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A revised classification of *Spongia mycofijiensis*

by Miranda L. SANDERS & Rob W.M. VAN SOEST

Abstract

The taxonomy of the Indo-Pacific sponge *Spongia mycofijiensis*, order Dictyoceratida, was investigated with particular regard to the appropriate genus assignment. This species, initially collected in Fiji in 1987, was noted for the presence of its unusual secondary metabolite chemistry. Since this time, there has been discussion of two alternative assignments for the species, namely *Leiosella* and *Hyattella*. Type specimens were studied from related genera of the families Spongiidae and Thorectidae, including *Spongia*, *Leiosella*, *Hyattella*, *Coscinoderma*, *Lendenfeldia*, *Hippospongia*, *Dactylospongia* and *Cacospongia*. It was found that the skeleton compared most closely to members of the genus *Cacospongia*, family Thorectidae (= Ircinidae) and is therefore concluded that the species be reassigned to this genus.
Keywords : sponges, *Spongia mycofijiensis*, taxonomy.

Résumé

La position générique de l'éponge indopacifique *Spongia mycofijiensis*, ordre Dicytoceratida est examinée. Cette espèce, initialement récoltée aux îles Fidji en 1987, fut remarquée par la nature inhabituelle de ses métabolites secondaires. Depuis, deux propositions ont été faites de transférer l'espèce à d'autres genres, *Leiosella* d'une part et *Hyattella* d'autre part. Pour résoudre la classification de *Spongia mycofijiensis*, des spécimens types des genres voisines dans les familles Spongiidae et Thorectidae, comprenant *Spongia*, *Leiosella*, *Hyattella*, *Coscinoderma*, *Lendenfeldia*, *Hippospongia*, *Dactylospongia* et *Cacospongia*, ont été étudiés. La charpente la plus proche figure parmi les membres du genre *Cacospongia*, famille Thorectidae (= Ircinidae) et le rattachement de l'espèce à ce genre est proposé.
Mots-clés : éponges, *Spongia mycofijiensis*, taxonomie.

Introduction

Spongia mycofijiensis KAKOU *et al.*, 1987 was first reported for its interesting chemistry and apparent association with the nudibranch *Chromodoris lochi* RUDMAN (KAKOU *et al.*, 1987). The sponge was initially found to contain two secondary metabolites : latrunculin A, previously identified from *Latrunculia magnifica* Keller in the Red Sea (KASHMAN *et al.*, 1980), and dendrolasin, a furanosesquiterpene found also in *Oligoceras hemorrhages*, a junior synonym of *Hyrtios violaceus* (VANDERAH & SCHMITZ, 1975) as well as a variety of terrestrial organisms. Subsequent natural products research on samples of *Spongia mycofijiensis* from both Fiji and other geographical sites revealed additional chemistry, including the unique compounds mycothiazole and the fijianolides (CREWS *et al.*, 1988, QUIÑOÁ *et al.*, 1988). Latrunculin A and mycothiazole are also of interest to the pharmaceutical industry due to their potent bioactivity against cancer cells (NATIONAL CANCER INSTITUTE, unpubl.).

This species was originally assigned to the genus *Spongia*, but closer investigation reveals that its skeletal characteristics do not meet the diagnosis of the genus as provided by revisions of the Dictyoceratida (BERGQUIST, 1980, 1995). *S. mycofijiensis* has very prominent, regular, cored primary fibres and clear, regular, ladder-like secondaries. These features clearly set this sponge apart from typical species of *Spongia* where the primary fibres are less conspicuous and often few in number and the secondary fibres are clear but prominent, forming a complex network (BERGQUIST, 1980, 1995).

Since its original classification *Spongia mycofijiensis* has been subject to several taxonomic reevaluations. Based on gross morphology we initially suggested that the sponge could be *Leiosella* aff. *levis*. However, the notable regularity of the skeleton and the prominence of the primary network separate the sponge from typical members of *Leiosella*. Furthermore, this genus is characterised by a sand armour in the ectosome, which is found only in occasional individuals of *S. mycofijiensis*. The most recent reassessment of this sponge was made by BERGQUIST in GULAVITA *et al.* (1992) based on a comparison of three sponges showing similar chemical profiles : the sponge collected by GULAVITA *et al.* (1992) from Tonga and initially described as a new genus of Thorectidae, *S. mycofijiensis*, and one specimen from the material used by CORLEY *et al.* (1988). BERGQUIST suggested that all three sponges

belong to the same species which has highly variable morphology and should be assigned to the genus *Hyattella* by amending its diagnosis to include forms with clear, laminated fibres.

Although the skeletal diagnosis of the genus *Hyattella* accommodates *S. mycofijiensis* based on the presence of prominent and cored primary fibres, there are two objections to assigning this sponge to *Hyattella* : Firstly, as BERGQUIST notes, the genus would need to accommodate forms with clear, laminated fibres. However, extension of the genus to encompass laminated and ladder-like fibres would make distinction from several thorectid genera difficult. Secondly, the type and other species of *Hyattella* have characteristic growth forms with huge cavities often covered by a transparent collagenous ectosome which are not present in *S. mycofijiensis*.

Clarification of BERGQUIST's suggestion necessitated a comparison of *S. mycofijiensis* to type (or representative) species of potentially related genera in the families Spongiidae and Thorectidae. In this study, species from eight genera were examined and compared to *S. mycofijiensis*. *Spongia*, *Leiosella* and *Hyattella* were chosen because they have been used as previous assignments. Species of the genus *Hippospongia* have frequently been confused with those now assigned to *Hyattella*; therefore the type specimen of *Hippospongia* was examined to eliminate ambiguity between these genera. *Coscinoderma* and *Lendenfeldia* were selected as potentially related genera because they are both characterised by the presence of cored primary fibres. *Dactylospongia* was chosen due to its regular secondary network of uncored fibres. *Cacospongia* was also investigated as a likely candidate as suggested by J. VACELET and R. PRONZATO (pers. comm.)

Materials and Methods

Specimens of *Spongia mycofijiensis* were provided by Phil CREWS (UC Santa Cruz) in addition to the type material at the Natural History Museum (London). Collection sites for these specimens include Benga Lagoon (Fiji), Gizo (Solomon Islands), Milne Bay (Papua New Guinea) and Manado (Indonesia). Type species (where available) from the genera *Hyattella*, *Spongia*, *Leiosella*, *Coscinoderma*, *Hippospongia*, *Lendenfeldia*, *Dactylospongia* and *Cacospongia* were also acquired from the Natural History Museum (London) for skeletal analysis. Reference numbers for these specimens are listed below.

Spongia mycofijiensis KAKOU *et al.*, 1987
BMNH 1986-9-18-1,2 (holotype)

Spongia officinalis LINNÉ, 1759
BMNH 30-8-13-188

Leiosella levis LENDENFELD, 1889
BMNH 86-8-27-319 (syntype)

Leiosella silicata LENDENFELD, 1889
BMNH 86-8-27-342

Hyattella clathrata CARTER, 1881
BMNH 1930-8-13-158

Hyattella intestinalis LAMARCK, 1814 (=*H. clathrata*)
BMNH 54-2-20-26

Hyattella sinuosa PALLAS, 1766
BMNH 90-1-31-1

Hippospongia communis LAMARCK, 1814
BMNH 1954 : 2:20:8 (syntype)

Luffariella elegans THIELE, 1899
BMNH 1908-9-24-223 (syntype)

Phyllospongia dendyi var. *frondosa* LENDENFELD, 1889
BMNH 1877-5-21-1697 (holotype)

Coscinoderma lanuginosum CARTER, 1883
unregistered (syntype)

Cacospongia mollior SCHMIDT, 1862
BMNH 39-3-6-128

Cacospongia scalaris SCHMIDT, 1862
E. HAJDU, Univ. Amsterdam

Sections were taken from dry material and prepared for light microscopy as follows: they were soaked in 50% bleach to allow tissue dissolution, rinsed in water, slide-mounted with Permount and viewed under a Leitz Diaplan light microscope.

Results

Figure 1a-c shows three distinct morphological forms of *Spongia mycofijiensis* : massive, lobate, or tubular, sometimes with a short stalk (2-3 cm). The size varies from 3 to 20 cm in height, and 2-10 cm in diameter. The surface is microconulose, and the texture is compressible and flexible. In colour, the sponge is dark brown/black externally and tan inside. The sponge is also recognisable by a sweet, pungent odour. It is generally found in sheltered reef habitats, under ledges or in caves, and is fairly rare despite its broad range of distribution in the South and Indo Pacific.

Skeletal features are characterised by the presence of prominent, cored primary fibres, regularly spaced and oriented perpendicular to the surface. The secondary network is composed of clear, regular fibres linking the primaries at right angles. The extent of coring and incorporation of foreign spicules is highly variable as illustrated in Fig. 1d-e. Lamination of the fibres can be observed at the SEM level (Fig. 1f-g). The overall organisation of the skeleton appears regular and has a ladder-like reticulation.

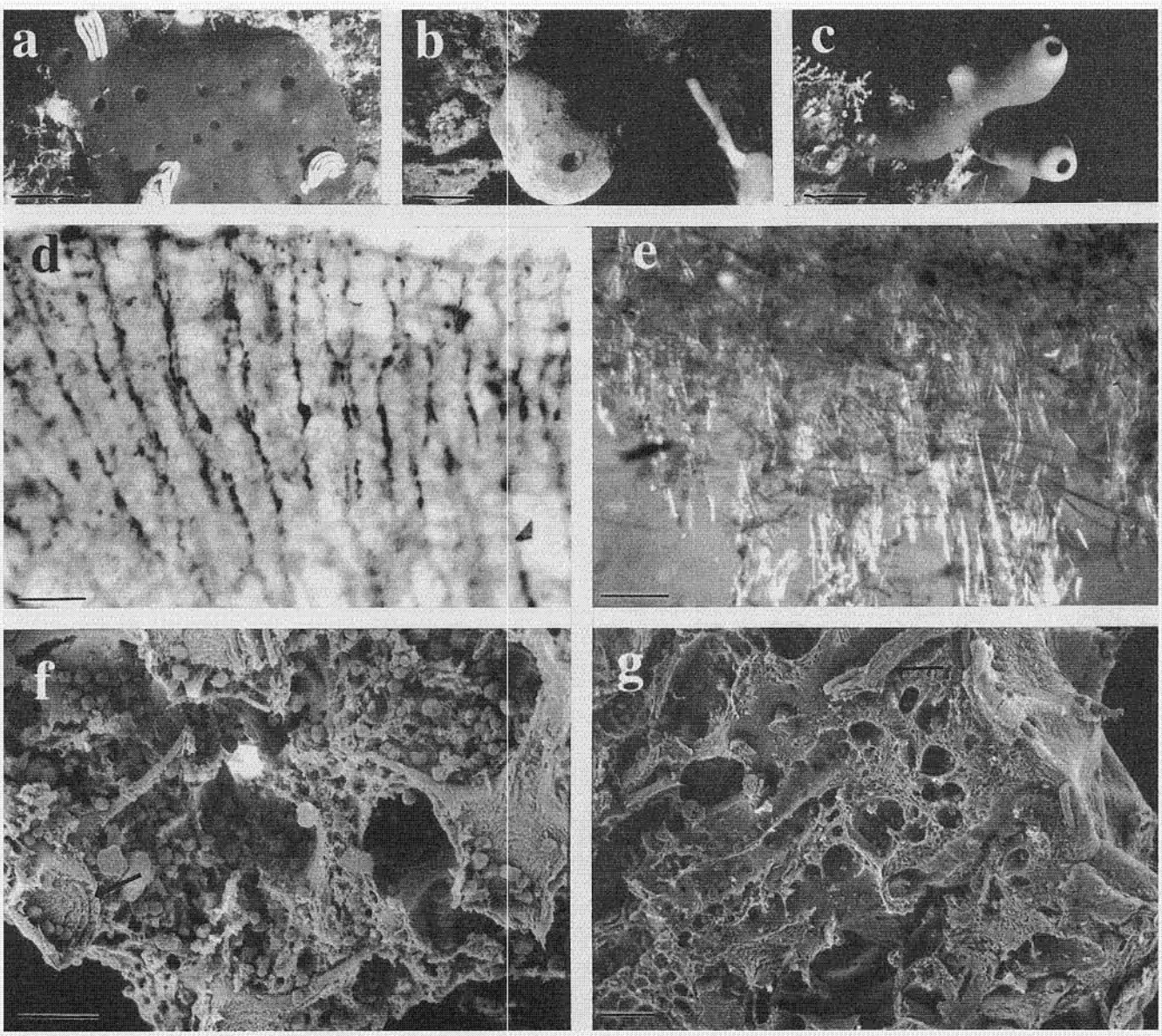

Fig. 1. - Morphology of *Spongia mycofijiensis*. a-c : 3 separate growth forms (scale bars = 3 cm); d-e : light microscope images of the skeleton showing different extents of coring (scale bars = 500 μm); f-g : SEM images showing laminated fibres (f : scale bar = 120 μm; g : scale bar = 60 μm).

Of the type specimens studied, species of *Cacospongia* and *Hyattella* are the only examples with regular, primary-network dominated skeletons (Fig. 2a-d) and are therefore most similar to *S. mycofijiensis*. Species of *Spongia* and *Leiosella* are less similar to *S. mycofijiensis* because of their reduced primary fibres; in addition, *Leiosella* species are characterised by a very consistent and prominent sand armour in the cortex (Fig. 3a-b). In skeletal form, *Lendenfeldia*, *Coscinoderma*, *Hippospongia* and *Dactylospongia* are substantially different from *S. mycofijiensis* and are therefore not illustrated; only their characteristics are summarised in Table 1. The type species of *Lendenfeldia* has prominent, cored primary fibres, but they are irregular and not consistently oriented toward the surface. *Coscinoderma lanuginosum* also has cored primary fibres, but they are less prominent than the secondaries which are fine and very tangled making the overall skeleton highly irregular in nature. *Hippospongia communis* is also characterised by a tangled, irregular skeleton and its virtual lack of primary fibres makes it markedly different from *S. mycofijiensis*. Lastly, *Luffariella elegans*, the type species of *Dactylospongia*, has relatively regular, clear secondary fibres, but differs by the complete absence of a primary network.

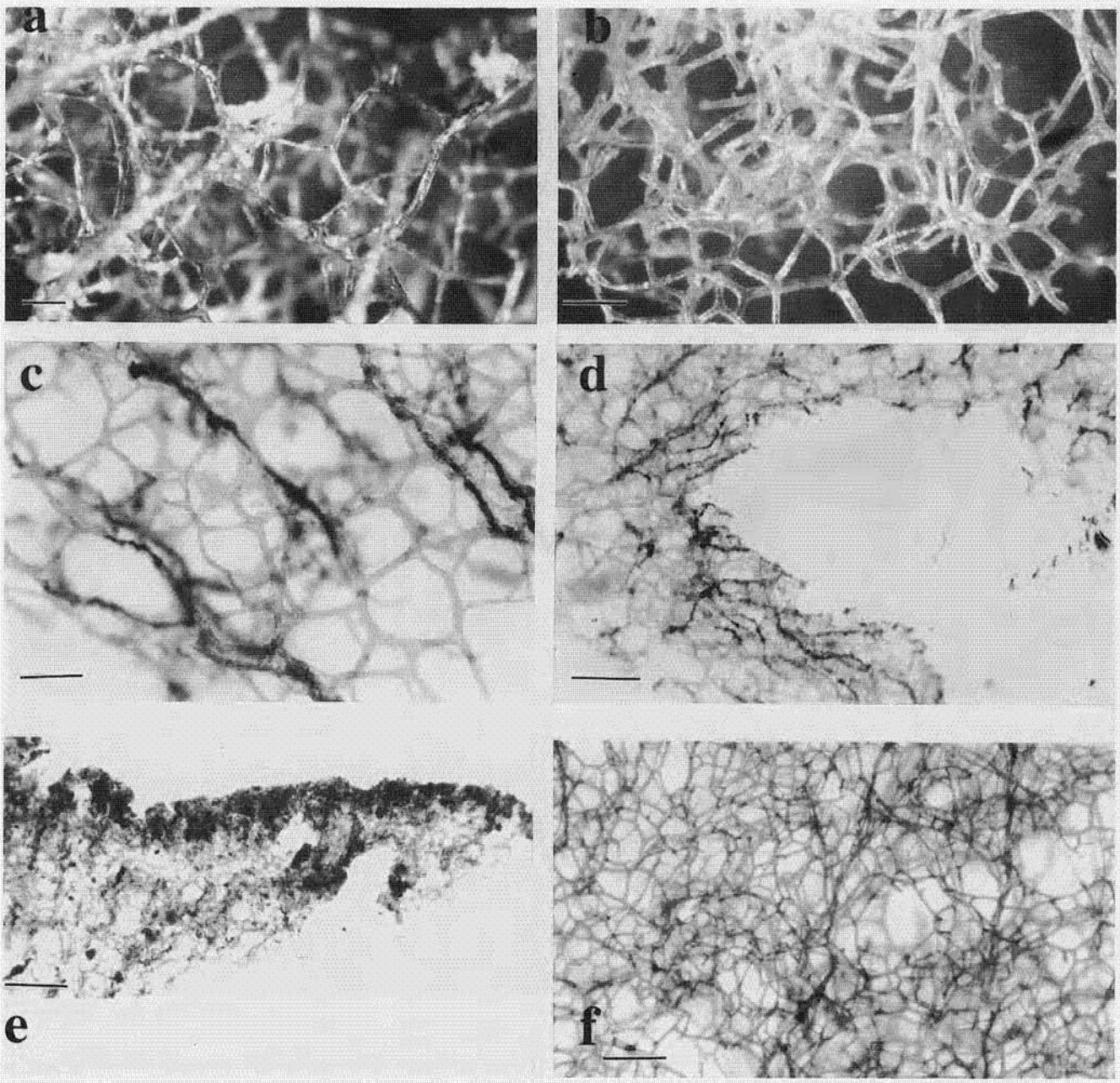

Fig. 2. - Comparison of skeletons. a : *Cacospongia mollior* (scale bar = 300 μm); b : *Cacospongia scalaris* (scale bar = 300 μm); c : *Hyattella clathrata* (scale bar = 300 μm); d : *Hyattella simuosa* (scale bar = 500 μm); e : *Leiosella levis* (scale bar = 500 μm); f : *Spongia officinalis* (scale bar = 500 μm).

Discussion

Keratose sponges are described according to skeletal characteristics, such as the nature and organisation of the primary, secondary and sometimes tertiary spongin fibre networks. Genera are defined by the extent of coring, prominence and regularity of each hierarchical network (BERGQUIST, 1980, 1995). Based on these criteria, it seems that *S. mycofijiensis* is clearly not a *Spongia*. It is morphologically similar to *Leiosella levis*, but more similar to a *Hyattella* species in skeletal character. Out of the eight genera studied, *Cacospongia* emerges as the most suitable genus for this species due to similarity in fibre lamination and coring, rectangular reticulum, and the regularity and character of the overall networks.

In the last century, the genus *Cacospongia* was used for many different kinds of dictyoceratids, but subsequent revision has reduced the genus to accommodate only Mediterranean species. However, wider distributions of species within a genus are common (VAN SOEST, 1994). This assignment means moving *S. mycofijiensis* to a different family. Such a change is warranted by the lamination of the fibres seen in this sponge, a defining feature of the family Thorectidae.

Table 1.
Summary of definitive skeletal characteristics for *Spongia mycofijiensis* and species representing 8 genera of Dictyoceratida (families Spongiidae and Thorectidae). A great degree of variation among the species occurs, spanning the range from heavily cored to clear fibres, and the relative dominance and regularity of individual networks.

Genus	Primary Fibres			Secondary Fibres			Lamination[1]
	Coring	Predominance	Characteristics	Coring	Predominance	Characteristics	
S. mycofijiensis	Yes	Yes	Regular	No	> primaries	Regular, ladder-like	Yes
Cacospongia	Yes	Equal to secondaries	Regular	No	Equal to primaries	Regular	Yes
Hyatella	Yes	Yes	Regularly spaced	No	> primaries	Regular and dense	No
Lendenfeldia	Yes	Equal	Not regular with surface	No	Equal	Irregular, not dense	No
Leiosella	Lightly	No	Sparse	Spicules	Moderately	Tangled	No
Spongia	Yes	Reduced in number, mainly at surface	Sparse	No	Yes	Intertwined	No
Coscinoderma	Yes	< secondaries	Irregular	No	Yes	Fine, intertwined "whorls of wool"	No
Hippospongia	N/A	Almost none	N/A	No	Yes	Tangled	No
Dactylospongia	N/A	None	N/A	No	Yes	Relatively regular, dense	No

[1] All specimens were viewed by light microscopy only, except *S. mycofijiensis* which was also imaged using SEM.

This study illustrates the difficulty frequently found in separating members of the two families Thorectidae and Spongiidae. Although the families have been distinguished by the presence of laminated fibres in the Thorectidae, it is now apparent that there are several members of the Spongiidae family that fulfil this criterion. The frequent use of electron microscopy allowing higher magnification of skeletal features reveals concentric rings in fibres which otherwise appear homogeneous under the light microscope. (BERGQUIST *et al.*, 1988). Other morphological characters such as choanocytes and chamber dimensions have been used to distinguish between families (VACELET *et al.*, 1989). However, Spongiidae and Thorectidae remain very similar within these parameters.
We conclude that reevaluation of the distinctness and generic content of these two dictyoceratid families is in order.

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Miranda L. SANDERS
Department of Chemistry & Biochemistry
University of California at Santa Cruz
Santa Cruz, CA 95064
USA

&

Rob W. M. VAN SOEST
Institute for Systematics and Population Biology
(Zoologisch Museum)
University of Amsterdam
PO Box 94766, 1090 GT Amsterdam
The Netherlands