9th International Meeting on the Secondary Adaptation of Tetrapods to Life in Water

Virtual Meeting

CHILE

April 19-23, 2021

ABSTRACT BOOK

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FINGERS ZIPPED UP OR BABY MITTENS? TWO MAIN TETRAPOD STRATEGIES TO RETURN TO THE SEA

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The application of network methodology in anatomical structures offers new insights on the connectivity pattern of skull bones, skeletal elements, and their muscles. Anatomical networks helped understanding better the water-to-land transition and how the pectoral fins were transformed into limbs via their modular disintegration. Here, we apply the same methodology to the forefins of 19 tetrapods that have been secondarily adapted to the marine environment, including turtles, ichthyosaurs, mosasaurs, plesiosaurs, metriorhynchid crocodylomorphs, and mammals (whales, dolphins, sea lions, seals, and sea cows). We find that these animals achieved their return to the sea with four types of morphological changes, which can be grouped into two different main strategies. In all marine mammals and the majority of the reptiles the fin is formed by the persistence of superficial and interdigital connective tissues, like a “baby mitten”, whereas the underlying connectivity pattern of the bones does not influence the formation of the forefin. These tetrapods managed to explore regions outside the known morphospace, attempting higher disintegration of the limb or some moderate reintegration — but without losing their digits. On the contrary, ichthyosaurs “zipped up” their fingers and transformed their digits into carpal-like elements, forming a homogeneous and better-integrated forefin, showing a costly reintegration of their limb to a modular pattern that is analogous to fishes, with the addition of interdigital bony elements and lateral connections. These strategies led these vertebrates into three different macroevolutionary paths exploring the possible spectrum of morphological adaptations. Mosasaurs and plesiosaurs placed new limits in the disintegration of the limb, by adding numerous new phalanges on their digits, increasing its modularity, while reducing its density and integration. Marine crocodiles, and possibly basilosaurids, lost elements and increased connections of the metapodials, resulting in forefins that were more complex and better integrated. The most impressive changes are noted in the forefins of ichthyosaurs, who reintegrated their digits into the mesopodium with the addition of anterior and posterior contacts and articulations. Their metacarpals and phalanges radically adopted the connectivity pattern of carpal bones (increased clustering, betweenness centrality, and degree), forming forefins that were highly integrated and homogeneous. However, this strategy allowed ichthyosaurs to have forefins that did not lose much of their modularity. Anatomical networks help understanding that all these secondary adaptations to the marine