

# The 3D microanatomy and redescription of the acochlidian *Strubellia paradoxa* (Gastropoda, Opisthobranchia)

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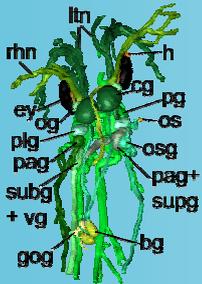
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## INTRODUCTION

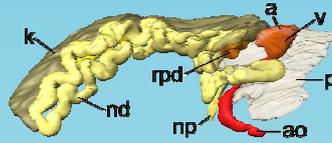
Acochlidia is one of the traditional "orders" of opisthobranch gastropods. Acochlidians show a particularly high morphological and ecological diversity. Exclusively among the otherwise marine opisthobranchs, several acochlidian species succeeded to invade freshwater systems. Colonization of limnic systems probably occurred twice independently; once in the Caribbean (the small interstitial *Tantulum elegans*), and second in the Indo-Pacific, with a radiation of large-sized benthic acochlidian species. This study aims to re-examine in detail the microanatomy of the sequential hermaphrodite *Strubellia paradoxa* (Strubell, 1892). The paratype from Ambon is compared with recently collected *Strubellia* specimens from the geographically distant Solomon and Vanuatu Islands. Histological semi-thin serial sections of all *Strubellia* species were prepared and a computer-based three-dimensional reconstruction of all major organ systems was made using AMIRA software.

## CENTRAL NERVOUS SYSTEM



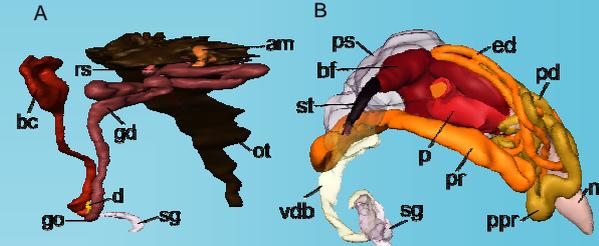
3D-reconstruction of the central nervous system (dorsal view). bg, buccal ganglion; cg, cerebral ganglion; ey, eye; gog, gastro-oesophageal ganglion; h, Hancock's organ; ltn, labial tentacle nerve; og, optic ganglion; os, osphradium; osg, osphradial ganglion; pag, parietal ganglion; pg, pedal ganglion; plg, pleural ganglion; rhn, rhinophoral nerve; subg, subintestinal ganglion; supg, supraintestinal ganglion; vg, visceral ganglion.

## EXCRETORY and CIRCULATORY SYSTEMS



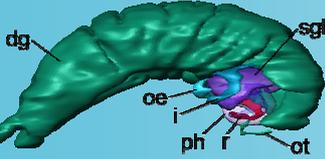
3D-reconstruction of the excretory and circulatory systems (right view). a, atrium; ao, aorta; k, kidney; nd, nephroduct; np, nephropore; p, pericardium; rpd, renopericardioduct; v, ventricle.

## GENITAL SYSTEM (MALE PHASE)



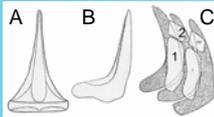
3D-reconstruction of the genital system (left view). A: posterior part. B: cephalic male copulatory organs. am, ampulla; bc, bursa copulatrix; bf, basal finger; d, diverticle; ed, ejaculatory duct; gd, gonoduct; go, genital opening; m, retractor muscle; ot, otestis; p, penis; pd, paraprostatic duct; ppr, paraprostate; pr, prostate; ps, penial sheath; rs, receptaculum seminis; sg, external sperm groove; st, stylet; vdb, back leading vas deferens.

## DIGESTIVE SYSTEM

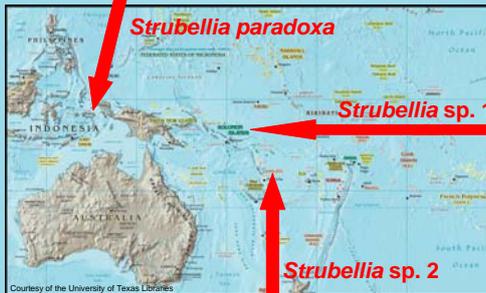


3D-reconstruction of the digestive system (right view). dg, digestive gland; i, intestine; oe, oesophagus; ot, oral tube; ph, pharynx; r, radula; sgl, salivary gland.

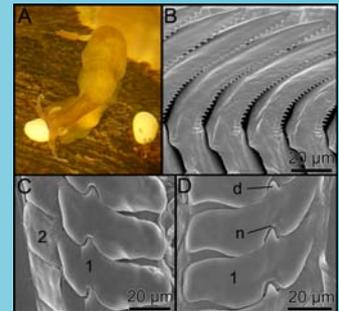
Schematic overview of the radula (Küthe 1935). A, B: rhachidian tooth. C: lateral teeth. 1, first lateral tooth; 2, second lateral tooth.



*Strubellia paradoxa* from Ambon. A: drawing (Küthe 1935). B: 3D-reconstruction of paratype (right view). f, foot; h, head; vs, visceral sac.



Photograph of *Strubellia* sp. 1 from Solomon Islands.



Feeding habits of *Strubellia* sp.1 and SEM-micrographs of radula. A: living specimen feeding on neritid eggs. B: rhachidian tooth. C: right lateral tooth. D: left lateral tooth. d, denticle; n, notch; 1, first lateral tooth; 2, second lateral tooth.

	<i>S. paradoxa</i> Strubell, 1892		<i>Strubellia</i> sp. 1		<i>Strubellia</i> sp. 2
Data source	Küthe 1935	present study	Wawra 1974, 1979, 1988	present study	present study
Collecting site	Ambon, Indonesia	Ambon, Indonesia	Solomon Islands	Solomon Islands	Vanuatu
Body size	~ 2 cm (l)	~ 1 cm (f)	~ 2 cm (l)	< 2.5 cm (l)	~ 3.5 cm (l)
Body shape	?	?	?	slender	robust
Radula formula	48-56 x 2.1.2	?	48-51 x 1.1.2	43-46 x 1.1.2	59 x 1.1.2
1. lateral tooth denticle	absent	?	present	present	present
Basal finger stylet length	0.5 mm	0.6 mm	1 mm	?	0.75-1 mm
Paraprostatic duct	divided	divided	?	?	undivided
Gland inside of basal finger	absent	absent	?	?	present

Comparison of *S. paradoxa* with other *Strubellia* specimens from the South Pacific. l, living specimen; f, fixed specimen; ?, no data available.

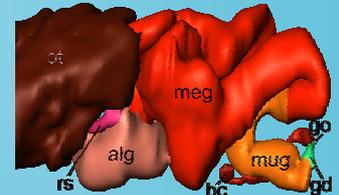


Photograph of *Strubellia* sp. 2 from Vanuatu.



SEM micrograph of the hollow curved stylet on the basal finger. Inlay: tip of stylet with groove.

## GENITAL SYSTEM (FEMALE PHASE)



3D-reconstruction of the female genital system (dorsal view, only anterior part of ovotestis shown). alg, albumen gland; bc, bursa copulatrix; gd, distal gonoduct; go, genital opening; meg, membrane gland; mug, mucus gland; rs, receptaculum seminis; ot, ovotestis.

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## CONCLUSIONS

- Strubellia paradoxa* from Indonesia was redescribed in detail. Küthe's (1935) description was corrected in several aspects, e.g. regarding the misinterpreted central nervous and genital systems. Several additional structures were discovered, such as Hancock's organs, osphradium and glands associated to the male copulatory organs.
- Specimens from Solomon Islands were assigned to *Strubellia paradoxa* by Wawra (1974), but differ regarding body size, shape of the first lateral radula tooth and length of the hollow stylet on the basal finger.
- South Pacific *Strubellia* specimens from Solomon Islands and Vanuatu are similar to each other. Slender, but mature female *Strubellia* sp. 1 resemble juveniles of the more robust and larger *Strubellia* sp. 2.
- Molecular studies will confirm or reject our hypothesis on a radiation of limnic *Strubellia* species on distant South Pacific Islands.

## REFERENCES

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