# Coleoid Cephalopod Retinae – A Comparative Morphological Approach

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## Introduction

Morphological and morphometrical investigations of visual systems provide structure data that allow the derivation of probable visual functions and their adaptation in terms of visual ecology. The photoreceptor size can be interpreted as proportional to sensitivity, the photoreceptor density as proportional to visual acuity. Interspecific differences can result from disparate habitats and/or habits during adaptive radiation, e.g. diurnal/nocturnal activity or shallow/deep water dwelling. Stimulated by the well known conditions in teleosts (see e.g. Lythgoe 1979) it seemed worthwhile to approach a comparative study on cephalopod retinae to find analogous interdependencies between structure and habitat, habit or phylogenetic relation.

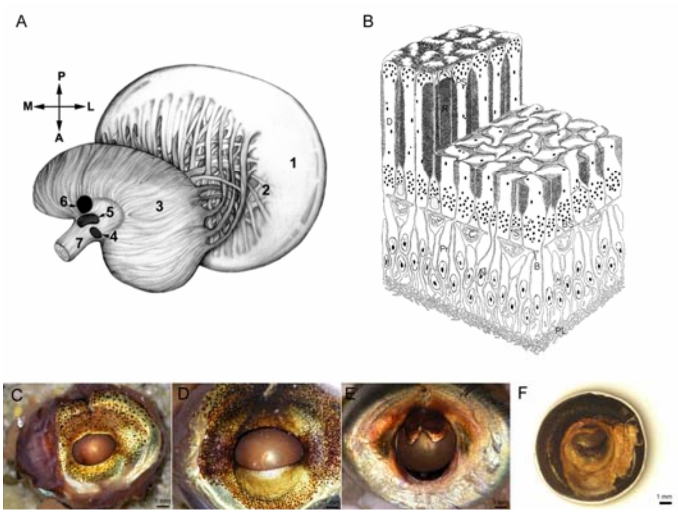


**Figure 2: Coleoid cephalopod eyes (+ retinal fine structure)**

**A:** Schematic drawing of an *Octopus* eye (back view, from D'Este et al. 2008), **B:** Schematic drawing of an *Octopus* retina (from Yamamoto et al. 1965) , **Isolated eyes: C:** *Eledone cirrhosa,* **D:** *Octopus vulgaris*, **E:** *Sepia officinalis,* **D:** *Sepietta neglecta*

## Results

Longitudinal sections through the retinae of all examined species (figs. 3A-C) show the characteristic stratification of the photoreceptors with proximal and distal segments, supporting-cell nuclei in between and the plexiform layer close to the eye cartilage (see Yamamoto et al. 1965). The length of distal segments (containing the rhabdomers) varies strikingly with retinal location, culminating in a horizontal streak near the eye-equator (figs. 4A1/B1/C1/D). Tangential sections at the level of the distal segments (figs. 3D/E) show the photoreceptor profiles for enumeration. The corresponding density maps show horizontal streaks (figs. 4B2/C2) or an area (fig. 4A2) of increased density, more or less concurrent with the topography of distal segment lengths.

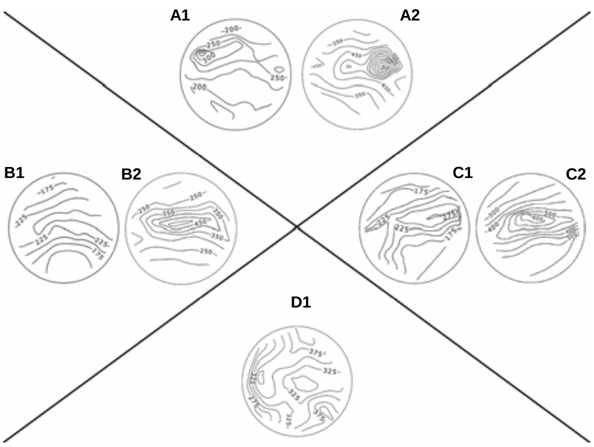


**Figure 4: Photoreceptorlength and density distribution maps of coleoid cephalopods**

**A:** *Sepia officinalis*, **B:** *Octopus vulgaris,* **C:** *Eledone cirrhosa,* **D:** *Sepietta neglecta;* **1:** distal segment length distribution, **2:** photorezeptor density distribution

**Acknowledgements**:
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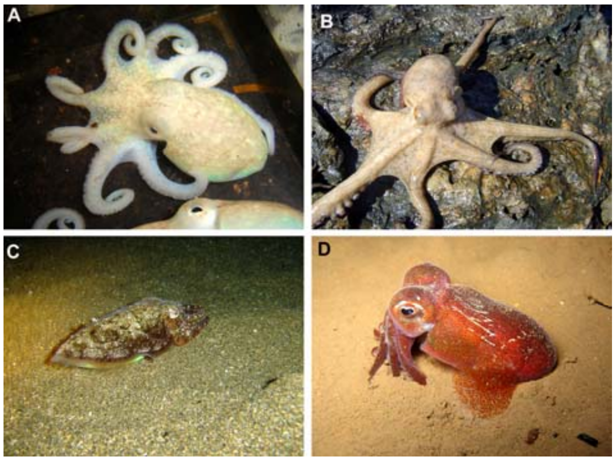


**Figure 1: The four examined coleoid cephalopod species**

**A:** *Eledone cirrhosa,* **B:** *Octopus vulgaris*, **C:** *Sepia officinalis,* **D:** *Sepietta oweniana*

## Material & Methods

We investigated the retinae of four coleoid cephalopod species collected from the Mediterranean off Banyuls-sur-mer (France), two from shallow water: *Octopus vulgaris* and *Sepia officinalis* and two from greater depths: *Eledone cirrhosa* and *Sepietta neglecta*. Eyes were excised, fixed in buffered glutaraldehyde and sub-sequently each retina was dissected into 24 pieces. The retina fragments were bisected, embedded in epoxy resin and cut in radial and tangential direction respectively. Semithin sections were used to demonstrate retinal histology, to measure layer extensions and to determine photoreceptor densities. Ultrathin sections were made to investigate fine structures. To plot retinal maps of various morphological characters (e.g. distal segment length and photoreceptor density)
the polar coordinates of each measured value were determined and isolines were calculated after linear interpolation with a self-made computer algorithm (IDL).

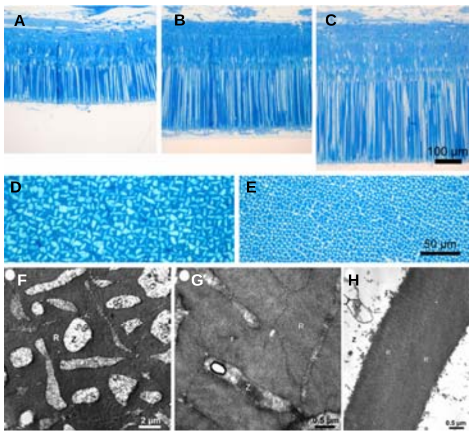


**Figure 3: Histology and fine structure of coleoid cephalopod retinae**

**A-E:** *Octopus vulgaris* retina, histological sections. A-C: radial, D/E: tangential,
**F-H:** *Sepia officinalis* retina, fine structure, F/G: horizontal, H: radial.

## Discussion

The two complex retinal characters determined here (distal segment length- and density-distribution) expand the data given by Young (1963). They point at an in-creased visual acuity without loss in sensitivity in the central to temporal visual field and a corresponding attention focus in the examined octobrachia. Different dwelling depths evidently had no morphogenetic effect. The small and steep area in *Sepia* may sub-serve a precise visual distance determination during binocular fixation before prey-strokes, thus representing an adaptation to the hunting behavior of decabrachia. The deviating structure of the *Sepietta* retina may be connected with the buried way of life, but more data are needed for a solid interpretation.

**Literature:**
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Lythgoe JN1979 - The ecology of vision. Clarendon Press, Oxford, 270 p.
Yamamoto T et al. 1965 - Fine structure of the octopus retina. Journal of Cell Biology 25: 345-359.
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