Keeping nerves – Central nervous system of the acochlid *Parhedyle cryptophthalma* (Gastropoda, Opisthobranchia)

Jörger, Katharina[1]; Kristof, Alen[2] ; Klussmann-Kolb, Annette[3]; Schrödl, Michael[1]

1) Zoologische Staatssammlung München, Sektion Mollusca, Münchhausenstr. 21, 81247 München, Germany
2) University of Copenhagen, Institute of Biology, Research Group of Comparative Zoology, Universitetsparken 15, 2100 Copenhagen, Denmark
3) Johann-Wolfgang von Goethe Universität, Institut für Ökologie, Evolution und Diversität, Siesmayerstr. 70, 60054 Frankfurt am Main; Germany
Email: k_joerger@hotmail.com, akristof@bio.ku.dk, Klussmann-Kolb@bio.uni-frankfurt.de, schroedl@zi.biologie.uni-muenchen.de

INTRODUCTION

Acochlidia are a small group of mainly minute interstitial opisthobranchs. Due to the small body size (i.e. 1-4 mm) older descriptions often lack detail and thus require redescription using modern technologies. Especially the highly complex nervous system offers a wide range of valuable morphological details (i.e. the presence of ganglia, innervation patterns and sensory structures). With an adult size reaching only 1.5 mm the microhedylid *Parhedyle cryptophthalma* (Westheide & Wawra, 1974) is one of the smallest described acochlids. It inhabits the interstitial with direct wave impact in the Mediterranean. *Parhedyle cryptophthalma* was recollected at the type locality in Naples, Italy. The CNS, peripheral nervous system and sensory structures were analysed using computer-based 3D reconstruction from serial sections and scanning electron microscopy (SEM). Histological results were supplemented by the examination of Tyrosine hydroxylase (TH) and FMRF-amid immunoreactivity – the minute size of sub-adult specimens enabled entire penetration of the laser scanner.

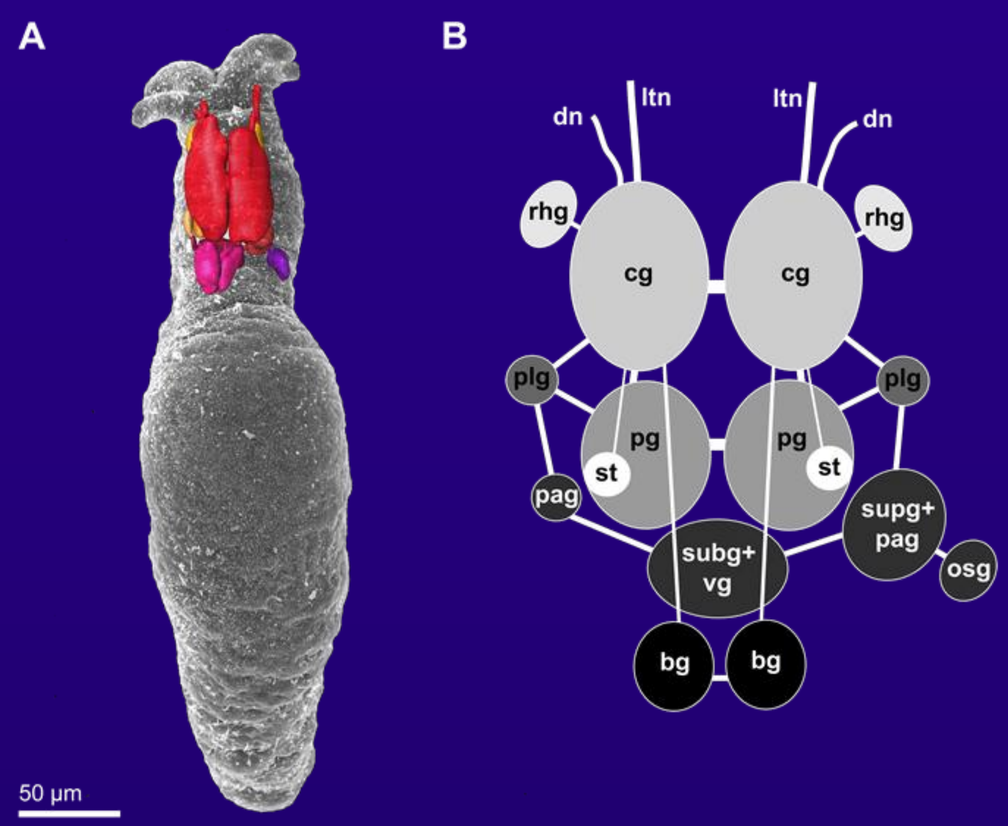

Figure 1: Complex central nervous system (CNS) of sub-adult *P. cryptophthalma*. A. SEM-micrograph with mounted 3D-reconstruction of CNS in natural position. B. Schematic overview. C-D. 3D reconstructions. C. Ventral view. D. Lateral left view. E. SEM-micrograph of head-foot complex.

bc: bundle of cilia, **bg:** buccal ganglion, **cg:** cerebral ganglion, **dn:** dorsal nerve, **ltn:** labiotentacular nerve, **osg:** osphradial ganglion, **ot:** oral tentacle, **pag:** parietal ganglion, **pg:** pedal ganglion, **plg:** pleural ganglion, **rh:** rhinophore, **rhg:** rhinophoral ganglion, **st:** statocyst, **subg:** subintestinal ganglion, **supg:** supraintestinal ganglion, **vg:** visceral ganglion.

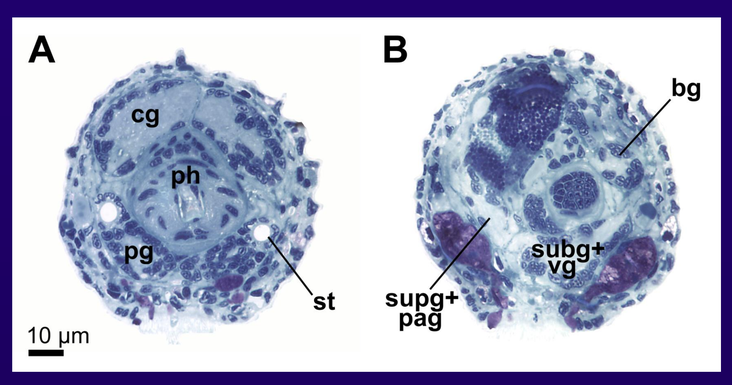

Figure 2: Semithin sections (1 µm) of *P. cryptoph-thalma*. A. Cerebral and pedal gaglia. B. Ganglia of visceral nerve cord.

bg: buccal ganglion, **cg:** cerebral ganglion, **pag:** parietal ganglion, **ph:** pharynx, **pg:** pedal ganglion, **st:** statocyst, **subg:** subintestinal ganglion, **supg:** supraintestinal ganglion, **vg:** visceral ganglion.

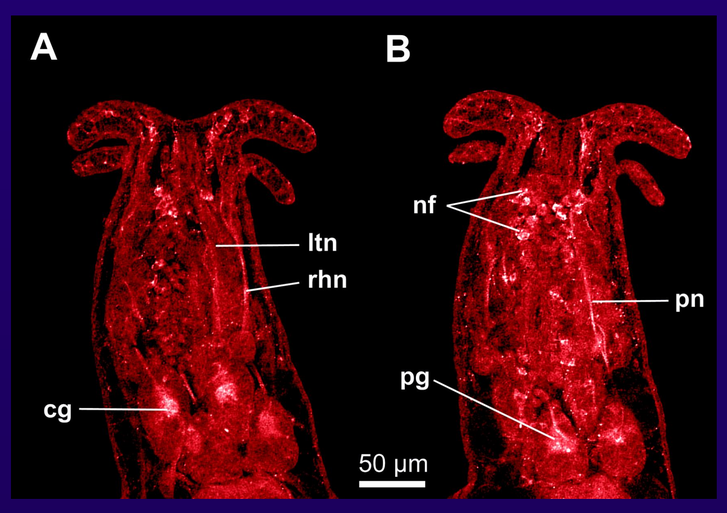

Figure 3: TH-immunoreactivity in the nervous system of *P. cryptophthalma*. A. Cerebral ganglia and nerves. B. Pedal ganglia and neurons bordering the foot sole.

cg: cerebral ganglion, **ltn:** labiotentacular nerve, **nf:** neurons bordering the foot sole, **pg:** pedal ganglion, **pn:** pedal nerve, **rhn:** rhinophoral nerve.

RESULTS AND CONCLUSIONS

- **CNS:** The prepharyngeal CNS of *Parhedyle cryptophthalma* consists of paired cerebral, rhinophoral, pedal, pleural and buccal ganglia, and three distinct unpaired ganglia on the visceral nerve cord. This confirms to the general setting within Acochlidia (see Neusser *et al.* 2008). An additional unpaired, putative osphradial, ganglion is attached to the right parietal/supraintestinal ganglion, detected for the first time in a microhedylid species.
- **Accessory ganglia:** Anterior to the cerebral ganglia a still undifferentiated mass of accessory ganglia is found. The presence of accessory ganglia can be considered as characteristic for microhedylids - and the enigmatic *Tantulum elegans*. In contrast to “true” ganglia, accessory ganglia do not show FMRF-amid expression, their function remains unknown.
- **Cerebral nerves:** Three cerebral nerves could be detected in sub-adult specimens: the ventrally emerging labiotentacular nerve; the dorsally emerging dorsal nerve, herein interpreted as rhinophoral nerve, and the static nerve.
- **Sensory structures:** surprisingly, the eponymous cryptic eyes could not be detected in sub-adult specimens. A pair of un-pigmented minute nervous globules are found nestling anterior on the cerebral ganglia. These structures might either develop to eyes in adult stages or can be interpreted as relicts of eyes. No Hancock’s organ – as reported for some other Microhedylidae – could be detected. Some bundles of cilia, supposedly with sensoric function, are located in the anterior region of the head-foot-complex and frontal of the oral tentacles.
- **Retraction:** Protective complete retraction of the head-foot complex into the visceral hump is achieved by the action of strong retractor muscles: this condition leaves none of the above mentioned sensory structures exposed.
- **Keeping nerves:** Despite of the minute size the nervous system of *P. cryptophthalma* confirms with the general characteristics known of larger acochlids. Remarkable, at least in sub-adult stages, is the elongated shape of the cerebral and pedal ganglia.

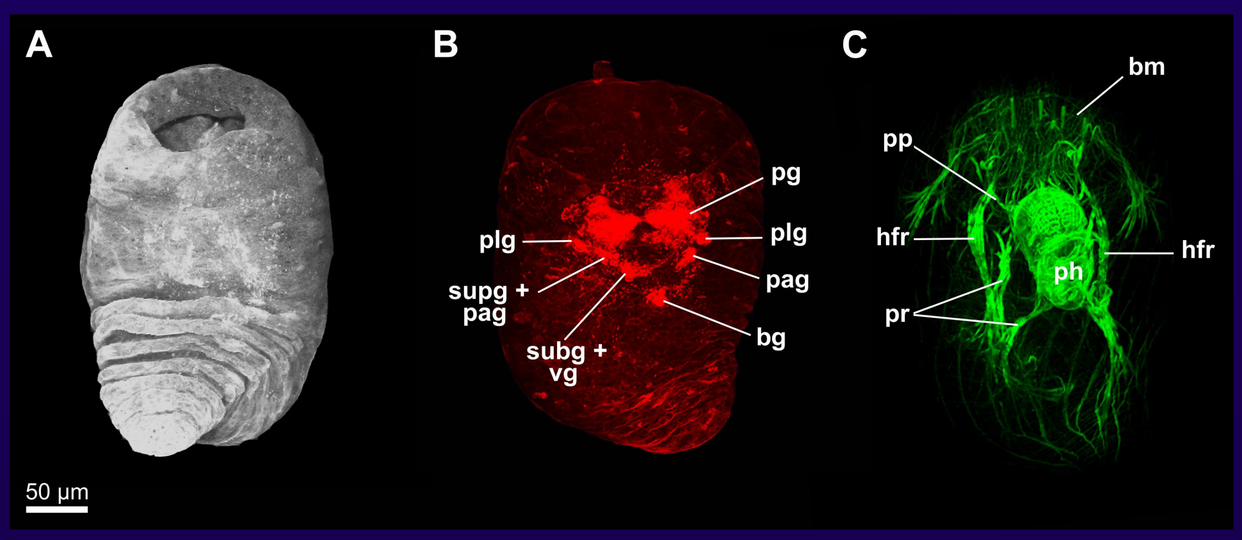

Figure 4: Retraction of the head-foot complex into the visceral hump and its effects on ganglia position and sensorics in *P. cryptophthalma*. A. Confocal laser scanning micrograph of a completely retracted specimen. B. FMRF-amid expression in ganglia (note: no FMRF-expression in accessory ganglia) C. Phalloidin-staining showing arrangement of (preliminarily identified) muscles in a retracted specimen.

bg: buccal ganglion, **hfr:** head-foot retractor, **bm:** body wall muscles, **pag:** parietal ganglion, **ph:** pharynx, **plg:** pleural ganglion, **pp:** pharyngeal protractor, **pr:** pharyngeal retractor, **subg:** subintestinal ganglion, **supg:** supraintestinal ganglion, **vg:** visceral ganglion.

ACKNOWLEDGEMENTS

This study was partially financed by a PhD-scholarship of the “Volkswagenstiftung” to KJ. The GeoBio Center (LMU) is thank for supporting AMIRA Software.

REFERENCES

Westheide, W.; Wawra, E. 1974. Organisation, Systematik und Biologie von *Microhedyle cryptophthalma* nov. spec. (Gastropoda, Opisthobranchia) aus dem Brandungsstrand des Mittelmeeres. Helgoländer wiss. Meeresunters. 26, 27-41.

Neusser, T.P.; Martynov, A.V.; Schrödl, M. 2008. Heartless and primitive? 3D reconstruction of the polar acochlidian gastropod *Asperspina murmanica*. Acta Zool. doi: 10.1111/j.1463-6395.2008.0342.x