes, it spends most of its life, including spawning, in water, preferring to stay in shelters and other low-lit areas [13]. In addition, it is known that the tailed amphibians have electroreceptors at least at the larval stage [14].

The study was performed with eight pairs of 2-year-old salamanders *Andrias davidianus,* which were kept on the territory of the salamander breeding base of the Shaanxi Hanzhong Tianli company (China, Shaanxi Province). To record electrical discharges, we used two experimental devices that differed in both the hardware implementation and the applicable software. Each device consisted of a aquarium (60 × 40 × 30 cm), recording electrodes placed on opposite walls of the tank, and the recording equipment. Water (electric conductivity 375 μS/cm, temperature 14–16°C) was poured into the aquariums to a height of 25 cm.

In the first device, electrodes were represented by stainless steel plates measuring 8 × 8 cm. In the second device, we used two pairs of graphite electrodes measuring 1 × 1 × 20 cm, placed on the four side walls of the aquarium. This electrode placement scheme allows a more reliable detection of electrical events in any orientation of their source. Both devices, the software, and the recording procedure were described in detail earlier [4, 9, 15].

A pair of salamanders approximately 30–40 cm long, whose sex at this age cannot be determined visually, was placed in each aquarium. Recording was performed in the autonomous mode of fixing electrical events whose amplitude exceeded a threshold value varying during experiments. To emit electrical discharges, the animals were stimulated by slightly touch-

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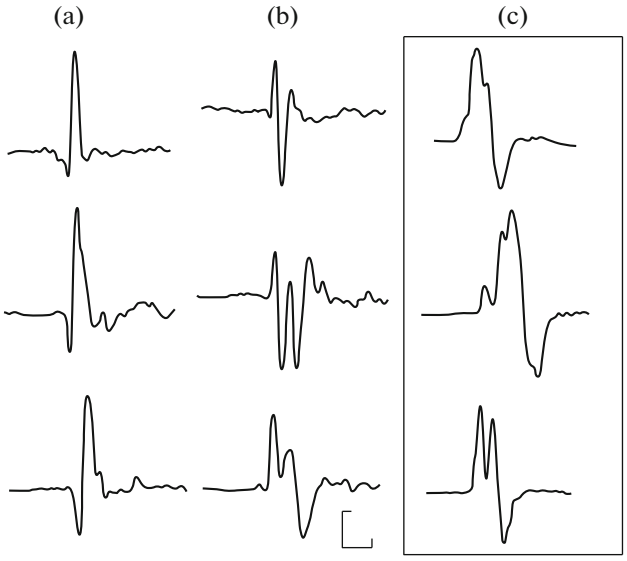

Fig. 1. (a) Biphasic and (b) polyphasic electrical discharges of the Chinese salamander *Andrias davidianus* and (c) electrical discharges of *Protopterus aethiopicu* (modified from [6]). Bar scale in the right lower corner: amplitude 2 mV and time 5 ms.

ing the dorsal surface of the body with a wooden stick. In the dark time, recording was performed without the intervention of experimenters. The detected electrical events were displayed in real time on a computer screen and were saved in the computer memory.

In the daylight time, the behavior of salamanders in the aquarium was calm, they rarely moved along the bottom, remaining motionless for a few minutes. They did not show any aggression against each other.

In the aquariums with salamanders, electric potential oscillations were recorded, which can be divided into two types: (1) electromyograms arising from abrupt movements of animals, the amplitudes of which usually did not exceed 100 μV, and (2) electrical discharges of a characteristic bipolar shape (sometimes more than three of four phases lasting up to 10 ms each) and an amplitude up to 5 mV. When the threshold value was 50 μV, we recorded both myograms and discharges; at a threshold value of 500 μV, only discharges were recorded. In devices nos. 1 and 2 at night after 11:00 p.m. (local time), we recorded two and four discharges, respectively, and several electromyograms. Discharges and myograms were spontaneous, i.e., were not the result of tactile or another stimulation of animals. A small number of electrical events was probably related to the fact that, in this period of life and in the given season, salamanders exhibit low activity and low aggressiveness towards each other.

In response to tactile stimulation, we recorded several dozen discharges of a similar pattern. The pattern of electrical discharges of the Chinese salamander (Fig. 1) resembled the electrical discharges of weakly electric catfish [4, 8], Polypteriformes [12] and Protopteridae [11]. The locomotor response of salamanders to touching was either absent or weak.

The recorded potential oscillations in salamanders definitely differ from the electromyograms emitted by nonelectric fishes during active locomotion. The character of the electrical activity of muscles determines only very weak and primarily chaotic oscillations of the electric field. The duration of the peak component of these low-amplitude pulses is much less than 10 ms. In addition, as can be seen from the presented waveforms, the potential oscillations recorded near the salamanders are characterized not only by a relatively high amplitude but also by a stereotypical pattern of discharges.

On the basis of the results of comparison of these potential oscillations with the electrical discharges of weakly electric fishes of the families Mochokidae [8], Claroteidae [7], Polypteridae [12], and some others [11], the Chinese salamander with a high probability can be classified as weakly electric animals. It is clear, however, that the role of these discharges requires special consideration.

The possible role of discharges that do not play killer of electric protective functions was widely discussed during intensive research of weakly electric fish. At this time, the first studies on the identification of electrical sensitivity of fish were performed and the terms “electroreception” in general and “weakly electric fish” in particular were introduced.

It should also be noted that the electrical pulses emitted by these fishes do not always can be attributed to the implementation of specific functionals (communication, location, spawning behavior, etc.).

A similar situation is faced in the case of the discovery of electric activity in the salamander *Andrias davidianus,* described in this paper. We have attempted to find any information about the possible sensitivity of these amphibians to weak electric fields in the available literature. It was found that receptors (“electroreceptors”) are present in the skin of salamanders only until the stage of metamorphosis and then disappear [14].

Thus, at present, any reasonable hypothesis on the possible role of the detected electrical discharges in *Andrias davidianus* is absent. To clarify this issue, further experimental studies are required, including the behavioral experiments in search for situations when the responses of animals to weak electrical fields may develop synchronously with the signals emitted by them.

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