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THE SEAHORSE TAIL AS INSPIRATION FOR SERIALLY ARTICULATED SYSTEMS

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Seahorses and pipehorses both possess a prehensile tail, a unique characteristic among fishes, allowing them to grasp and hold onto substrates. Syngnathid fishes, to which seahorses, pipehorses, pipefishes and seadragons belong, are characterized by a body armor of dermal bony plates. These plates form a serially articulated system that encloses the vertebral column and its musculature. In the ancestral condition, as observed in pipefish, the whole surface of the tail is covered with plates, making it a rigid structure with limited flexibility, mainly used for steering (pipefishes use their pectoral and dorsal fins for swimming). During evolution, this rigid tail became modified into a grasping apparatus multiple times independent in seahorses and multiple lineages of pipehorses. Our starting hypothesis states that there is a relationship between the organization and form of these dermal plates and the flexibility of the tail. The tail morphology of the different studied species was studied by combining µCT-scanning, phase contrast synchrotron scanning and histological sections with virtual 3D reconstructions.

In order to better understand the structural basis of the different tail grasping mechanics, a parameterized model of the seahorse tail was developed. By combining multibody dynamics analysis with finite element analysis, we analysed the implication of partial contribution of epaxial and hypaxial myomere contraction, versus ventral median muscle contractions, as well as aspects of the bony plate geometry. Passive bending patterns and resting tail positions were determined using resp. cleared and stained specimens and living animals. The analyses showed that several characteristics influence particular aspects of bending kinematics, which can explain how seahorses control for ventral versus lateral bending. Using this seahorse model, the morphological variation in the caudal system in syngnathid fishes can be further analysed to test hypotheses on adaptive evolution towards tail grasping, as well as to develop biomimetic designs of serially articulated systems that meet particular application demands related to traits such as strength, rigidity and flexibility.