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## Two new desma-less species of *Theonella* Gray, 1868 (Demospongiae: Astrophorida: Theonellidae), from the Great Barrier Reef, Australia, and a re-evaluation of one species assigned previously to *Dercitus* Gray, 1867

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### Abstract

Extensive surveys of the biodiversity on the seafloor of the inter-reef regions of the Great Barrier Reef, Australia, have resulted in the collection of large numbers of sponges, many of which are likely new to science. Identification of these sponges, however, was made difficult by the absence in some specimens of key diagnostic characters, such as megascleres. We used an integrated approach to the taxonomy of these sponges, incorporating morphological examination by SEM, analysis of DNA sequence data (using the COI barcoding fragment of mtDNA) and preliminary studies of the chemistry of the sponges, to describe the new species, which were found to contain no native spicules other than acanthose microrhabds. Here, we propose two new species of *Theonella* Gray, 1868: *Theonella deliqua* n. sp. (found in association with a single unidentified species of siliquariid mollusc) and *Theonella maricae* n. sp. from the Great Barrier Reef. Further, we propose the new combination of *Theonella xantha* (Sutcliffe, Hooper and Pitcher 2010) n. comb. for another microrhabd-only-bearing species. On the basis of our gene trees, we recognise *Theonella* (and Theonellidae Lendenfeld, 1903) within Astrophorida Sollas, 1887. We discuss the potential for chemotaxonomic and DNA-based insights into the origins and radiation of species of *Theonella* and explore the evolutionary significance of the reduced morphology of the three additional species recognised here.

**Key words:** Porifera, Demospongiae, Astrophorida, Theonellidae, *Theonella deliqua* n. sp., *Theonella maricae* n. sp., *Theonella xantha* n. comb., taxonomy, systematics, biodiversity, sponges, Great Barrier Reef, Queensland, Indo-West Pacific

### Introduction

Sponges of the Family Theonellidae Lendenfeld, 1903 are distributed worldwide and are found generally in deeper waters. As a lithistid group, theonellids are characterised largely by their megascleres; the spicule complement is dominated by a rigid silica skeleton, formed by an interlocking network of ornate tetracclone desmas. Species of theonellids are known also to contain other tetractinal spicules, notably phyllostriaenes, dichotriaenes and discotriaenes at the surface, in addition to some monactinal megascleres; the microsclere component of theonellids is dominated by the presence of finely spined monactinal microrhabds, although amphiasters and streptasters are known from some members (Pisera and Lévi 2002). Currently, the group is conceived as comprising 51 species classified within five genera: *Theonella* Gray, 1868 (14 spp.), *Discodermia* du Bocage, 1869 (29 spp.), *Manihinea* Pulitzer-Finali, 1993 (2 spp.), *Racodiscula* Xittel, 1878 (5 spp.) and *Siliquariaspongia* Hoshino, 1981 (1 sp.) (see van Soest 2012a, b).

The type-genus for the family, *Theonella* Gray, 1868, is morphologically homogenous, with the group being defined by a surface coat of aligned phyllostriaenes or dichotriaenes, internal tetracclone desma network with tuberculate zygosis, large monactinal spicules, and microscleres, which are only small acanthose microrhabds, often with bends in the middle (Pisera & Lévi 2002; Ilan *et al.* 2004). Ilan *et al.* (2004) studied the reproduction of

protocols related to the generation of sponge barcode data and for providing access to the Sponge Barcoding Database ([www.spongebarcodes.org](http://www.spongebarcodes.org)). Our sequences were visualised at the Griffith University DNA Sequencing Facility, and we express our thanks to Ms Nicole Hogg and the team for their timely and professional services. We are grateful to two anonymous reviewers for their feedback and for their insights and comments which have helped to improve this paper.

## References

- Angawi, R.F., Bavestrello, G., Calcinai, B., Dien, H.A., Donnarumma, G., Tufano, M.A., Paoletti, I., Grimaldi, E., Chianese, G., Fattorusso, E. & Tagliatalata-Scafati, O. (2011) Aurantoside J: an new tetramic acid glycoside from *Theonella swinhoei*. Insights into the antifungal potential of aurantosides. *Marine Drugs*, 9, 2809–2817.  
<http://dx.doi.org/10.3390/md9122809>
- Aoki, S., Higuchi, K., Ye, Y., Satari, R. & Kobayashi, M. (2000) Melophlins A and B, novel tetramic acids reversing the phenotype of ras-transformed cells, from the marine sponge *Melophlus sarassinorum*. *Tetrahedron*, 56, 1833–1836.  
[http://dx.doi.org/10.1016/S0040-4020\(00\)00092-2](http://dx.doi.org/10.1016/S0040-4020(00)00092-2)
- Bieler, R. (2004) Sanitation with sponge and plunger: western Atlantic slit-wormsnails (Mollusca: Caenogastropoda: Siliquariidae). *Zoological Journal of the Linnean Society*, 104, 307–333.  
<http://dx.doi.org/10.1111/j.1096-3642.2003.00104.x>
- Cárdenas, P. & Rapp, H.T. (2012) A review of Norwegian streptaster-bearing Astrophorida (Porifera: Demospongiae: Tetractinellida), new records and a new species. *Zootaxa*, 3253, 1–52.
- Cárdenas, P., Xavier, J., Tendal, O.S., Schander, C. & Rapp, H.T. (2007) Redescription and resurrection of *Pachymatisma normani* (Demospongiae: Geodiidae), with remarks on the genus *Pachymatisma*. *Journal of the Marine Biological Association of the United Kingdom*, 87, 6, 1511–1525.  
<http://dx.doi.org/10.1017/S0025315407058286>
- Cárdenas, P., Menegola, C., Rapp, H.T. & Diaz, M.C. (2009) Morphological description and DNA barcodes of shallow-water Tetractinellida (Porifera: Demospongiae) from Bocas del Toro, Panama, with description of a new species. *Zootaxa*, 2276, 1–39.
- Cárdenas, P., Rapp, H.T., Schander, C. & Tendal, O.S. (2010) Molecular taxonomy and phylogeny of the Geodiidae (Porifera, Demospongiae, Astrophorida) – combining phylogenetic and Linnaean classification. *Zoologica Scripta*, 39, 1, 89–106.  
<http://dx.doi.org/10.1111/j.1463-6409.2009.00402.x>
- Cárdenas, P., Xavier, J.R., Reveillaud, J., Schander, C. & Rapp, H.T. (2011) Molecular phylogeny of the Astrophorida (Porifera, Demospongiae<sup>sp</sup>) reveals an unexpectedly high level of spicule homoplasy. *PLoS ONE*, 6, 4, e18318, 1–18.  
<http://dx.doi.org/10.1371/journal.pone.0018318>
- Chombard, C., Boury-Esnault, N. & Tillier, S. (1998) Reassessment of homology of morphological characters in tetractinellid sponges based on molecular data. *Systematic Biology*, 47, 3, 351–366.  
<http://dx.doi.org/10.1080/106351598260761>
- D’Auria, M.V., Zampella, A. & Zollo, F. (2002) The chemistry of lithistid sponges: a spectacular source of new metabolites. *Studies in Natural Products Chemistry*, 26, G, 1175–1258.  
[http://dx.doi.org/10.1016/S1572-5995\(02\)80027-8](http://dx.doi.org/10.1016/S1572-5995(02)80027-8)
- Erpenbeck, D., Duran, S., Rützler, K., Paul, V., Hooper, J.N.A. & Wörheide, G. (2007) Towards a DNA taxonomy of Caribbean demosponges: a gene tree reconstructed from partial mitochondrial CO1 gene sequences supports previous rDNA phylogenies and provides a new perspective on the systematics of Demospongiae. *Journal of the Marine Biological Association of the United Kingdom*, 87, 6, 1563–1570.  
<http://dx.doi.org/10.1017/S0025315407058195>
- Faulkner, D.J., Harper, M.K., Salomon, C.E. & Schmidt, E. (1999) Localisation of bioactive metabolites in marine sponges. *Memoirs of the Queensland Museum*, 44, 167–173.
- Fromont, J. (1999) Demosponges of the Houtman Abrolhos. *Memoirs of the Queensland Museum*, 44, 175–183.
- Fromont, J. & Pisera, A. (2011) A new species of the lithistid sponge genus *Manihinea* (Demospongiae: Theonellidae) from Western Australian waters. *Records of the Western Australian Museum*, 26, 109–114.
- Gray, J.E. (1868) Note on *Theonella*, a new genus of coralloid sponges from Formosa. *Proceedings of the Zoological Society of London*, 1868, 37, 565–566.
- Hartman, W.D. & Hubbard, R. (1999) A new species of *Thrombus* (Porifera: Demospongiae: Astrophorida) from Trinidad, West Indies. *Bulletin of Marine Science*, 64, 1, 1–8.
- Ilan, M., Gugel, J. & van Soest, R.W.M. (2004) Taxonomy, reproduction and ecology of new and known Red Sea sponges. *Sarsia*, 89, 388–410.  
<http://dx.doi.org/10.1080/00364820410002659>
- Kelly, M., McCormack, G.P. & McInerney, J.O. (1999) Morphology and molecules in lithistid taxonomy: new solutions for old problems. *Memoirs of the Queensland Museum*, 44, 274.
- Kumar, R., Subramani, R., Feussner, K.-D. & Aalbersberg, W. (2012) Aurantoside K, a new antifungal tetramic acid glycoside

- from a Fijian sponge of the genus *Melophlus*. *Marine Drugs*, 10, 200–208.  
<http://dx.doi.org/10.3390/md10010200>
- Lendenfeld, R. von (1907) Die Tetraxonia. *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf der Dampfer Valdivia 1898–1899*, 11, (1–2), i–iv, 59–374 + 37 plates.
- Maldonado, M. (1996) On the presence of anatrienes in Pachastrellidae (Porifera: Demospongiae): evidence for a new phylogenetic family concept. *Journal of Natural History*, 30, 389–405.  
<http://dx.doi.org/10.1080/00222939600770211>
- Matsunaga, S., Fusetani, N., Kato, Y. & Hirota, H. (1991) Aurantosides A and B: cytotoxic tetramic acid glycosides from the marine sponge *Theonella* sp. *Journal of the American Chemical Society*, 113, 25, 9690–9692.  
<http://dx.doi.org/10.1021/ja00025a054>
- Meyer, C.P., Geller, J.B. & Paulay, G. (2005) Fine scale endemism on coral reefs: archipelagic differentiation in turbinid gastropods. *Evolution*, 59, 113–125.  
<http://dx.doi.org/10.1554/04-194>
- Nichols, S.A. (2005) An evaluation of support for order-level monophyly and interrelationships within the class Demospongiae using partial data from the large subunit rDNA and cytochrome oxidase subunit I. *Molecular Phylogenetics and Evolution*, 34, 81–96.  
<http://dx.doi.org/10.1016/j.ympev.2004.08.019>
- Pansini, M., Cattaneo-Vietti & Schiaparelli, S. (1999) Relationship between sponges and a taxon of obligatory inquillines: the siliquariid molluscs. *Memoirs of the Queensland Museum*, 44, 427–438.
- Pisera, A. & Lévi, C. (2002) Family Theonellidae Lendenfeld, 1903. In: Hooper, J.N.A. & van Soest, R.W.M. (Eds.), *Systema Porifera. A guide to the classification of sponges. Volume 1*. Kluwer Academic/Plenum Publishers, New York, pp. 327–337.
- Ratnayake, A.S., Davis, R.A., Harper, M.K., Veltri, C.A., Andjelic, C.D., Barrows, L.R. & Ireland, C.M. (2005) Aurantosides G, H, and I: three new tetramic acid glycosides from a Papua New Guinea *Theonella swinhoei*. *Journal of Natural Products*, 68, 1, 104–107.  
<http://dx.doi.org/10.1021/np049721s>
- Ronquist, F. & Huelsenbeck, J.P. (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics*, 19, 1572–1574.  
<http://dx.doi.org/10.1093/bioinformatics/btg180>
- Sata, N.U., Matsunaga, S., Fusetani, N. & van Soest, R.W.M. (1999a) Aurantosides D, E, and F: new antifungal tetramic acid glycosides from the marine sponge *Siliquariaspongia japonica*. *Journal of Natural Products*, 62, 7, 969–971.
- Sata, N.U., Wada, S., Matsunaga, S., Watabe, S., van Soest, R.W.M. & Fusetani, N. (1999b) Rubrosides A–H, new bioactive tetramic acid glycosides from the marine sponge *Siliquariaspongia japonica*. *Journal of Organic Chemistry*, 64, 2331–2339.
- Schiaparelli, S. (2002) Taxonomy of the family Siliquariidae (Mollusca, Caenogastropoda) in Eastern Atlantic Ocean and Mediterranean Sea: description of a new genus and a new species. *Italian Journal of Zoology*, 69, 245–256.  
<http://dx.doi.org/10.1080/11250000209356467>
- Schmidt, E.W., Obratzsova, A.Y., Davidson, S.K., Faulkner, D.J. & Haygood, M.G. (2000) Identification of the antifungal peptide-containing symbiont of the marine sponge *Theonella swinhoei* as a novel  $\delta$ -proteobacterium, “*Candidatum Entotheonella palauensis*”. *Marine Biology*, 136, 969–977.  
<http://dx.doi.org/10.1007/s002270000273>
- Silvestro, D. & Michalak, I. (2011) raxmlGUI: a graphical front-end for RAXML. *Organisms Diversity and Evolution*, 12 (4), 335–337.  
<http://dx.doi.org/10.1007/s13127-011-0056-0>
- Sollas, W.J. (1888) Report on the Tetractinellida collected by H.M.S. Challenger, during the years 1873–1876. Report on the Scientific Results of the Voyage of H.M.S. Challenger, 1873–1876. *Zoology*, 25, 63, 1–458 + Plates I–XLIV + 1 map.
- Stamatakis, A. (2006) RAXML-vi-hpc: Maximum Likelihood-based phylogenetic analyses with thousands of taxa and mixed models. *Bioinformatics*, 22, 2688–2690.  
<http://dx.doi.org/10.1093/bioinformatics/btl446>
- Sutcliffe, P.R., Hooper, J.N.A. & Pitcher, C.R. (2010) The most common sponges on the Great Barrier Reef seabed, Australia, include species new to science (Phylum Porifera). *Zootaxa*, 2616, 1–30.
- Tamura, K., Dudley, J., Nei, M. & Kumar, S. (2007) MEGA4: Molecular Evolutionary Genetics Analysis (MEGA) software version 4.0. *Molecular Biology and Evolution*, 24, 1596–1599.  
<http://dx.doi.org/10.1093/molbev/msm092>
- van Soest, R. (2012a) Theonellidae. In: van Soest, R.W.M., Boury-Esnault, N., Hooper, J.N.A., Rützler, K., de Voogd, N.J., Alvarez de Glasby, B., Hajdu, E., Pisera, A.B., Manconi, R., Schoenberg, C., Janussen, D., Tabachnick, K.R., Klautau, M., Picton, B., Kelly, M., Vacelet, J. & Dohrmann, M. (Eds.), *World Porifera database*. Available from: <http://www.marinespecies.org/porifera/porifera.php?p=taxdetails&id=131682> (accessed 14 November 2012)
- van Soest, R. (2012b) *Theonella* Gray, 1868. In: van Soest, R.W.M., Boury-Esnault, N., Hooper, J.N.A., Rützler, K., de Voogd, N.J., Alvarez de Glasby, B., Hajdu, E., Pisera, A.B., Manconi, R., Schoenberg, C., Janussen, D., Tabachnick, K.R., Klautau, M., Picton, B., Kelly, M., Vacelet, J. & Dohrmann, M. (Eds.), *World Porifera database*. Available from: <http://www.marinespecies.org/porifera/porifera.php?p=taxdetails&id=171248> (accessed 14 November 2012)

- van Soest, R. (2012c) *Dercitus (Stoeba) xanthus* Sutcliffe, Hooper & Pitcher, 2010. In: van Soest, R.W.M, Boury-Esnault, N., Hooper, J.N.A., Rützler, K., de Voogd, N.J., Alvarez de Glasby, B., Hajdu, E., Pisera, A.B., Manconi, R., Schoenberg, C., Janussen, D., Tabachnick, K.R., Klautau, M., Picton, B., Kelly, M., Vacelet, J. & Dohrmann, M. (Eds.), *World Porifera database*. Available from: <http://www.marinespecies.org/porifera/porifera.php?p=taxdetails&id=555787> (accessed 14 November 2012)
- van Soest, R.W.M., Beglinger, E.J. & de Voogd, N.J. (2010) Skeletons in confusion: a review of astrophorid sponges with (dicho-)calthrops as structural megascleres (Porifera, Demospongiae, Astrophorida). *ZooKeys*, 68, 1–88.  
<http://dx.doi.org/10.3897/zookeys.68.729>
- van Soest, R.W.M. & Braekman, J.C. (1999) Chemosystematics of Porifera: a review. *Memoirs of the Queensland Museum*, 44, 569–589.
- Wang, C.-Y., Wang, B.-G., Wiryowidagdo, S., Wray, V., van Soest, R., Steube, K.G., Guan, H.-S., Proksch, P. & Ebel, R. (2003) Melophlins C–O, thirteen novel tetramic acids from the marine sponge *Melophlus sarassinorum* {sic}. *Journal of Natural Products*, 66, 51–56.  
<http://dx.doi.org/10.1021/np0202778>
- Winder, P.L., Pomponi, S.A. & Wright, A.E. (2011) Natural products from the Lithistida: a review of the literature since 2000. *Marine Drugs*, 2011, 9, 2643–2682.  
<http://dx.doi.org/10.3390/md9122643>
- Wolf, D., Schmitz, F.J., Qiu, F. & Kelly-Borges, M. (1999) Aurantoside C, a new tetramic acid glycoside from the sponge *Homophymia conferta*. *Journal of Natural Products*, 62, 1, 170–172.  
<http://dx.doi.org/10.1021/np980283x>