An Experimental Study of the Peripheral Auditory Mechanics in the Goldfish (Carassius auratus) and Oscar (Astronotus ocellatus)

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Abstract: Frequency responses of peripheral auditory organs in the goldfish (Carassius auratus) were measured in vivo using an underwater non-contact, noninvasive ultrasonic system. Measurements were made in both species with swimbladders intact and swimbladders deflated. Results indicate that the swimbladder controls auditory bandwidth not only in the goldfish, but also in the oscar which has no special coupling between the swimbladder and inner ear. Measured displacement of the saccular otolith relative to its sensory epithelium in both species correlates with auditory thresholds reported in the literature.

INTRODUCTION

The purpose of this study was to determine the characteristics of the dynamic response of the peripheral auditory organs in the goldfish (Carassius auratus) and the oscar (Astronotus ocellatus). The former is considered a hearing “specialist” because it has an extension of the spine, the Weberian ossicles, that directly couples the swimbladder to the saccule the inner ear. The latter has no special coupling and is deemed a “non-specialist.”

EXPERIMENT

A noncontact, noninvasive ultrasonic system (1, 2) was used to measure the amplitude and phase of the motions of the peripheral auditory organs in response to pure tones at frequencies ranging from 200 to 3000 Hz. Experimental trials were conducted in a small swimming pool, approximately 0.5 m deep and 2.4 m in diameter. Each fish was anesthetized, tethered, and suspended in the water from a post that was fixed to a computer-controlled positioning system. A low-frequency, harmonic sound field was produced in the pool using a Naval Research Labs Type J-9 transducer. The amplitude and phase (with respect to the low-frequency excitation) of the induced motion of each peripheral auditory organ was obtained along the medial-lateral axis by demodulating the phase-modulated echo resulting from ensonifying it with a 15 MHz continuous wave beam. Measurements were made in both species with swimbladders intact and swimbladders deflated. Deflation was verified by X ray.

RESULTS

Thirty-two goldfish and 38 oscars of similar size were examined. Fig. 1 shows typical frequency responses of the swimbladder chambers and saccular otoliths in the goldfish and oscar. These data indicate that the motion of the saccular otolith is controlled by the dynamic motion of the swimbladder in both species. Fig. 2 shows that the saccular otolith in the goldfish has some induced motion transmitted through the Weberian ossicles even with a deflated swimbladder. This implies that the Weberian coupling may aid audition in the absence of a swimbladder.

CONCLUSIONS

The frequency ranges of the measured motions of the swimbladders and saccular otoliths in both species correspond to auditory bandwidths reported in the literature (3). This indicates that the swimbladder plays a primary role in fish hearing in auditory “non-specialists” as well as “specialists.”
FIGURE 1. Typical frequency responses of the (left) goldfish anterior (GF - ASB) and posterior (GF - PSB) swimbladders, and oscar (OS - SB) swimbladder, and (right) the oscar and goldfish saccular otoliths.

FIGURE 2. Typical frequency responses before and after deflation of the swimbladder in the goldfish: A. motion of the largest Weberian ossicle, the tripus (TR), and B. motion of the saccular otolith (SA)

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REFERENCES