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SHORT COMMUNICATION

EFFECT OF TEMPERATURE ON THE DISCHARGE RATES OF THE ELECTRIC ORGAN OF SOME GYMNOTIDS*

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Abstract—1. The discharge rates of the electric organs of six species of Gymnotidae, living in the Rio Negro, were between 60 and 1600/sec at 28°C—which was the surface temperature of the river—and had Q_{10}-values of around 1·5.

2. The lower and upper tolerated temperatures were 19–25° and 30–37°C, respectively.

INTRODUCTION

The discharge rates of the electric organs of high-frequency gymnotids are known to be remarkably constant at constant temperatures (Grundfest, 1957; Lissmann, 1958, 1961). Concerning the temperature dependence of the discharge, Lissmann (1958) found that the discharge rate in *Gymnotus carapo* had a Q_{10} of about 1·5 in the 22–32°C temperature range, but at temperatures higher than 33°C the discharge frequency fell. Coates *et al.* (1954) found Q_{10}-values of 1·5 in three gymnotid species. During the 1967 Amazon Expedition of the R/V *Alpha Helix* of the University of California, we had the opportunity to study several species of gymnotids living in the Rio Negro. We felt that an examination at closely spaced temperatures over a range revealing some of the limits of tolerance in the wide variety of species available there, might be of interest.

MATERIALS AND METHODS

The discharge frequency was determined rather crudely by measuring the pulse interval on the oscilloscope screen where the electric organ discharge was displayed. The temperature was changed in steps of 1–2°C by adding colder or warmer water to the container where the fish was kept. The fish was kept at each temperature for a few minutes in most cases, but in several tests this time was extended up to 2 hr without any measurable change in discharge rate taking place. The temperature was measured with a small mercury thermometer having a small heat capacity.

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RESULTS AND DISCUSSION

In newly caught specimens the discharge frequency of the electric organs ranged from about 60/sec in *Sternopygus* sp. to 1600/sec in *Sternarchorhynchus* sp. at 28–29°C which was the surface temperature of the river (Fig. 1). The discharge

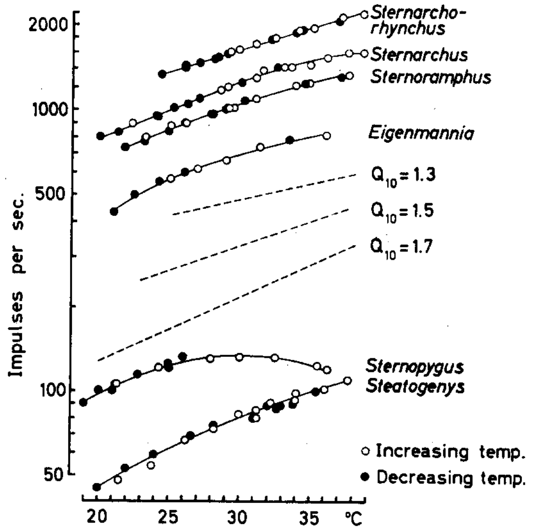

FIG. 1. Relation between the water temperature and the discharge rates of the electric organs of six species of gymnotids. Open and filled circles represent values obtained by increasing and decreasing the water temperatures, respectively. Broken lines giving different Q_{10}-values are added for comparison.

rates in all high-frequency species (*Eigenmannia* sp., *Sternarchus* sp. and *Sternarchorhynchus* sp.) have Q_{10}-values close to 1·5 in the 23–33°C temperature range. For the low-frequency species the Q_{10}-value for *Sternopygus* sp. was 1·3, but the discharge rate decreased for temperatures above 30°C. For *Steatogenys* the value was as high as 1·9 in the 20–30°C and 1·6 in the 27–37°C range. The latter value is probably the most reliable since the lower temperatures had a strong effect on the shape of the discharges as well as on the frequency.

In *Gymnotus carapo*, Lissmann (1958) found that the discharge frequency was dependent not only upon the temperature, but also upon whether a given temperature was reached from a previously higher or lower level. Thus, in the temperature range 30–36°C the discharge rate was about 25 per cent lower at falling than at rising temperatures and had a maximum value of 85/sec at 33°C reached from below. In contrast to this finding, we could not observe any hysteresis between values for discharge rates obtained for increasing and decreasing water temperatures. Since the discharge rates in repeated tests were reproducible only within 1–2 per cent in the high-frequency species and within 5–6 per cent in the low-frequency ones, the possibility for a hysteresis cannot be excluded. In fact, a small hysteresis has been observed by Bullock (1958) by using an accurate frequency meter and a thermistor thermometer. In the present experiments, a deviation of 1–2 per cent would certainly be hidden in the poor accuracy in reading temperatures and time intervals on the oscilloscope screen.

The temperature tolerance was different for the various species. Thus, specimens of *Sternarchorhynchus* sp. died at temperatures below 25°C while *Sternopygus* sp. easily tolerated 19°C (Fig. 1). On the other hand, the first species showed no signs of discomfort at 37°C, while in *Sternopygus* the discharge rate decreased with increasing temperatures above 30°C. The other species studied had tolerance limits in between these two temperatures (Fig. 1).

In experiments on *Sternarchus*, the temperatures of the head and trunk were changed independently, and it was found that the rate of organ discharges varies with the temperature of the head and not of the trunk—as was also the result of Coates *et al.* (1954). There can be little doubt that it is the temperature of the pace-maker in the brain (Szabo & Enger, 1964) that determines the discharge rate, because the time delay between a change in temperature and a change in discharge frequency is rather long. Jets of water from a glass pipette directed towards the head of the fish elicited a change in discharge rate in 5–12 sec, depending on the temperature difference between the jet of water and the water in the container. This time delay is much too long for assuming that the temperature of the skin receptors plays a role in determining the discharge rate of the electric organ.

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