論文内容の要旨

PALEOECOLOGY AND EVOLUTION OF SHARKS: THEIR VENTILATION SYSTEM, FEEDING BEHAVIOR AND SWIMMING CAPABILITY

(サメ類の古生態と進化：彼らの呼吸システム、摂食様式、遊泳能力)

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Active-swimming and benthic modes are the two fundamental lifestyles of aquatic vertebrates. This study has focused on elasmobranchs (sharks and rays), a large group of primitive vertebrates, and has clarified the evolutionary process of these two modes. In order to distinguish between the active-swimming and benthic lifestyles of extinct sharks, three features (ventilation systems, feeding strategies, and swimming capabilities) were reconstructed. Ventilation systems of extinct sharks can be reconstructed by their gill-arch morphologies. In extant sharks, benthic sharks tend to have an “active-ventilation system” (they have water- pumping capabilities for breathing) or the active-swimming type, a “passive-ventilation system” (they do not have water-pumping capabilities and can only breathe by sustained swimming). Gill-arch morphologies of extant sharks suggest that the proportions of skeletal elements of gill arches can predict the presence/absence of water pumping capabilities for breathing of extinct sharks. Feeding strategies can be reconstructed by ceratohyal cartilage (“tongue” cartilage) morphologies. Benthic sharks tend to have “suction-feeding” behavior, whereas active-swimming sharks have “ram-feeding”. Ceratohyal cartilages of extant sharks suggest that stiffness of ceratohyal cartilage is a good indicator of suction capability, and thus we can predict the feeding strategies of extinct sharks based on the stiffness of their ceratohyals. Scale morphology also provides important information for determination between active-swimming and benthic, because shark scale morphology reflects their swimming capabilities. Most of the active-swimming sharks have scales on which parallel ridges are aligned in the stream-wise direction. These ridges are known to function in reducing turbulent skin friction. The spacing between ridges is strongly correlated with the shark swimming speed, and thus swimming speeds of fossil sharks can be estimated based on this spacing. In addition, benthic sharks tend to have spine-shaped or multicusped scales which are expected to be advantageous for protection against parasites or for sustaining mucus on their body surfaces. Hence, scale morphology can be use to predict swimming capabilities of extinct sharks.

Based on these three reconstructed ecologies of extinct sharks (ventilation systems, feeding strategies, and swimming capabilities), active-swimming/benthic lifestyles of extinct sharks can be determined. Primitive “Paleozoic sharks” (cladodont and ctenacanthid sharks) are here reconstructed as being the active-swimming type, and from this state, benthic lifestyles independently evolved in three lineages; Hybodontiformes, Galeomorphii, and Squalea. Order-level diversification suggests that benthic sharks diversified during the Jurassic Period. This diversification in benthic sharks coincided with the timing of the breakup of the Supercontinent Pangea, which suggests that this great increase in shallow tropical oceans might have triggered the evolution of benthic lifestyles.