



Time for sex change! 3D-reconstruction of the copulatory system of the “aphallic” acochlidian *Hedylopsis ballantinei*

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Within hedylopsacean acochlidians an evolutionary trait from a simple, unarmed copulatory system towards complex hypodermal injection systems was recognized (Schrödl & Neusser, 2010). This culminates in the large, trap-like spiny raptopenis of several limnic Acochliidae, having a sperm injection stylet plus an additional injection system with an accessory gland. The only exception was the mesopsammic hedylopsacean species *Hedylopsis ballantinei* Sommerfeldt & Schrödl, 2005, since it was assumed to be aphallic. Specimens with mature autosperm and oogonia in the hermaphroditic gonad showed no trace of any copulatory organs (Sommerfeldt & Schrödl, 2005). Sperm transfer via spermatophores was thus suggested, as known to occur in the generally aphallic microhedylaceans.

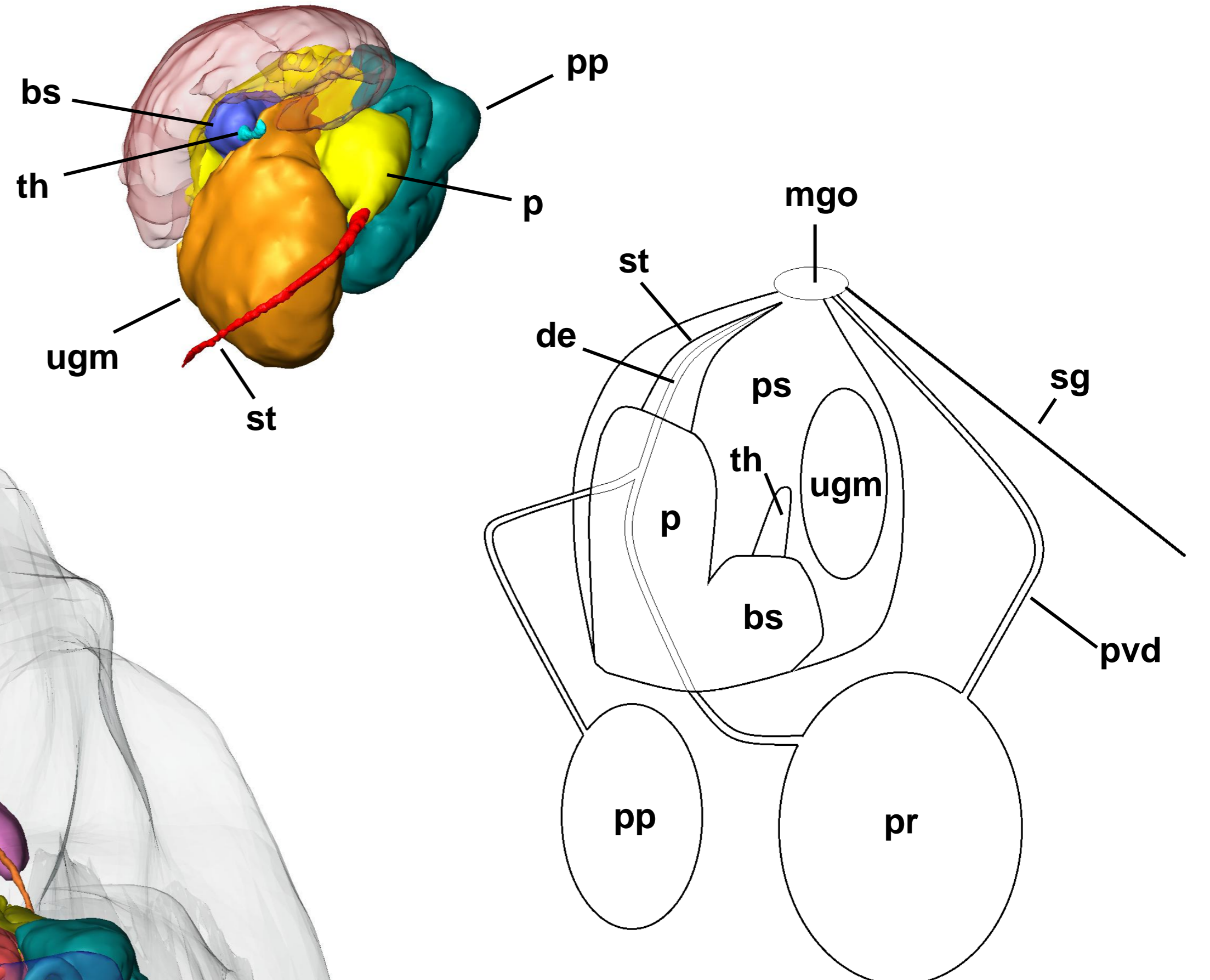
The present study examines some further, smaller specimens of *H. ballantinei*, that were newly collected at the type locality in the Red Sea. Serial semithin histological slides were prepared from resin-embedded specimens. Reproductive organs were identified, labeled and 3-dimensionally reconstructed using AMIRA software.



small, (putative) male-only *H. ballantinei*

Formerly unknown hermaphroditic phase of *H. ballantinei*:

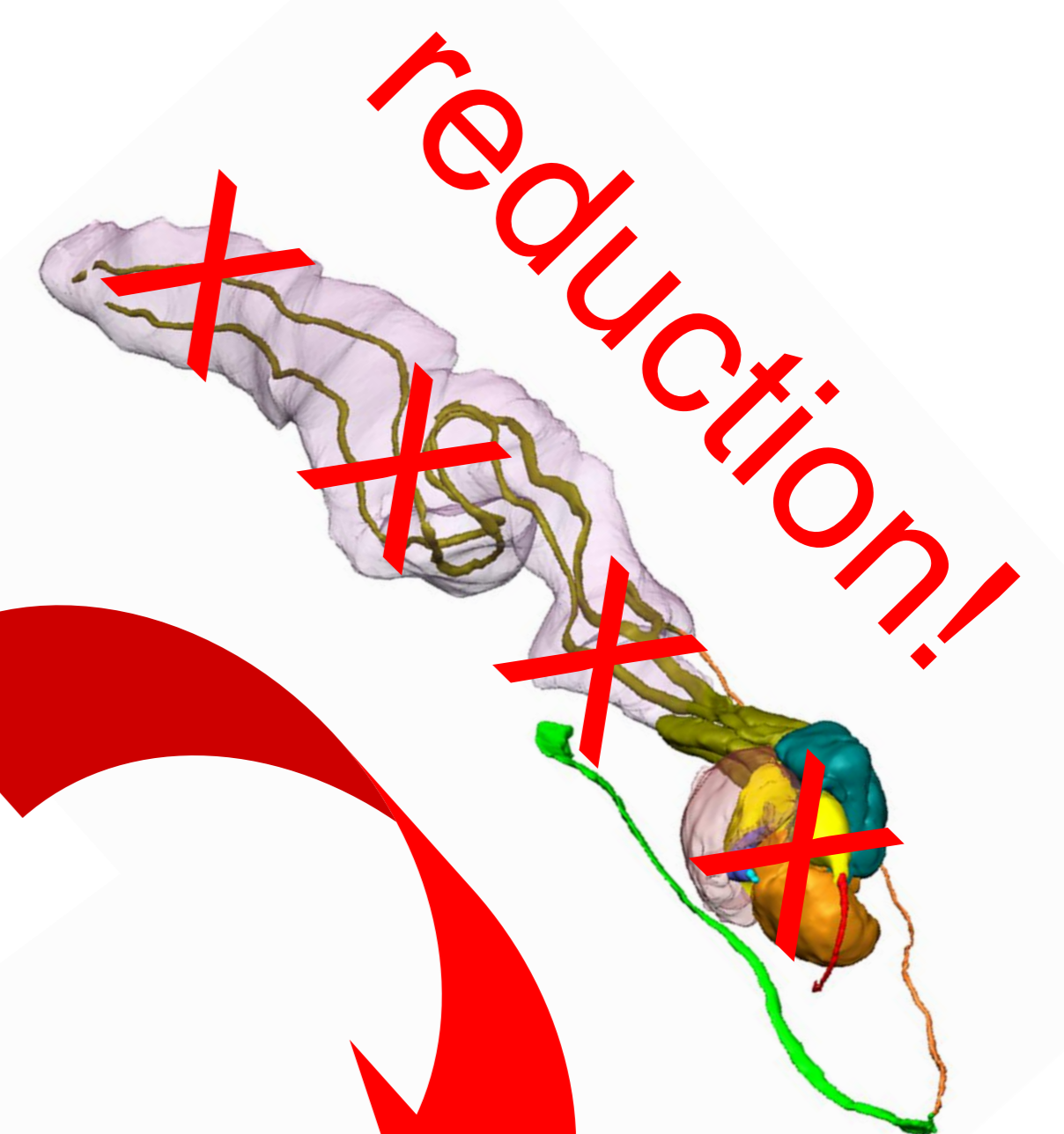
Lower left. 3D-model showing (colored) reproductive system within (transparent) body. Note gonad (greenish-yellow), external sperm groove (green), voluminous prostate (lilac and olive), large copulatory organ (yellow) with apical stylet (red), and associated glands (red, blue). Lower right: Schematic drawing of copulatory system and associated glands.



Abbreviations:

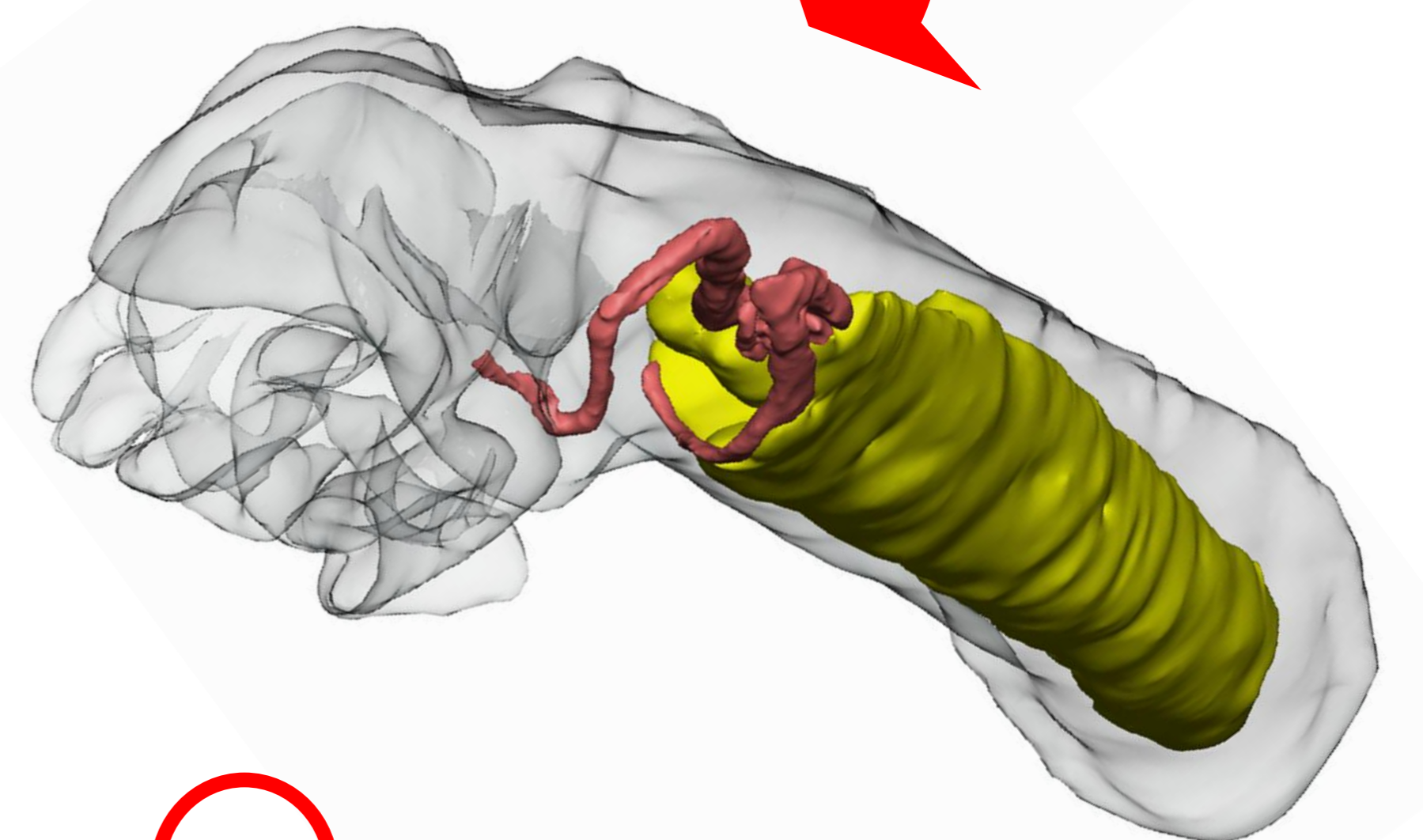
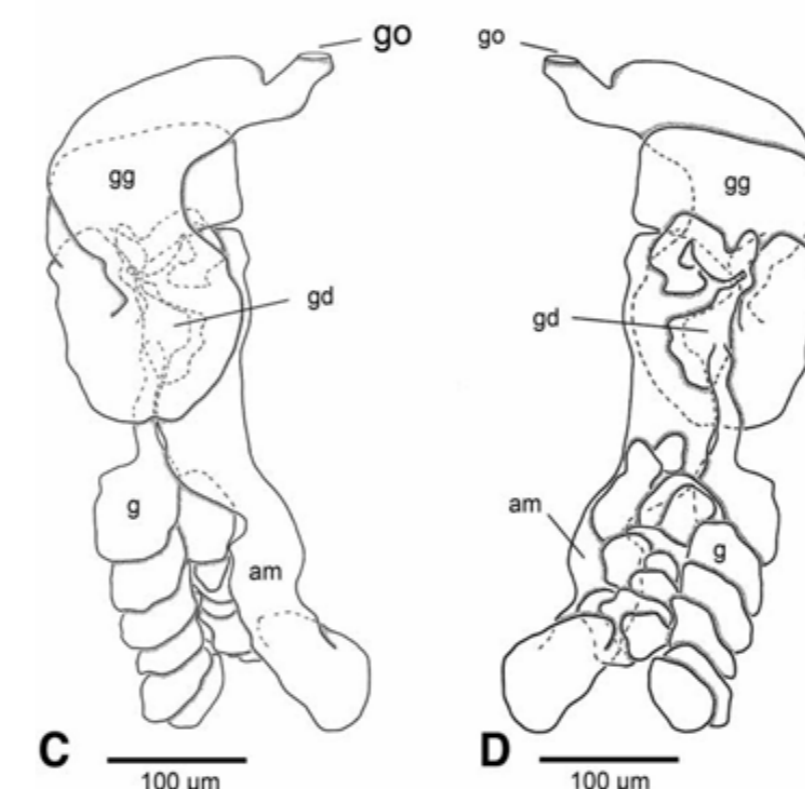
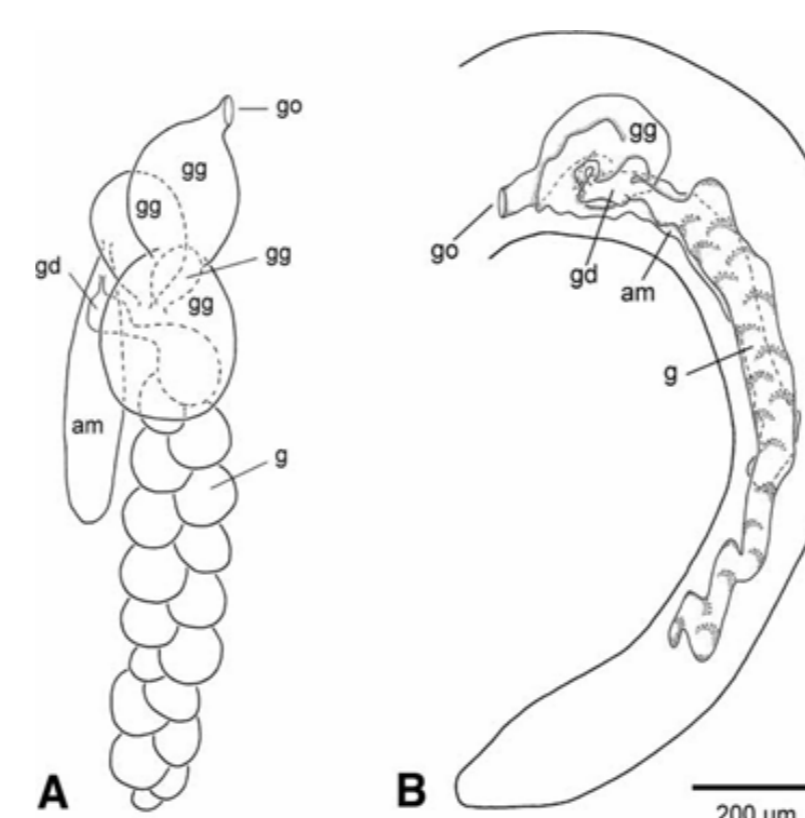
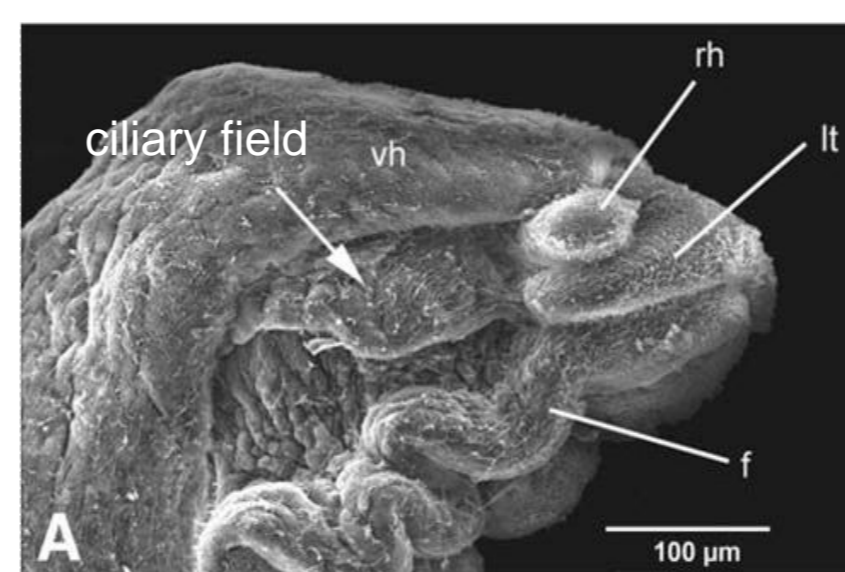
am	ampulla
bs	basal swelling
de	ejaculatory duct
f	foot
g	gonad
gd	gonoduct
gg	female glands
go	genital opening
lt	labial tentacle
mgo	male genital opening
p	penis
pp	paraprostate (?)
pr	prostate
ps	penial sheath
pvd	posterior leading vas deferens
rh	rhinophore
sg	external sperm groove
st	hollow stylet
th	solid thorn
ugm	unknown glandular mass
vh	visceral hump

hermaphroditic *H. ballantinei* (3 mm)



The small difference...

	Sommerfeldt & Schrödl, 2005	present study
hermaphrodite	simultaneous	sequential, protandric
male genitalia	aphallic	complex copulatory system including large bipartite penis with apical hollow stylet, voluminous prostate, potential paraprostate, plus accessory gland
sperm transfer	via spermatophore	hypodermic injection
ciliary field	for handling spermatophore	probably involved in egg mass deposition



female-only *H. ballantinei* (up to 6 mm)

CONCLUSIONS

- Hedylopsis ballantinei* is a sequential protandric hermaphrodite with sex change.
- H. ballantinei* has a large and complex copulatory organ with apical stylet and several accessory gland systems, which completely disappear in the early female phase. Some male parts of the gonad, however, may still persist after the loss of copulatory organs.
- The presence of an apical penial stylet and basal thorn resembles that of *Hedylopsis spiculifera*; the arrangement of glands, however, is unique.
- As a phallic species transferring sperm via hypodermic impregnation and lacking any allosperm receptacles, *H. ballantinei* now much better resembles its Mediterranean/eastern Atlantic sister species *H. spiculifera*, and fits well with evolutionary traits observed within hedylopsacean acochlidians.

Female phase of *H. ballantinei* as known from Sommerfeldt & Schrödl (2005).

Upper A. SEM-micrograph showing right anterior part of body with ciliary field that was assumed to handle spermatophores.

Lower A-D. Graphical reconstruction of (female phase) reproductive system in different views, structures agreeing with our results.

REFERENCES

- Sommerfeldt, N. & Schrödl, M. (2005) Microanatomy of *Hedylopsis ballantinei*, a new interstitial acochlidian gastropod from the Red Sea, and its significance for phylogeny. *Journal of Molluscan Studies* 71: 153-165.
- Schrödl, M. & Neusser, T.P. (2010) Towards a phylogeny and evolution of Acochliida (Mollusca: Gastropoda: Opisthobranchia). *Zoological Journal of the Linnean Society* 158: 124-154.

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