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Three New Species of *Tethya* (Porifera: Demospongiae) from German Aquaria

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With 32 figures and 1 table

Summary

Three new species of *Tethya* Lamarck, 1815 (Porifera, Demospongiae, Tethyidae), *T. wilhelma*, *T. minuta* and *T. gracilis* collected respectively in the public aquaria of the Zoological-Botanical Garden of Stuttgart, the Vivarium of the State Museum for Natural History Karlsruhe and the Aquazoo Löbekke-Museum Düsseldorf, are described. These species are likely to be of indo-pacific origin and show affinities with some indo-pacific species of the *T. seychellensis* group. The white colour and the delicate texture that distinguish these species from other *Tethya* may be due to the aquarium growth and life. In the aquaria the three species reproduce by budding.

Zusammenfassung

Drei neue Arten der Gattung *Tethya* Lamarck, 1815 (Porifera, Demospongiae, Tethyidae) *T. wilhelma, T. minuta* und *T. gracilis,* gesammelt im Aquarium des Zoologisch-Botanischen Gartens Wilhelma in Stuttgart, im Vivarium des Staatlichen Museums für Naturkunde Karlruhe und im Aquazoo Löbekke-Museum Düsseldorf, werden beschrieben. Diese Arten sind vermutlich indopazifischen Ursprungs und weisen Ähnlichkeiten auf zu indopazifischen Arten der *T. seychellensis*-Gruppe. Die weiße Farbe und fragile Textur, die diese Arten von anderen *Tethya*-Species unterscheiden, könnten auf Wachstum und Leben im Aquarium zurückzuführen sein. Alle drei Arten reproduzieren sich durch Knospung in den Aquarien.

Contents

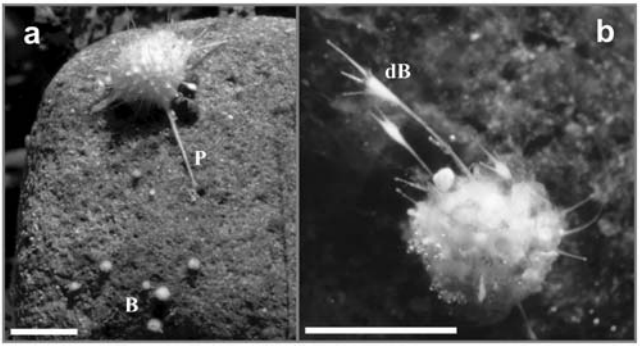


Fig. 1. Life habitus of *Tethya wilhelma* in the aquarium. Scale bars 10 mm. – a. Specimen attached to a stone showing podia *(P).* The spread small bud *(B)* are daughters of this specimen. The distance between mother sponge and daughters illustrates the movement ability. – b. Another specimen showing developing buds *(dB).* – Photographs: M. NICKEL.

1. Introduction

The study of *Tethya* specimens collected from the public aquaria of the Zoological-Botanical Garden Wilhelma of Stuttgart, the Vivarium of the State Museum for Natural History Karlsruhe and the Aquazoo Löbekke-Museum Düsseldorf shows that these speciments belong to three new species of the genus *Tethya* Lamarck, 1815 (Porifera, Demospongiae, Tethyidae). Their origin, presently unknown, is very probably indo-pacific. According to the available information the species appeared many years ago after indo-pacific material was brought into the aquaria (HEBBINGHAUS, personal communication). Some spicular traits, as the lacunar aquiferous system and the distinct categories of cortical and choanosomal micrasters show the affinity of *T. wilhelma* and *T. gracilis* with some indo-pacific species of the *T. seychellensis* group (SARÀ, 1998). But also *T. minuta,* in spite of the lack of choanosomal oxyasters, may be attributed to this group.

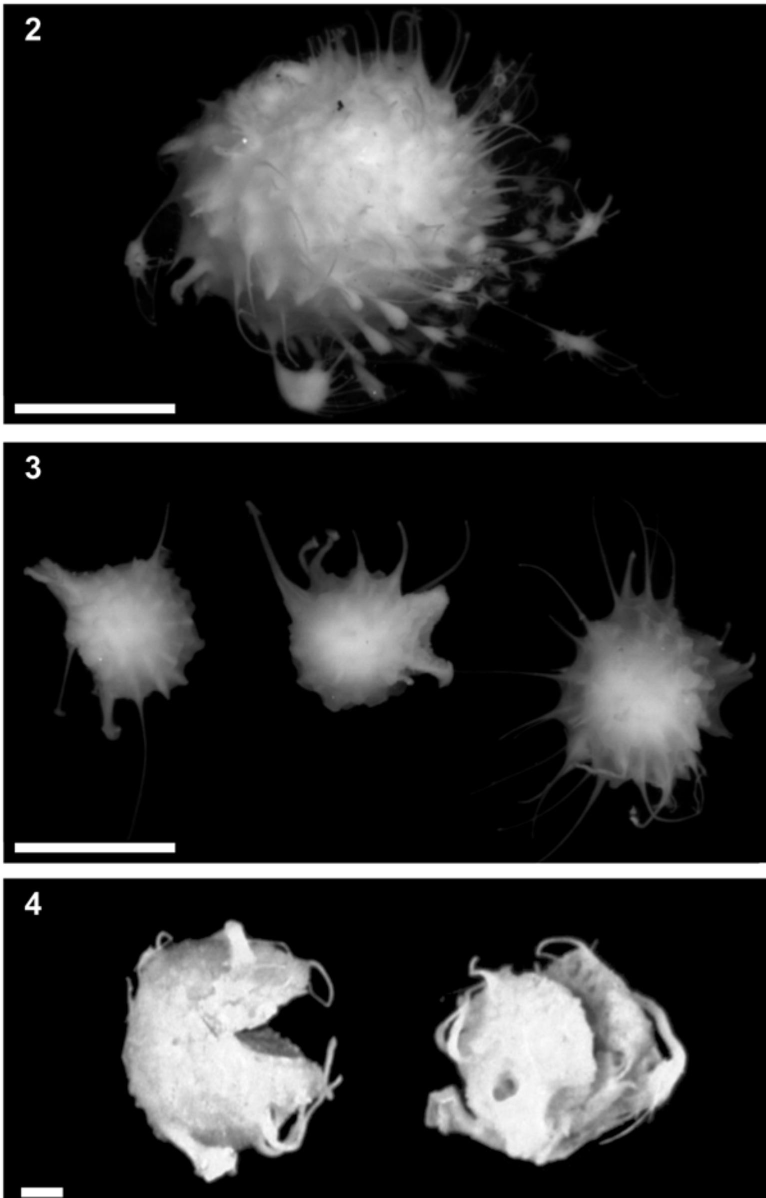
It is interesting to remark that some traits as the delicate texture and the white colour are unusual in *Tethya.* These traits common to the three species may be due to the growth and life in aquaria. These species reproduce asexually by thin external buds (Fig. 1). However, even if not observed, sexual reproduction cannot be excluded. All three species have the ability to move their bodies in a process of continuous morphological reorganisation.

2. Materials and methods

Life aspects and movements of *T. wilhelma* have been recorded in the aquarium habitat. Specimens of *T. wilhelma, T. minuta* and *T. gracilis* were removed from hard bottom substrate (stones, dead coral blocks) of the aquaria of Stuttgart, Karlsruhe and Düsseldorf and preserved in ethanol 70 %.

The holotypes of the species are deposited in the Museum of Natural History of Genova, Italy *(MSNG).* Paratypes are located in the Museum for Natural History in Stuttgart, Germany *(SMNS).*

Spicular slides by dissociation through nitric acid and transversal body-sections on paraffin-embedded material or by hand were prepared in order to study spiculation and skeleton



Figs. 2–4. Ethanol samples. Scale bars: 5 mm. – 2. *Tethya wilhelma,* paratype (SMNS); – 3. *Tethya minuta,* paratypes (SMNS); – 4. *Tethya gracilis,* holotype (MSNG). – Photographs: 2–3. M. NICKEL, 4. A. SARÀ.

architecture. For Scanning Electron Microscopy (SEM) spicules were prepared by repeated hot nitric acid digestion followed by washing in distilled water, 70 % ethanol and a final suspension in absolute ethanol. Samples were spread on glass cover slides (diameter 12 mm) mounted on alloy SEM stubs. The stubs were sputter coated with gold in an Edwards Sputter Coater S150B. The photographs were taken using an ISI-SS40 SEM (SMNS) exposed on Ilford FP4 125 ASA film and digitally on an Amray 1610 Turbo SEM (Eye of Science). The terminology used for the spicular traits follows SARÀ (1994).

3. Species description

3.1. *Tethya wilhelma* new species

Examined material: Holotype (III. 1999) MSNG 50689, 2 Paratypes (VII. 2000) SMNS ZI 0050267; and other 4 specimens. Type locality: Aquarium of the Zoological-Botanical Garden "Wilhelma" in Stuttgart; leg. MICHAEL NICKEL.

Etymology: From the Zoological-Botanical Garden Wilhelma of Stuttgart where the specimens for the study of this species have been collected. This Garden was built in 1850 for WILHELM I, King of Württemberg, and named after him.

Morphology: Spherical, generally 0.5–1.0 cm in diameter, up to 2 cm in larger specimens. Colour white in life (Fig. 1) and in ethanol (Fig. 2). Consistency compressible. The surface is covered by narrow cylindrical tubercles raised by the ends of megasclere bundles and by larger flattened tubercles where some bundles open in small fans. The tubercles, 0.5–1.0 mm high may produce longer filaments and, especially in bigger specimens, stalked buds. Cortex (without tubercles) 0.5–1.0 mm in thickness, very lacunar in the outer zone, compact in the inner zone (Fig. 5).

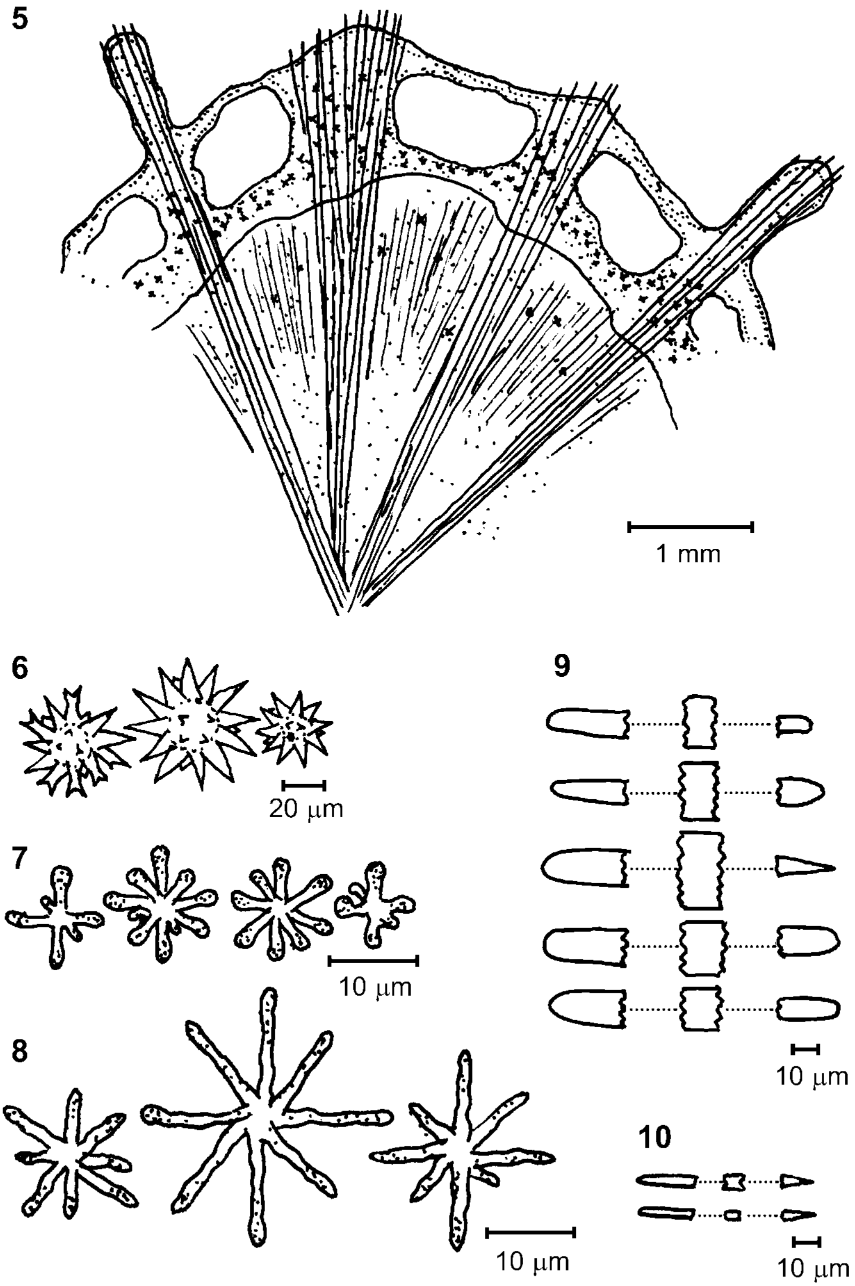
Skeleton structure: Radial bundles of megascleres end in the cortex without fans in raised tubercles or with little forked small fans in flattened tubercles (Fig. 5). Groups of interstitial megascleres are present in the choanosome among the main bundles. The megasters are placed in few continuous layers all around the inner half of the cortex, above a narrow band of fibrous tissue which encircles the choanosome, and along the megasclere bundles until the surface. Few smaller spherasters in the outer choanosome. Tylasters form a dense covering on the sponge surface and occur in the cortex and in the choanosome. Larger strongylasters and oxyasters may be occasionally present in the cortex and are predominant in the choanosome.

Spicules: Main megascleres are strongyloxeas or anisostrongyles (Fig. 9), both approximately in the same number, 950–1470 µm in length x 10–25 in width. Auxiliary megascleres are slender strongyloxeas or styles, 300–700 x 2–8 µm (Fig. 10).

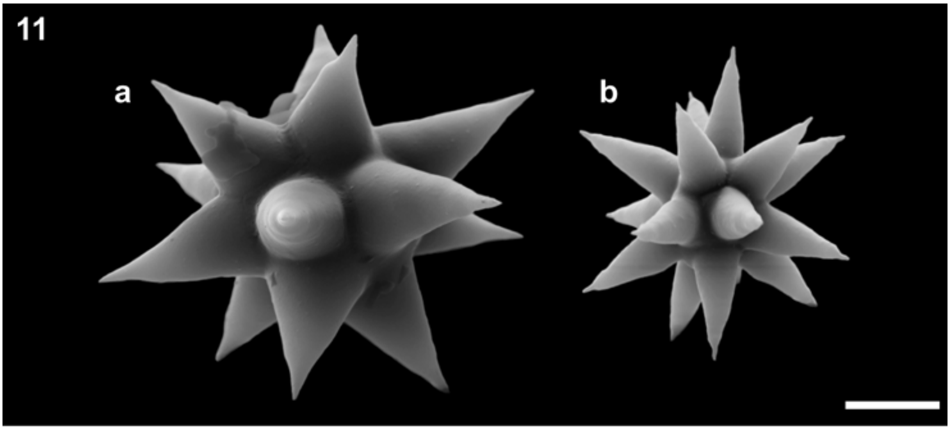
Megasters are spherasters 15–60 µm in diamater [generally 50 with R/C (ratio between ray length and center)] = 0.5–1.0 (mainly 0.8) and with 18–24 rays, sometimes forked or spined (Figs. 6, 11). Some small spherasters occur into the choanosome.

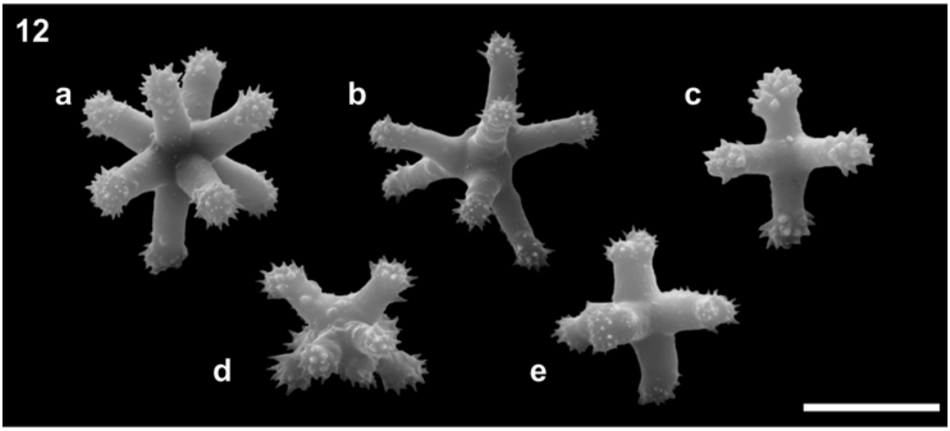
Micrasters belong to two categories. Cortical micrasters are tylasters, 10–12 µm in diameter with 8–12, sometimes 6, thick spined rays (Figs. 7, 12). This type occurs also in the choanosome. A second category, which predominates in the choanosome but may be occasionally found also in the cortex, is represented by larger and scattered strongylasters, sometimes oxyasters, with a diameter of 12–20, rarely 25 µm and 8–12 slender and little spined rays, frequently bent and with tips not well pointed (Figs. 8, 13).

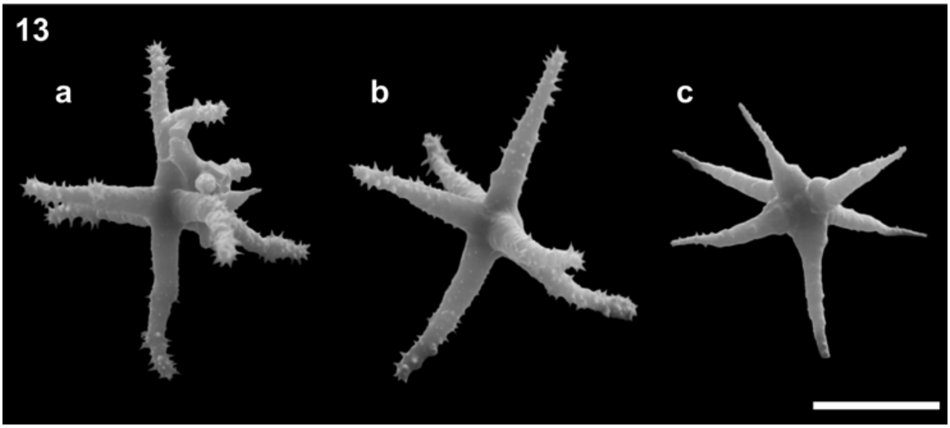
Remarks: The white colour and the delicate texture of this species, as mentioned above, may depend by its acclimatisation to the growth and life in aquaria. The great



Figs. 5–10. *Tethya wilhelma.* – 5. General skeletal arrangement; – 6. spherasters; – 7. tylasters; – 8. choanosomal strongylasters; – 9. main megascleres: strongyloxeas and anisostrongyles; – 10. auxiliary megascleres: strongyloxeas and styles. – Drawings: M. & A. SARÀ.







Figs. 11–13. *Tethya wilhelma;* SEM micrographs of spicules of the SMNS paratype. Scale bar: 5 µm. – 11. a–b. Spherasters; – 12. a–e. cortical tylasters; – 13. choanosomal micrasters; a–b. scattered strongylasters, c. oxyaster. – Photographs: O. MECKES.

development of the cortical lacunes and the features of the two types of micrasters indicate an affinity of *wilhelma* with some Indo-Pacific species of the *T. seychellensis* (Wright, 1881) group (WRIGHT, 1881, SARÀ, 1988) as *T. orphei* Sarà 1990 and *T. viridis* Baer 1906 (BAER, 1906, SARÀ 1990, 1992) generally living under dead coral stones in the coral reef lagoons. *T. wilhelma,* however, is significantly distinguished in some traits by both species. From the more akin *T. orphei* to which *wilhelma* is similar in the cortical lacunae development, it differs for the colour, the tubercles shape, the megasclere categories, the spherasters distribution, the choanosome micraster shape and size.

3.2. *Tethya minuta* **new species**

Examined material: Holotype (V. 2000) MSNG 5068; 6 Paratypes (VII. 2000) SMNS ZI 0050266. Type locality: Vivarium of the Museum for Natural History in Karlsruhe; leg. MICHAEL NICKEL.

Etymology: The name *minuta* refers to the small body size, lack of choanosomal oxyasters and to the reduced size of its tylasters.

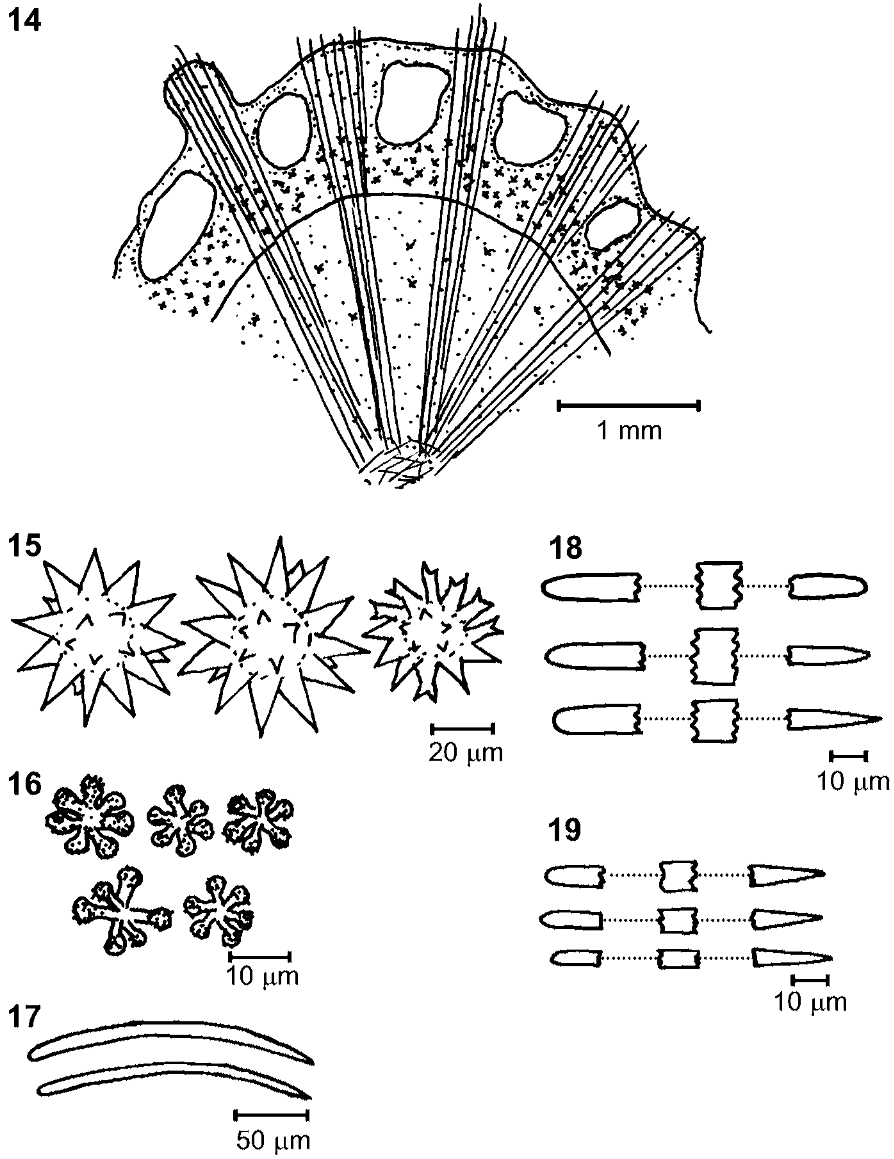
Morphology: Spherical, 0.3–0.6 cm in diameter. Colour white in life and in ethanol (Fig. 3). Consistency compressible. The surface is covered by narrow cylindrical or irregularly flattened tubercles raised by the ends of megasclere bundles. The tubercles, 0.2–0.5 mm high may produce long filaments and stalked buds. Cortex (without tubercles) 1 mm in thickness, very lacunar in the outer zone, compact in the inner zone.

Skeleton structure: Radial bundles of megascleres end in the cortex without terminal fans in more or less flattened or erect cylindrical tubercles (Fig. 14). Few interstitial auxiliary megascleres are scattered in the choanosome among the main bundles. In one specimen we have found a central nucleus, 5 mm in diameter, made by the bases of the megasclere bundles encircled by a felt of small curved styles and oxeas. The megasters, in many layers, fill densely the inner half of the cortex. Few are found in the outer cortex and, smaller, into the choanosome. Very small tylasters form a dense covering on the sponge surface and are found, as the only category of micrasters, in the cortex and choanosome. *T. minuta* lacks therefore the choanosomal category of strongylasters and oxyasters which occurs in *T. wilhelma.*

Spicules: Main megascleres are strongyloxeas, generally with a somewhat abredged or rounded distal end (Fig. 18). Only some of these may be called true anisostrongyles. They measure 800–1350 x 10–18 µm. Auxiliary megascleres are slender strongyloxeas and styles, 320–600 x 2–8 µm (Fig. 19). Nuclear megascleres are small styles and, in less number, oxeas, generally a little curved at one third of their length, 170–270 x 3–6 µm (Fig. 17).

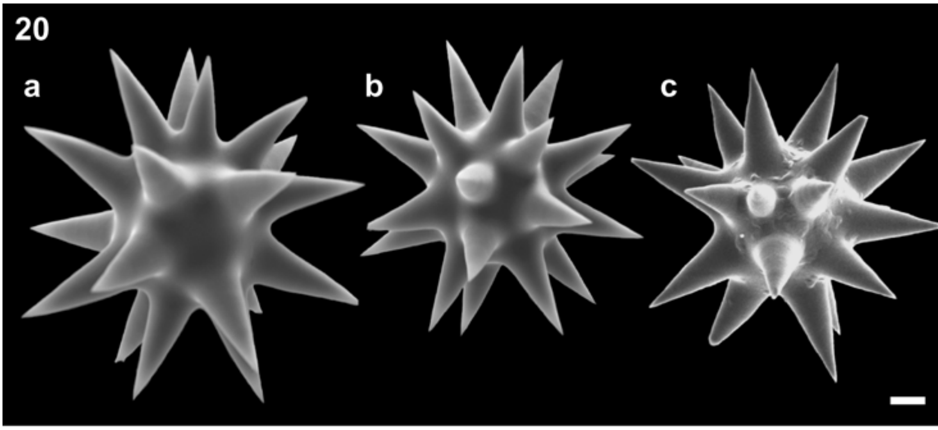
Megasters are spherasters 40–80 µm (generally 60–70) with R/C = 0.5–0.8 with 18–24 rays, sometimes spined or forked (Figs. 15, 20). Some small megasters occur in the choanosome. The spherasters of *T. minuta* are in the mean more robust (larger and with a greater center in relation to the rays) but also more heterogeneous (for size and R/C) than in *T. wilhelma.* Also the megaster cortical ring seems more developed in *T. minuta* than in *T. wilhelma,* occupying about one half instead than one third of the cortical thickness.

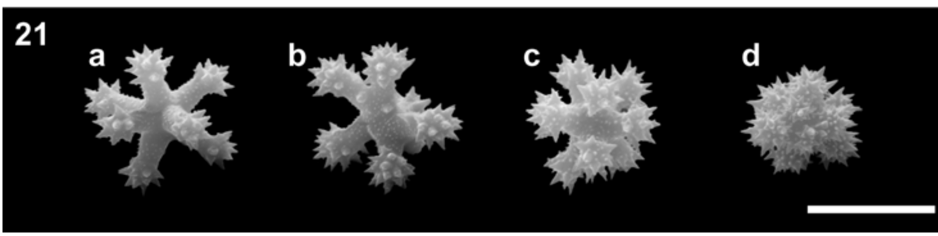
Micrasters are very small tylasters in the cortex and choanosome, 4.0–7.5 µm (mainly 5–6) in diameter, with 8–12, some among the largest 6 (then tetraradiate on the plane), spiny, more or less thick rays (Figs. 16, 21).



Figs. 14–19. *Tethya minuta.* – 14. General skeletal arrangement; – 15. spherasters; – 16. tylasters; – 17. nuclear styles; – 18. main megascleres: strongylasters and anisostrongyles; – 19. auxiliary megascleres: strongyloxeas and styles. – Drawings: M. & A. SARÀ.

Remarks: Morphological characters, as the white colour, the delicate texture, the small size, the very developed lacunae in the cortex, the tubercles shape, the type of asexual budding, show a striking convergence with the other aquarium species *T. wilhelma* with which *T. minuta* may be easily jumbled. A large part of the likeness may be due to the common life and growth in a very peculiar habitat as the





Figs. 20–21. *Tethya minuta;* SEM micrographs of spicules of the SMNS paratype. Scale bar: 5 µm. – 20. a–c. Spherasters; – 21. a–d. variants of tylasters. – Photographs: 20c. S. LEIDENROTH; others: O. MECKES.

aquarium hard substrate. On the other hand, spiculation show several discrepancies concerning the megascleres, the megasters and the micrasters. Among these the more important, and certainly of specific value, regard the size of the tylasters and the lack in *T. minuta* of the choanosomal strongylasters and oxyasters.

The more similar species for the minute size of the micrasters are the indo-pacific *Tethya microstella* Sarà 1990 and *T. parvistella* Baer 1906. *T. microstella,* with a large distribution in the lagoons of coral reefs in the Pacific and Indian Ocean, is very alike in the size of cortical tylasters, in the large development of the lacunae, in the tubercle shape and in sponge size but differs for the colour (but this may be due to the acclimation of *T. minuta* to the aquarium life), and several spicular details as the greater size of choanosome tylasters, a greater R/C of the spherasters, their distribution in the cortex and the size and shape of strongyloxeas. *T. parvistella* from Zanzibar, has larger micrasters (7 µm instead of 4–6), megascleres represented by strongyloxeas and amphistrongyles and the spherasters are smaller.

3.3. *Tethya gracilis* new species

Examined material: Holotype (VII. 2000) MSNG 50687; 2 Paratypes (VII. 2000) SMNS ZI 0050265. Type locality: Aquarium of the Aquazoo Löbekke-Museum Düsseldorf; leg. ROLF HEBBINGHAUS.

Etymology: The name refers to the oxyspheraster shape of its megasters and their thin cortical distribution.

Morphology: The holotype subspherical, 1.0 x 1.2 cm and one paratype spherical, 0.6 cm in diameter. Colour white in life and in ethanol (Fig. 4). Consistency compressible. The surface is covered by flattened tubercles, 0.2 mm high. At the upper pole of the sponge bud filaments. Laterally and below some flattened stolons, reaching 1.5 cm in length. Cortex, without tubercles, 1.25 mm in thickness (paratype), lacunar in the outer zone.

Skeleton structure: Radial bundles of megascleres, very coiled in a paratype, 250 µm thick, ending in the cortex with fans which show an irregular and faint subdivision in fascicles (Fig. 22). In the same paratype a central nucleus, 1 mm in diameter, similar to the *T. minuta* nucleus. The megasters, in one or two layers only, form a thin ring in the inner part of the cortex but separated by a tissue zone without asters from the choanosome. Some small megasters in the upper zone of the choanosome. Slender few-rayed tylasters cover the surface of the sponge and are distributed in the whole cortex. In the choanosome few larger and irregular oxyasters.

Spicules: Main megascleres are strongyloxeas, often a little curved in the proximal trait, sometimes with abridged or rounded distal end, and anisostrongyles (Fig. 26). Size: 900–1800 µm x 11–15. Auxiliary megascleres are slender styles and anisostrongyles. 275–950 µm x 2–5 (Fig. 27).

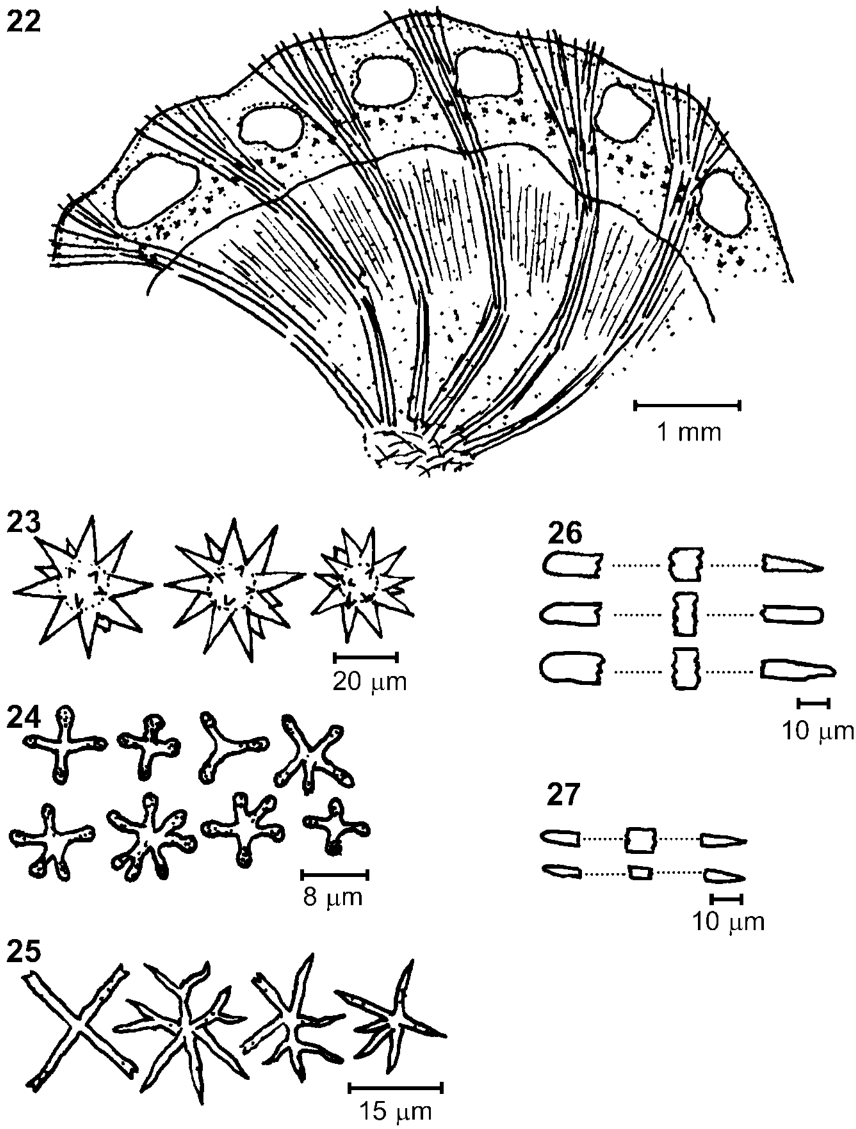
Megasters are generally oxyspherasters 15–45 µm with R/C = 1.0–1.5, with 16–18 rays (Figs. 23, 28). The megasters of *T. gracilis* are smaller and more slender and the cortical ring thinner than in *T. wilhelma* and *T. minuta.*

Micrasters of two categories are found. Cortical tylasters 6–10 µm in diameter with 3–6 rays, frequently tetraradiate (Figs. 24, 29). Sometimes anomalous with forked or distorted rays. Choanosomal oxyasters, and sometimes strongylasters or little swollen tylasters, 10–20 µm in diameter with 6–8 slender rays sometimes forked, distorted or with bifid tips (Figs. 25, 30). Some intermediates between the two categories may be found (Fig. 31).

Remarks: Some morphological characters as the white colour, the delicate texture, the lacunar cortex, the small size, show a convergence with the other aquarium species here described. But other morphological traits as the tubercle shape, the coiled megasclere bundles with terminal fans, the thin cortical ring of megasters and the stolons characterise this species. Also its spiculation show several differences as the higher R/C of its smaller megasters, the shape and size of its cortical and choanosomal micrasters. As indicated by the shape of its micrasters *T. gracilis* is among the three aquarium species the more akin to *T. seychellensis.* However it is distinguished from this species and the related *T. viridis* and *T. orphei* also for the smaller size of its choanosome oxyasters in addition to other morphological and spicular traits as the megaster shape and distribution.

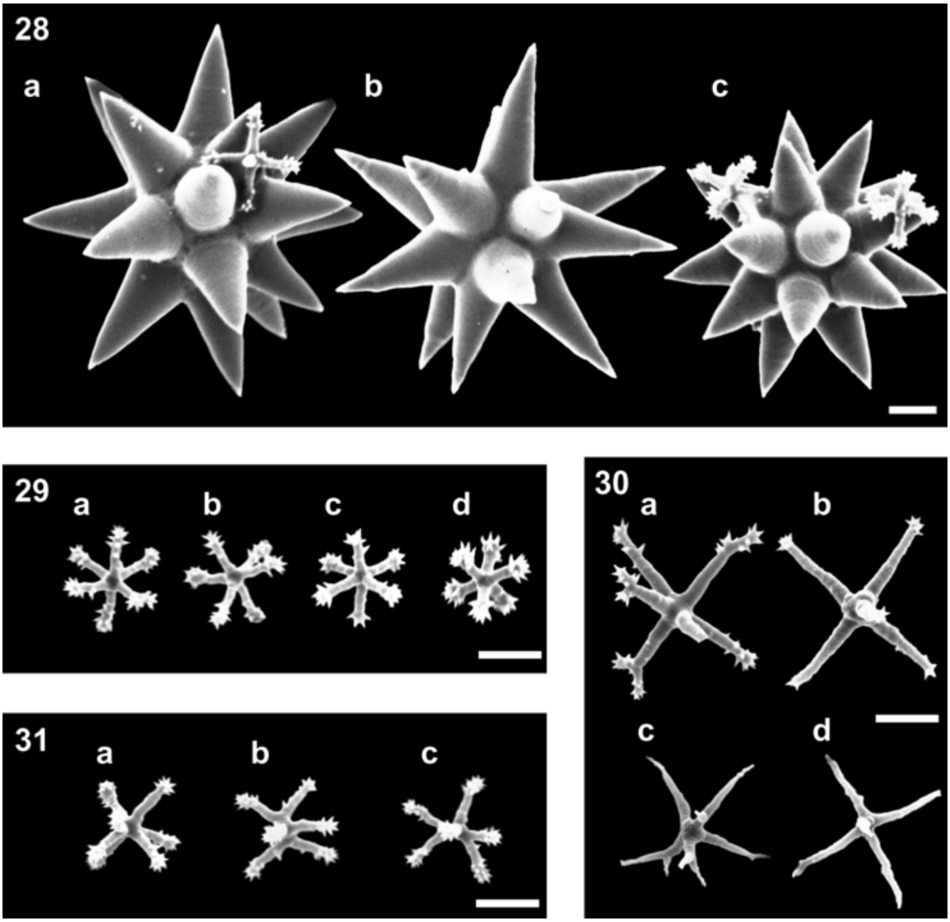
4. Species comparison

A comparison of spicular traits (Table 1) among the three German aquaria species shows that these species are well differentiated especially in the aster complement and that *T. gracilis* is the most divergent. *T. gracilis* differs from the other species in its megaster size and shape: the megasters are smaller, with a slender shape (oxyspherasters instead of spherasters) and with a lower ray number. *T. gracilis* is also well distinguished by the cortical and choanosomal micrasters: the cortical micrasters are tylasters, as in the other species, but in *T. gracilis* the ray number is distinct-



Figs. 22–27. *Tethya gracilis.* – 22. General skeletal arrangement; – 23. oxyspherasters; – 24. tylasters; – 25. choanosomal oxyasters; – 26. main megascleres: strongyloxeas and anisostrongyles; – 27. auxiliary megascleres: anisotrongyles and styles. – Drawings: M. & A. SARÀ.

ly lower. As in *T. wilhelma* the choanosomal micrasters differ from the cortical ones, but their shape is different, generally being oxyasters instead of strongylasters. *T. gracilis* differs from the other species also in the size and shape of their longer and thinner strongyloxeas or anisostrongyles.



Figs. 28–31. *Tethya gracilis;* SEM micrographs of spicules of the SMNS paratype. Scale bar: 5 µm. – 28. a–c. Spherasters (b and c with attached tylasters); – 29. a–d. cortical tylasters; – 30. choanosomal oxyasters; a–b. tylasters, c–d. strongylasters; – 31. a–c. intermediate forms of tylasters. – Photographs: S. LEIDENROTH.

T. wilhelma and *T. minuta* are differentiated mainly because of their micrasters. In *T. wilhelma* there are two distinct micraster categories in the cortex and in the choanosome while in *T. minuta* the micrasters are similar in both regions. Moreover, the tylasters of *T. wilhelma* are considerably larger than in *T. minuta.* Another difference between the species regards the shape and size of the spherasters: in *T. wilhelma* they are a little smaller and thinner than in *T. minuta.*

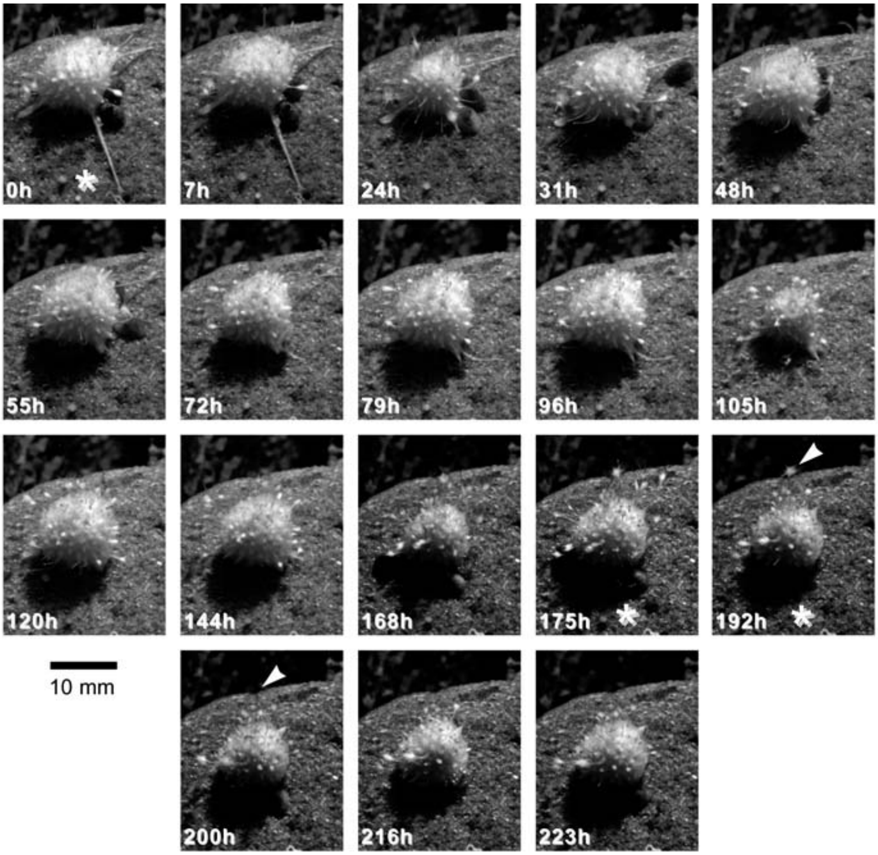
Tab. 1 Synopsis of the main spicular traits. – *Explications:* Measurements [in *µm*] refer to minimal and maximal values; main range in *brackets; L* = Length, *W* = Width, *D* = Diameter, *RN* = Ray Number, *R/C:* see in chapter 3.1.

	Main Megascleres		Megasters			Micrasters			
						Cortex		Choanosome	
	L	W	D	R/C	RN	D	RN	D	RN
T. wilhelma **new species**	Strongylo-xeas or anisostrongyles		Spherasters			Tylasters		Strongylasters (oxyasters)	
	950–1470	10–25	15–60 (40–60)	0.5–1.0	18–24	10–12	6–12	12–20	8–12
T. minuta **new species**	Strongylo-xeas (aniso-strongyles)		Spherasters			Tylasters		Tylasters	
	800–1350	10–18	20–80 (60–70)	4.0–7.5 (5–6)	6–12	4.0–7.5 (5–6)	6–12	4.0–7.5 (5-6)	6–12
T. gracilis **new species**	Strongylo-xeas or aniso-strongyles		Oxyspherasters			Tylasters		Oxyasters (strongylasters or tylasters)	
	900–1800	11–15	15–45	1.0–1.5	16–18	6–10	3–6	12–20	6–8

5. Movement and budding of *Tethya*

All three new species of *Tethya* show moving behaviour. For *T. gracilis* (found in the Aquazoo Düsseldorf) it has been reported by Hebbinghaus (1996), before the other species have been found in Stuttgart and Karlsruhe and before it has been realised to be a new species. Especially small specimens move from one place to another at a velocity of several cm per day. This behaviour was previously reported by Fishelson (1981) for young specimens of several *Tethya* species. The moving mechanism is unknown so far, though investigations have been performed by Bond & Harris (1988). The appearance of podia which attach to the surrounding substrate and the detachment of the sponge body from the substrate may play a role. On the other hand the sponges are also able to move when they are attached to the substrate. Another aspect is the combination of movement and budding which occurs frequently (Fig. 1). In this way a distribution of the daughter individuals is ensured and competition for food between related individuals is avoided. The continuous rearrangement of the body, budding and podial formation and reduction was shown by long-term photographic recording (Fig. 32). The body can also be slowly contracted to approximately 80 % of the body size. The changing of the texture of the surface is a consequence of cellular reorganisation of the outer lacunar zone of the cortex.

Cellular reorganisation is the basis of all kind of movements in *Tethya.* Recent investigations focused on the cell types and the bundled megascleres involved in motility (Nickel & Brümmer, manuscript in preparation). The biological function of



Figs. 32. *Tethya wilhelma,* time series over 223 hours. During the 72 hours the podias are withdrawn and the sponge starts producing buds at higher amount. The buds are either attached to the substrate (*star* at 0 h) or may be released from the stalks and taken away by current (*arrowheads* at 192 h and 200 h). The attached buds may also be taken away by current (*stars* at 175 h and 192 h). Note the ability of body contraction (24 h and 105 h). – Photographs: M. NICKEL.

this movement phenomenon may be intrinsic to the environmental conditons of the natural habitat. Some species of *Tethya* live in the shallow lagoons of coral reefs where sedimentation is a major problem to sessile animals. Spreading sand on *T. wilhelma* in the aquarium induces this movement in most cases, even changing the position of the substrate in the aquarium induces this behaviour. It seems that in this way some *Tethya* species are able to get rid of sediment and fined optimised living conditions.

6. Acknowledgements

This work has been financially supported by Italian Government (M.U.R.S.T.) funds. ISABEL KOCH (Wilhelma Stuttgart) and HANNES KIRCHHAUSER (Vivarium Karlsruhe) kindly permitted us to collect material from their aquaria and helped with sampling. ROLF HEBBINGHAUS (Aquazoo Düsseldorf) kindly provided material of his previously undetermined species. We thank SUSANNE LEIDENROTH (SMNS) and OLIVER MECKES (Eye of Science, Reutlingen, www.eyeofscience.com) for excellent technical assistance and for provinding SEM photographs. We like to thank Prof. HANS-DIETER GÖRTZ (Stuttgart) for the continuous support of our work.

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