Comparative 3D-Microanatomy of the Central Nervous System in Coleoid Cephalopod Hatchlings

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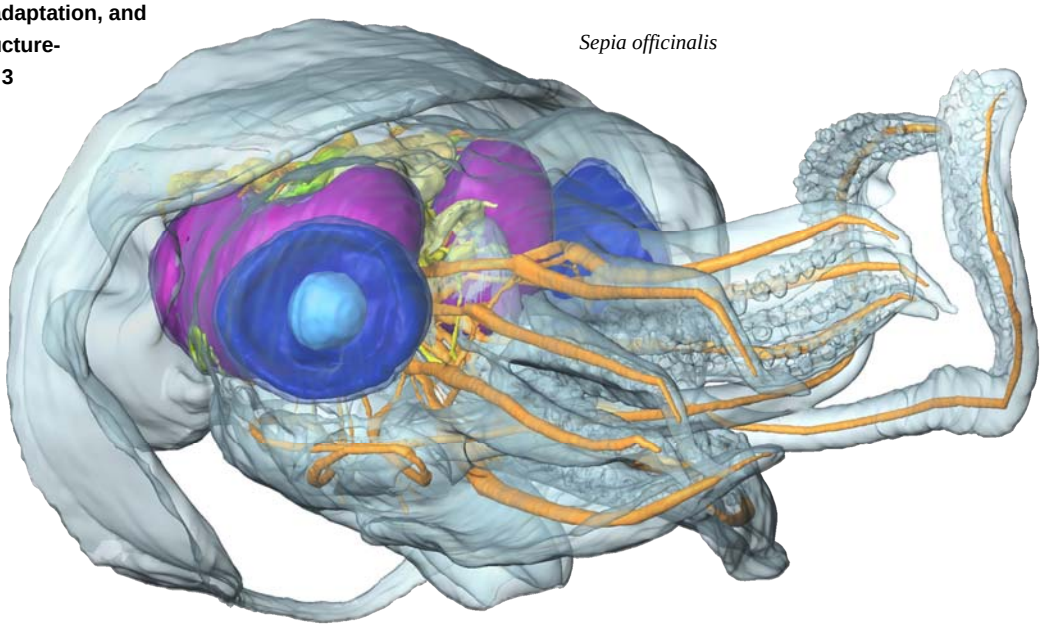
Introduction

After hatching, cephalopod paralarvae interact with the environment under the control of their sense organs (e.g. eyes) and their highly developed central nervous system. Interspecific differences concerning size, internal organization, and developmental stage of the CNS lead to differing integrative capabilities and behavioural patterns. To learn about interrelations between structure, function, adaptation, and evolution we acquired 3D structure-data of the cephalopodium of 3 coleoid cephalopod species (*Loligo vulgaris, Sepia officinalis, Octopus vulgaris*) with light microscopic resolution.

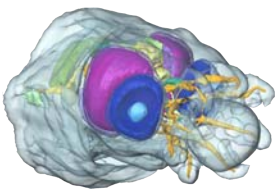
Material & Methods

Glutaraldehyde fixed cephalopod hatchlings were embedded in epoxy resin. Complete semithin section series (2 µm) were cut in transverse planes from the tentacle tips to the posterior end of the optic lobes. Digital light micrographs of the slices were aligned, segmented, surface-rendered, and analyzed with Amira® 3D software.

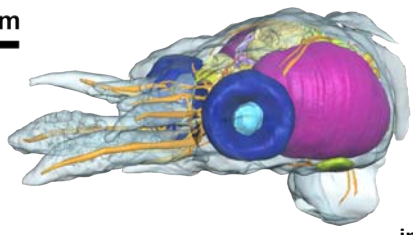
Sepia officinalis



Octopus vulgaris



500 µm



Loligo vulgaris

Results

With the help of the virtual 3D models obtained that way the complex structures of the central nervous systems can be displayed and compared qualitatively and quantitatively: The three investigated species have many lobes and nerves in common, whereupon *Octopus* has the smallest and *Sepia* the largest total volume. In *Octopus* the CNS is most compact, with notably short connections between brachial, buccal, pedal, and frontal lobes (Figs. A-C). The two decabrachian species in turn have conspicuous anterior chamber organs and show differences concerning innervation of the funnel and the oculomotor system. In *Loligo* two noticeable distinct plexiform layers can be observed in the optic lobes (Figs. D, E).

Discussion

Recent bio-imaging methods (navigating through aligned histo-logical slice series, handling interactive surface models, voxel based volumetry) render an in-deep comparative analysis of tiny and complex nervous systems possible in high resolution and stimulate functional interpretations: Structural differences in the visual system of yolk-feeding *Octopus* hatchlings and the decabrachian visual pre-dators are interpreted quite easily. Distinctions between *Loligo* and *Sepia* are more subtle and require more information about their visually guided behaviour.

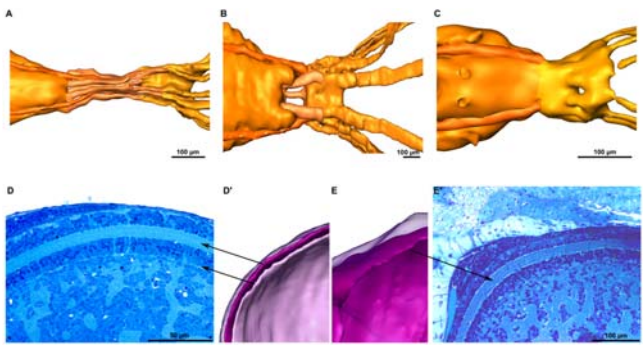
Figures

A-C: ventral view of suboesophageal CNS (3D renderings of neuropils only)

A *Loligo vulgaris*
B *Sepia officinalis*
C *Octopus vulgaris*

D plexiform layers in the optic lobe of *L. vulgaris* (LM)
D' plexiform layers in the optic lobe of *L. vulgaris* (3D)

E plexiform layer in the optic lobe of *S. officinalis* (LM)
E' plexiform layer in the optic lobe of *S. officinalis* (3D)



Volumina [mm³]	*Sepia officinalis*	*Loligo vulgaris*	*Octopus vulgaris*
total	17.06	1.113	0.655
eyes	0.957	0.124	0.038
lenses	0.106	0.006	0.002
retinae	0.382	0.086	0.018
optic lobes	1.964	0.297	0.056
suboesophageal lobes	0.447	0.069	0.025
supraoesophageal lobes	0.445	0.094	0.024