Stony Brook University
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Abstract

The Semicircular Canals of Birds and Non-avian Theropod Dinosaurs

By

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The invasion of aerial habits by primitive birds involved massive reorganization of neurological and sensory systems, many of which are coordinated in the brain by vestibular cues from the semicircular canals. These organs sense angular accelerations experienced by the head and body with every movement. Canal signals are combined with visual and somatosensory inputs and are used to generate a wide-range of reflexive behaviors necessary for stabilizing gaze, maintaining posture, and coordinating body movements. This thesis focuses on understanding the relationship between locomotor behavior and vestibular function in birds and non-avian theropod dinosaurs, both from a comparative and functional perspective. The otic capsules of 178 species of extant birds and 15 species of non-avian theropods were scanned using computed tomography (CT) and the vestibular structures reconstructed and measured from digitally prepared volumes. The morphology of the semicircular canals in non-avian theropods and many flightless birds is shown to reflect their status as bipedal cursors, while the pattern seen in volant avians is found to correlate strongly with different flying behaviors. Independent measures of aerobatic maneuverability, such as wing loading and wing aspect ratio, also correlate with canal morphology, demonstrating that, at least in flying birds, larger and thus more sensitive canals are possessed by agile species flying at slower speeds. Freed in air from the need for intermittent contact with a surface substrate, birds can employ a wider repertoire of body movements during locomotion, including forms of rotation that would be improbable on land. In the absence of somatosensory cues from postural interactions with the ground, it is argued that these movements place increased demands on the vestibular system of avian fliers. Investigation into the size and shape of avian semicircular canals permits evaluation of the mode of flight employed by primitive avialans, like Archaeopteryx, shedding light on some of the broader neurophysiological adaptations to flight behavior that characterize bird evolution.

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