



SWEDISH TAXONOMY INITIATIVE PROJECT REPORT

Project period: 2012

Mikael Thollesson
Uppsala University

SILICEOUS SPONGES:

Integrative taxonomy of Tetractenellida siliceous sponges (Demospongiae) from Sweden and Scandinavian waters, 2012–2013

Abstract

Our 2-year project proposal aimed at revising the Scandinavian Tetractinellida (Demosponges) comprising the orders Spirophorida and Astrophorida. STI awarded a grant for a 1-year investigation, which officially started in January 2012. Our project focused on two main revisions: 1) a revision of the Scandinavian *Geodia* (Astrophorida) species and 2) a revision of Scandinavian Spirophorida.

The first revision produced two articles: one article in *Invertebrate Biology* on morphological variability of Geodiidae species with depth, the other article published in *Zoological Journal of the Linnean Society* is a formal revision of boreo-arctic *Geodia* species.

In the second article we revised the 12 nominal species from the Atlantic boreo-arctic region, comparing populations from the northeast and northwest Atlantic, and concluded that only six species are valid: some are arctic species (*G. hentscheli*, *G. parva*), while others are typically boreal (*G. atlantica*, *G. barretti*, *G. phlegraei*); *G. macandrewii* is found in both boreal and arctic waters.

Morphological, genetic and geographical differences in *Geodia phlegraei* led us to recognize two sister species previously united under the same species name. We showed that *G. phlegraei* is the boreal species and *G. parva* (resurrected in our study) the arctic species.

We have studied Swedish *Geodia* specimens and confirm that only *G. barretti* and *G. phlegraei* are present on the Swedish west coast.

The revision of Spirophorida species is ongoing using morphological and molecular data. Our results so far indicate that boreo-arctic waters harbor at least 11–12 Tetillidae species, some morphotypes represent 4–5 potential new species from the boreo-arctic Atlantic region.

There is only one Swedish species but our preliminary results suggest that we have not been using the correct valid name for this species.

Altogether we consider that there are seven species of Tetractinellida sponges in Sweden (six Astrophorida and one Spirophorida): our study enabled to change the name of two (*Stryphnus fortis* and *Craniella ?pilosa*) and to find a third one not present on the Swedish checklist before this study (*Thenea muricata*).

Our 2-year project proposal aimed at revising the Scandinavian Tetractinellida (Demosponges) comprising the orders Spirophorida and Astrophorida. In the Astrophorida, the Scandinavian *Geodia* and Ancorinidae and Thoosidae were still in need of a formal revision insofar some of these species are poorly described and poorly known while others are suspected to be species complexes.

As for the Spirophorida, all of the Scandinavian species (ca. 8–9 species) were in need of a revision. We had also planned to investigate the feasibility of barcoding in those two orders using different markers. STI awarded a grant for a one-year investigation for this project which officially started in January 2012, but we were able to extend this grant since P. Cárdenas was on paternity leave for 7 months (March–October 2013).

Nonetheless, we had to cut down our initial project to two main revisions: 1) a revision of the Scandinavian *Geodia* species, for which we had already preliminary data and 2) a revision of Scandinavian Spirophorida species since the name of the species occurring in Sweden was unsure.

We included DNA barcoding data within each revision (and not as a separate paper as initially proposed). We have not completely abandoned the idea of revising the Ancorinidae, although a revision of some species (although not as comprehensive as for *Geodia* and Spirophorida) is being integrated on a paper describing demosponges collected on the North Atlantic mid-Atlantic Ridge, from a collaborating project with the University of Bergen (Cárdenas & Rapp, 2015).

Material and Methods

Type material was re-described. For survey and distribution maps, essentially museum material was used (Bergen Museum, Tromsø Museum, Zoological Museum of Copenhagen, Uppsala Zoological Museum, Swedish Museum of Natural History in Stockholm). Our collaborators in Norway and Canada collected fresh material. All the specimens collected from Canada and sent to us were deposited at the Uppsala Zoological Museum, among those two potential new species from the Flemish Cap under description. We also participated in one ROV survey in the Kosterfjord in May 2012 (Tjärnö Marinbiologiska Laboratorium).

To study the skeleton organization of each species, thick sections (100–800 µm) were made by our collaborators (University of Bergen). I also made standard spicule preparations

for most of the specimens studied. Spicule preparations from specimens from Uppsala Museum were deposited at the Uppsala Zoological Museum.

DNA extraction from samples was performed using a standard Quiagen DNA extraction kit. For barcodes and phylogeny, I have successfully partially sequenced *cox1* and 18S in *Geodia* and Spirophorida species.

Results and Discussion

1. Revision of boreo-arctic *Geodia*

We have published in *Invertebrate Biology* a first study on how environmental parameters change the skeleton phenotype (i.e. spicules) of some deep-sea Scandinavian *Geodia* species growing in shallow waters (Cárdenas & Rapp 2013). These results were not expected when we started the revision, they are the byproducts of studying specimens collected at different depths.

This study is important not only for *Geodia* taxonomy but also for sponge taxonomy in general since sponge taxonomy relies mainly on spicules. In this study we show that because of this phenotype variability, a sponge on the Norwegian red list (*Geodia simplicissima*) is actually a synonym of *Geodia barretti*, a very common sponge found on the Norwegian/Swedish coasts.

We also published in the *Zoological Journal of the Linnaean Society* a revision of the boreo-arctic Atlantic *Geodia*, including biogeography data and DNA barcodes (Cárdenas *et al.* 2013). Biological data (reproduction, biochemistry, microbiology, epibionts) for each species was also reviewed in this paper.

We revised the 12 nominal species from the Atlantic boreo-arctic region, comparing populations from the northeast and northwest Atlantic, and concluded that only six species are valid: some are arctic species (*G. hentscheli*, *G. parva*), while others are typically boreal (*G. atlantica*, *G. barretti*, *G. phlegraei*); *G. macandrewii* is found in both boreal and arctic waters.

Morphological, genetic and geographical differences in *Geodia phlegraei* led us to recognize two sister species previously united under the same species name. We showed that *G. phlegraei* is the boreal species and *G. parva* (resurrected in our study) the arctic species.

We have studied Swedish *Geodia* specimens from collections at the Uppsala Museum and Stockholm Museum and confirm that only *G. barretti* and *G. phlegraei* are present on the Swedish west coast. We have discovered through our collaboration with the Bedford Institute of Oceanography (Canada) that these two *Geodia* species found on the Swedish coast also occur off Canadian coasts, which raises many interesting biogeography issues.

A follow-up phylogeography and population genomic study of *G. barretti* across its wide distribution range is considered and new funds (to M. Thollessen) have enabled us to get some preliminary results.

Swedish *G. barretti* populations are currently threatened by diseases related to unusual water temperature shocks so investigating the genetic ties of the Swedish population will bring important information for conservationists. Furthermore, *Geodia* species are the

dominant species of boreo-arctic Atlantic deep-sea 'sponge grounds' (i.e. mass aggregations of large sponges, which are known to enhance biodiversity), so understanding the distribution of these species will directly help conservation efforts of these sponge grounds, now heavily impacted by bottom-trawling in the North Atlantic.

Also, collaboration with the Pharmacognosy Division (Dept. of Medicinal Chemistry, Uppsala University) is ongoing to compare metabolic fingerprints of boreo-arctic *Geodia* species. The main aim of this study is to use metabolic fingerprints as an additional dataset in order to i) test the phylogenetic relationships previously found and ii) see if we can discriminate populations of *G. barretti* based on their metabolic fingerprints.

2. Spirophorida revision

The World Porifera Database (<http://www.marinespecies.org/porifera/>) currently lists only four valid species in the boreo-arctic Atlantic region: *Craniella cranium*, *C. polyura*, *C. zetlandica* and *Tetilla sibirica*. However, our results so far indicate that boreo-arctic waters harbor at least 11–12 Tetillidae species.

The revision of Spirophorida species is ongoing using morphological and molecular data (Cárdenas *et al.* in prep.-b). We have started to look at type material from many boreo-arctic spirophorids (*Craniella zetlandica*, *C. infrequens*, *Craniella unca*, *Tetilla sibirica*) but some types seem to have been lost (*C. abyssorum* in the Natural History Museum in London). Other types still need to be found, requested and examined (*Tetilla polyura*, *Craniella pilosa*). We have examined recent and museum material essentially from Norway and Sweden, but also from Newfoundland, the Flemish Cap and the Davis Strait. Indeed, as for boreo-arctic *Geodia* species, many of the boreo-arctic Spirophorida seem to be amphiatlantic.

We obtained DNA barcodes (COI gene) for all of the species found except *T. sibirica* for which no new material has been collected. We are also in the process of sequencing the nearly complete 18S for most of these species. We are currently redescribing the six 'historic' species, which are all valid in our opinion: *Craniella abyssorum*, *C. pilosa* (= *C. cranium?*), *C. infrequens*, *C. zetlandica*, *Tetilla polyura* and *T. sibirica*.

Further morphotypes and genospecies appeared in the course of this revision, and their status is currently investigated: *C. cf. zetlandica* (1 specimen from Bergen, Norway), *C. aff. sigmoancoratum* (Greenland Sea), *Craniella* sp. nov. 1 (Newfoundland), *Craniella* sp. nov. 2 (Newfoundland), *Craniella* sp. nov. 3 (Rockall Bank). Overall, these morphotypes represent 4–5 potential new species from the boreo-arctic Atlantic region.

Only *Craniella cranium* (Müller, 1776) has been recorded from the Swedish west coast. But *C. cranium* has a long and complex taxonomic history and according to preliminary results, the species 'cranium' would actually be a *Geodia*. Consequently, the species in Sweden should be *Craniella pilosa* (Montagu, 1814), a former synonym of *C. cranium*. More work is needed to confirm this, notably the examination of the type of *C. pilosa*. We have found specimens in the Swedish Museum of Natural History, Stockholm of *Craniella* collected on the Swedish west coast, and have made thick sections of these. Unfortunately, these specimens were too old to obtain molecular data from.

We recently found three additional specimens of *C. cranium* collected on the Swedish West Coast in the Göteborg Natural History Museum. One was collected in 1995, so we might get molecular data from this one to confirm its identification.

Conclusion

Updated checklist of Tetractinellida species in Sweden:

Astrophorida

Geodiidae

- *Pachymatisma normani* (we identified a large specimen: SMNH 124633).
- *Geodia barretti* (fairly common in Sweden).
- *Geodia phlegraei* (less common than *G. barretti*)

Ancorinidae

- *Stryphnus fortis* (**new species for Sweden**, it had until now been misidentified as *Stryphnus ponderosus* on the Swedish west coast but the latter has never been formally identified from the Swedish west coast).
- *Stelletta normani*

Theneidae

- *Thenea muricata* (**new species for Sweden**, we found the specimen SMNH 1408 identified by H. Alander and confirmed his identification. Unfortunately, the collecting locality is not more specific than “Bohuslän”).

Spirophorida

- *Craniella pilosa* (temporary name until we can confirm this by examining the type of *C. pilosa*).

All these species except *P. normani* were found to be amphi-Atlantic, so they are present throughout the boreal region of the North Atlantic from Sweden/Norway to the Flemish Cap (off Newfoundland).

Results on the *Geodia* and Spirophorida revisions were presented at a talk given at the ‘*International Workshop on Atlanto-Mediterranean deep-sea sponge fauna*’ at the University of the Azores in Ponta Delgada (16–21 April 2012). These results were also presented in two posters at the *9th World Sponge Conference* in Freemantle, Australia (3–8 Nov. 2013). More of these results will be presented in a talk at the ‘*International Workshop on Atlantic deep-sea sponge fauna*’ at the University of Bergen in Bergen, Norway (1–7 June 2014).

List of publications as a direct or partial result of this project

- Cárdenas, P. & Rapp, H.T. (2015) Demosponges from the Northern Mid-Atlantic Ridge shed more light on the diversity and biogeography of North Atlantic deep-sea sponges. *Journal of the Marine Biological Association of the United Kingdom*, 95, 1485-1515. DOI: [10.1017/S0025315415000983](https://doi.org/10.1017/S0025315415000983)
- Cárdenas, P. & Rapp, H.T. (2013) Disrupted spiculogenesis in deep-water Geodiidae (Porifera, Demospongiae) growing in shallow waters. *Invertebrate Biology*, 132, 173-194. DOI: 10.1111/ivb.12027
- Cárdenas, P., Rapp, H.T., Best, M., Murillo, F.J., Gerasimova, E., Thollessen, M. & Tendal, O.S. (in prep.) A revision of Atlantic boreo-arctic Tetillidae (Porifera, Demospongiae, Spirophorida) with the description of five new species.
- Cárdenas, P., Rapp, H.T., Klitgaard, A.B., Best, M., Thollessen, M. & Tendal, O.S. (2013) Taxonomy, biogeography and DNA barcodes of *Geodia* species (Porifera, Demospongiae, Tetractinellida) in the Atlantic boreo-arctic region. *Zoological Journal of the Linnean Society*, 169, 251-311. DOI: 10.1111/zoj.12056

Reviewed and approved: 2015-12-16