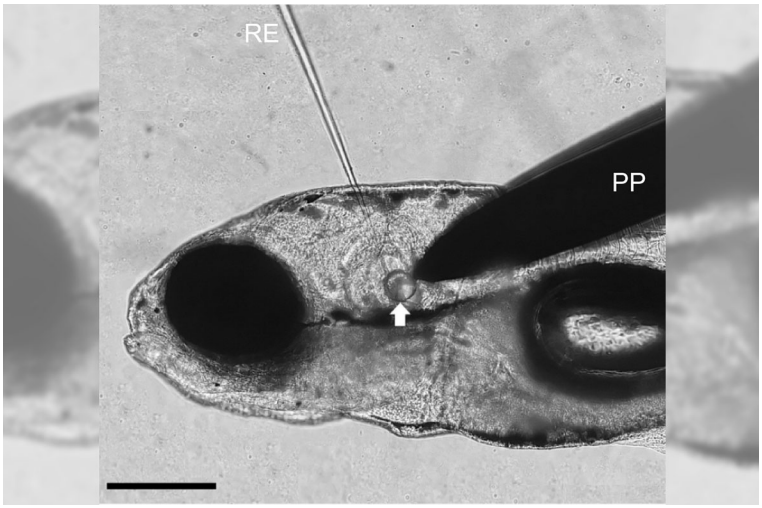
INSIDE JEB

Loud noise in early development wrecks zebrafish hearing



Testing the hearing of a 5 dpf larva by stimulating the inner ear otolith with a vibrating probe (PP) and recording electric signals from the hair cells with an electrode (RE).

It used to be rare to see people in noisy industrial situations wearing ear defenders. Now, bulky ear protection is everywhere, as we appreciate the damage that can be done to hearing even after short periods of loud sound. But are other species also falling prey to human noise pollution encroaching on their environments? 'Few studies have evaluated long-term noise effects on animal health and even less have focused on early critical periods for the development and establishment of adult characteristics', says Raquel Vasconcelos from the University of Saint Joseph, Macao, China, who, with Rafael Lara (University of Saint Joseph) began wondering what impact loud sound might have on the developing ears of zebrafish larvae. 'Zebrafish have become an important model to investigate the mechanisms of inner ear development and hair cell development', says Vasconcelos, adding that this made the embryos an ideal candidate for the investigation.

Lara played loud (150 dB) white noise to the developing embryos for the first 3 and 5 days post-fertilisation (dpf) of the eggs, then collected the zebrafish larvae around the time of hatching (3 dpf) and 2 days later (5 dpf), the age at which they begin to flee when startled. '150 dB is a sound amplitude [volume] representative of freshwater habitats characterized by anthropogenic noise activity such as shipping', says Vasconcelos. Then, Lara tested the youngsters' hearing by recording the electrical signals produced by their ears as they listened to 100, 200, 300 and 400 Hz beeps. Although the hearing of the 3 dpf embryos didn't suffer too badly, that of the 5 dpf embryos was quite badly affected, especially when listening to the two deeper beeps; their hearing sensitivity plummeted by ∼7 dB. But what impact would this hearing loss have on an embryo's ability to escape a threat?

This time, Lara, with colleagues from Macao and from South University of Science and Technology in mainland China, played the 5 dpf larvae a series of soft beeps, at either 100 or 200 Hz, before startling them with a loud (150 dB) beep at the same pitch while filming their reactions. The team realised that the loud noise experienced by the larvae as they developed had made them more sensitive to startling sounds, nipping off 41% faster (∼6 mm s^{-1} at 100 Hz and ∼8 mm s^{-1} at 200 Hz), compared with larvae that had developed without the persistent loud noise (∼4 mm s^{-1} at 100 Hz and ∼6 mm s^{-1} at 200 Hz).

Finally, the team was curious to find out how loud noise affected the structure of the larvae's inner ears. When they viewed the sound-sensitive hair cells in the tiny fish inner ears, in addition to losing ∼21% of their hair cells at 3 dpf (down from 49 hair cells to 38 in fish that developed in a noisy tank) the fish also lost 19% of their hair cells at 5 dpf. The total area of the inner ear that can sense sound was also smaller in the fish from a noisy tank.

The young fish that developed in a noisy environment had definitely suffered hearing loss as a result of their loud upbringing. 'The results reveal noise-induced effects on inner ear structure–function in a larval fish', says Vasconcelos, adding that it is essential to find out how noise impacts developing youngsters, as they may suffer the consequences for the rest of their lives.

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Lara, R. A., Breitzler, L., Lau, I. H., Gordillo-Martinez, F., Chen, F., Fonseca, P. J., Bass, A. H. and Vasconcelos, R. O. (2022). Noise-induced hearing loss correlates with inner ear hair cell decrease in larval zebrafish. *J. Exp. Biol.* **225**, jeb243743. doi:10.1242/jeb.243743

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