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School Sharks (Galeorhinus Galeus) Have Inner Ear Maculae that are on the Rise

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Abstract

Fundamental knowledge regarding the early development of vertebrate hearing can be gained from research on fish auditory systems. Although elasmobranchs hold a crucial basal position in the evolution of vertebrates, there is comparably little information available regarding their auditory systems compared to that of bony fishes. Although the neurological system is highly malleable, little is known about how the many sensory epithelia in the inner ear of elasmobranchs change over the course of a lifetime. In the saccule, lagena, utricle, and macula neglecta of school sharks (Galeorhinus galeus) of various body sizes, we measured macular area, the quantity of sensory hair cells, hair cell density, and hair cell orientations using immunohistochemistry and fluorescence microscopy. Macular area and the total number of hair cells significantly increased in all maculae throughout ontogeny, although hair cell density showed a parallel ontogenetic decline (excluding the utricle). The four maculae also differed significantly in terms of macular area, hair cell quantity, and hair cell density. However, the orientation patterns of hair cells did not differ between people or alter as the body grew. These results demonstrate morphological alterations that may have ramifications for hearing ability over ontogeny and are among the most thorough characterizations of the inner ear sensory epithelia in an elasmobranch.

Keywords: Inner ear maculae; Sharks; Ontogeny

Introduction

The size, form, and complexity of auditory organs are highly diverse in fishes, a group of speciose vertebrates Since many of the early developmental stages in fish are generally shared by vertebrates, characterising this morphological variation can reveal important details regarding the history of vertebrate hearing. Additionally, fish can provide information about auditory systems that may help distinguish mechanisms underlying ontogenetic changes in auditory capacity throughout life in vertebrates because their auditory structures continue to develop from embryonic through adult life stages For cartilaginous fishes (Chondrichthyes), studies on the ontogenetic development of inner ear structures are much less common than for bony fishes (Osteichthyes). [1, 2]

Methods

Sample collection

Twenty-one G. galeus, measuring between 40.8 and 160.0 cm in total length, were taken from nearby commercial fishers in Leigh, New Zealand (13 female, 8 male). School sharks can grow up to 175 cm in total length after reaching sexual maturity at 125–135 cm for males and 135–140 cm for females. School sharks are born at a total length of about 30-35 cm (Francis and Mulligan, 1998). Each animal's sex and overall length, to the nearest 0.1 cm, were noted [3].

Ontogenetic changes

Studies on the development of the fish auditory system have shown that, in both bony and cartilaginous fish, the inner ears continue to develop. This growth is typically accompanied by an increase in the size and number of sensory epithelia.

However, not all species exhibit these findings, with some exhibiting an increase in hair cell density. The extent to which these patterns are consistent across taxa is unknown given that ontogenetic data on the inner ear are only accessible for a tiny portion of the approximately 34,000+ (fishbase.org) species of fishes.

The majority of fish auditory system research has focused on bony fish; cartilaginous fish inner ear anatomy and hearing capacity are far less well understood. Since they diverged over 400 million years ago, elasmobranchs, which include sharks, rays, and skates, make up about 95% of the chondrichthyan species see 2022 for review. Elasmobranchs, which are primitive gnathostomes, present a chance to research an early stage in the evolution of hearing in vertebrates. They are, however, comparatively understudied compared to other species due to factors like their vast body size, the expense and practicality of capture, and the difficulties of maintaining them in captivity [4, 5].

The saccule, lagena, utricle, and macula neglecta are the four hearing end organs found in nearly all fishes' inner ears (both bony and cartilaginous fishes), together with a smaller macula neglecta in some fishes While the macula neglecta has a gelatinous cupula overlying its macula which is composed of two epithelia in some species, the saccule, lagena, and utricle are all made up of a sensory epithelium (macula) overlaid with an otoconial mass (otolith or otoconia) The macula and otoconial mass perform the role of a differential accelerometer, that is, a mass that moves in relation to a receptor and reacts to sound-induced movements.

In essence, the otoconial mass moves differently from the sensory hair cells (HCs), which shears the HCs and causes a reaction from the neurological system It is believed that the macula neglecta uses its gelatinous cupula to function similarly to the other end organs [6,7,8].

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Discussion

The school shark, Galeorhinus galeus, is a basic fish species that exemplifies some of the earliest stages of vertebrate evolution. This study assessed ontogenetic alterations in the inner ear maculae of this fish species. The findings showed that all hearing end organs had ontogenetic increases in macular area and hair cell quantity (HCT), but the saccule, lagena, and macula neglecta had contemporaneous decreases in hair cell density (HCD). The macular area, HCD, and HCT varied significantly among the four hearing end organs. [9, 10].

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Potential Conflict of Interest

No conflict or competing interests in the publication of this paper.

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