

Pseudo-4D visualization of the seahorse larva head during ontogenesis

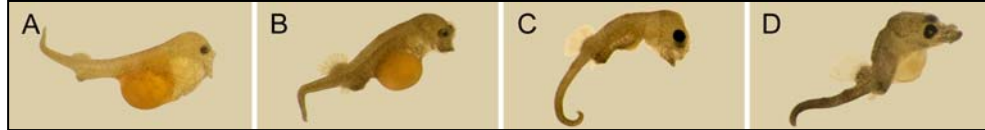


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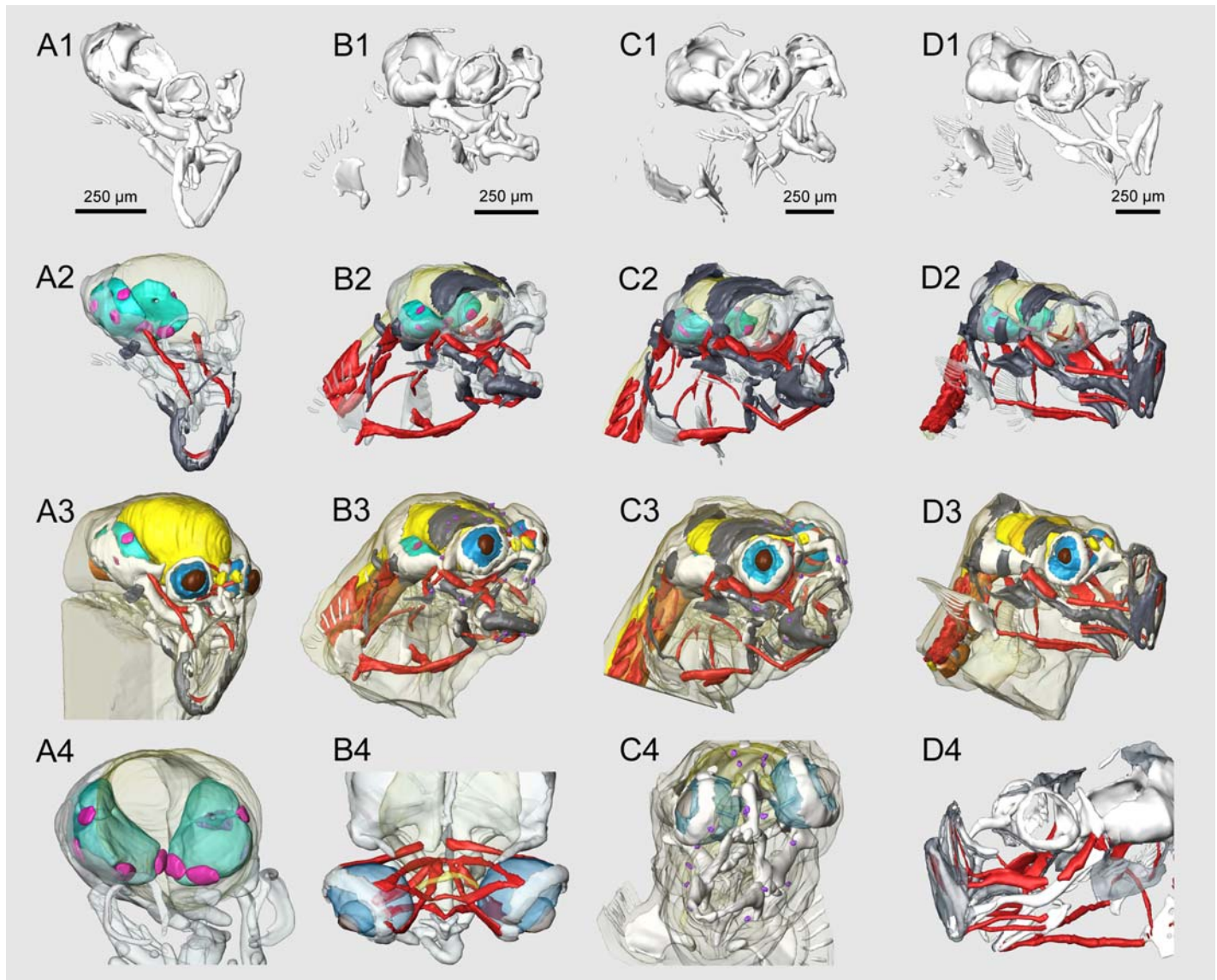
Introduction

The developing seahorse larva passes through a remarkable formation of its head morphology. At hatching, the seahorse larvae look similar to the larvae of many teleost species, with a voluminous yolk sac and a short "snub nose". During development in the male brood pouch the larvae shape up towards the erected seahorse habit with its typical elongated snout. The possibilities of digital imaging encouraged us to investigate the head microanatomy of *H. cf. reidi*.



Material & Methods

Serial semithin sections through the heads of four larval stages of the seahorse *Hippocampus cf. reidi* (released from the brood pouch at the same time) were made from the snout-tip to the back of the head. 3D surface renderings of selected organ systems were generated with the Amira® visualization software based on digital light micrographs after precise alignment and manual segmentation. Figures were arranged with Photoshop.



Results

The lifelike digital models, together with the sections, allow a detailed sterical insight into the growth and differentiation of the seahorse head.

E.g. the increasing complexity of the chondrocranium, the ossification of the skull, the development of muscles and their insertion points, the rapid snout elongation and changes concerning mouth bearing and the orientation of eye axes get visible.

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3D-renderings of different organ systems of the larval seahorse head

A – D: Four selected larval stages of *Hippocampus cf. reidi* (bars = 250 µm). 1: chondrocranium; 2: chondrocranium, osteocranium, muscles, brain, labyrinth with sensory epithelia; 3: synopsis of all organs reconstructed in 3D; A4: labyrinth with sensory epithelia; B4: eye muscles and optic nerves; C4: supraorbital neuromasts in the epidermis; D4: chondrocranium and osteocranium with jaw muscles.

chondrocranium: light grey; osteocranium: dark grey; muscles: red; labyrinth: turquoise; sensory epithelia: magenta; brain, olfactory epithelia, optic nerves: yellow; retina: blue; lens: dark brown; chorda: light brown; neuromasts: purple;

Discussion

The seahorse is one of many impressive examples for the specialization of the teleost groundplan during adaptive radiation. Digital tomographic reconstruction opens the door to

an understanding of complex morphological constellations of tiny, more or less transparent anatomical structures in 3D and the interdependent changes of single elements in space and time (4D). The data set created in this study allows to display organ systems of the seahorse head in any combination, transparency and perspective at different developmental stages – sort of handling a virtual "transparent fish" in space and time.