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Tridacna (*Chametrachea*) *costata* ROA-QUIAOIT, KOCHZIUS, JANTZEN, AL-ZIBDAH & RICHTER from the Red Sea, a junior synonym of *Tridacna squamosina* STURANY, 1899 (Bivalvia, Tridacnidae)

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Abstract

Analysis of the material of Tridacnidae collected during the Pola Red Sea Expeditions 1895/96 and 1897/98 revealed that the recently described *Tridacna* (*Chametrachea*) *costata*, ROA-QUIAOIT, KOCHZIUS, JANTZEN, AL-ZIBDAH & RICHTER in RICHTER, ROA-QUIAOIT, JANTZEN, AL-ZIBDAH & KOCHZIUS, 2008 is identical with *T. elongata* var. *squamosina* STURANY, 1899. For more than one hundred years the material has been kept in the Mollusca collection of the Natural History Museum in Vienna without proper identification. During the analysis of the material it was possible to identify the relevant specimens with the consequence that *T. costata* has to be considered a junior synonym of *T. squamosina*. With this newly designated lectotype the southernmost occurrence of *T. squamosina* is recorded.

Key Words: Red Sea, Bivalvia, Cardioidea, *Tridacna*, *squamosina*, *costata,* Sturany, Pola type material.

Zusammenfassung

Bei Untersuchung der Tridacnidae, die während der Pola Expeditionen ins Rote Meer 1895/96 und 1897/98 aufgesammelt wurden, zeigte sich, dass die jüngst beschriebene *Tridacna* (*Chametrachea*) *costata*, ROA-QUIAOIT, KOCHZIUS, JANTZEN, AL-ZIBDAH & RICHTER in RICHTER, ROA-QUIAOIT, JANTZEN, AL-ZIBDAH & KOCHZIUS, 2008 mit *T. elongata* var. *squamosina* STURANY, 1899 identisch ist. Über 100 Jahre war das Expeditionsmaterial in der Molluskensammlung des Naturhistorischen Museum in Wien aufbewahrt worden, ohne eingehende Identifizierung. Während der Bearbeitung des Materials konnten die entsprechenden Exemplare identifiziert werden, mit der Konsequenz, dass *T. costata* als Juniorsynonym von *T. squamosina* anzusehen ist. Mit dem neu designierten Lectotypus wird gleichzeitig auch die südlichste Verbreitung dokumentiert.

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Introduction

Giant clams are among the most spectacular marine bivalves. Huge size, ease of recognition, peculiar feeding mechanism and shallow reef habitats are well known features of this group. *Tridacna* BRUGUIÈRE, 1797 encompasses the heaviest and after *Kuphus* GUETTARD, 1770 the second largest recent bivalve. Numerous tridacnids have been described. Most modern authors consider currently seven extant *Tridacna* as valid; in one case, however, the validity is disputed. For *Tridacna rosewateri* SIRENKO & SCARLATO, 1991 it is unclear if this species is a habitat-variant – as indicated by BENZIE & WILLIAMS (1998), or a distinct species endemic to the Mascarene Plateau, in the sense of NEWMAN & GOMEZ (2000). LUCAS et al. (1990, 1991) described a new species from Tonga and Fiji which turned out to be a junior synonym of *T. mbalavuana* LADD, 1934 from the Upper Tertiary of Fiji. Paleontological studies, which tried to reconstruct the evolution and radiation of Tridacnidae implied that modern lineages originated in the Paleogene and early Neogene of the East African-Arabian Province (see HARZHAUSER et al. 2008).

Difficulties in the morphological classification of tridacnids have led to modern DNA-based genetic studies. These molecular genetic analyses tried to clarify the situation of giant clam populations in the northern part of the Red Sea and concluded that there live at least three species of *Tridacna* (ROA-QUIAOIT 2005; MOHAMED et al. 2006). In fact MOHAMED et al. (2006) even indicate the possibility of five extant Red Sea species. Furthermore, there are doubts, whether the species commonly identified as *T. squamosa* LAMARCK, 1819 from the Red Sea is indeed Lamarck's true *T. squamosa* (J.J. ter Poorten, pers. comm., Oct. 2010). Definitely, the number and identity of the living Red Sea tridacnids is currently unresolved. Consequently, the respective Red Sea species is here termed *T.* cf. *squamosa*.

Recently, an 8th *Tridacna* species has been described from the northern Red Sea. *Tridacna costata* ROA-QUIAOIT KOCHZIUS, JANTZEN, AL-ZIBDAH & RICHTER, 2008 presents clear morphological, habitat and genetic diagnostics compared to the other two well known tridacnids occurring in the Red Sea, *T maxima* (RÖDING, 1798) and *T.* cf. *squamosa* LAMARCK, 1819.

In 1899, Sturany published the results of the "Pola"-Expedition to the Red Sea. He mentioned three *Tridacna* taxa found during this expedition of which one was new.

The material from the Pola expeditions forms a significant part of the scientific collections in the Naturhistorisches Museum Wien, Austria (NHMW). In the course of 7 expeditions - all carried out by SM Ship Pola - clearly defined areas of the ocean were systematically explored. Between 1890 and 1894, the eastern Mediterranean, and from 1895 to 1898, the Red Sea were sampled. Compared to larger expeditions of other countries, these expeditions by the Austro-Hungarian monarchy turned out to be highly efficient and minutely planned. Thanks to the use of modern oceanographic instruments, the eastern Mediterranean and the Red Sea became the most thoroughly explored areas of sea at that time. For more details concerning the expeditions, their scientific results and the history of oceanography, see SCHEFBECK (1991).

Molluscs alone collected during the Pola expeditions in the Red Sea amount to 1300 series of gastropods and bivalves (STAGL et al. 1996). As the curator responsible at the

k.u.k. Hofmuseum, Rudolf Sturany worked on the mollusc material gathered during the Pola expeditions. Sturany published a series of papers on gastropods (STURANY 1896; 1900a, b; 1904) and bivalves (STURANY 1896; 1899). Unfortunately, his works either remained disregarded or were inaccessible to English speaking researchers.

Sturany's publications are mandatory reading for every Red Sea bivalve specialist. His report on the Red Sea "Lamellibranchiaten" dating from 1899 was first published separately as a "Sonderdruck" and 1901 reprinted as part of the "Berichte der Commission für oceanographische Forschungen" which were published in the "Denkschriften der mathematisch-naturwissenschaftlichen Classe der kaiserlichen Akademie der Wissenschaften, Wien"

Sturany described many rare deepwater species dredged during the Pola Expedition. Included were also many shallow water species collected near or on shore.

Material

The complete dry and wet material of the Pola Expeditions - including the syntypes of *T. elongata* var. *squamosina* – was originally inventoried at the Mollusca Collection under the number NHMW Moll. 38076.

Sturany did not individually label each specimen. However, Sturany stated the respective Red Sea stations in his report and the station data are available for each of the specimens. With very few exceptions the whole wet and dry material of Sturany was available and conformed to the stations indicated.

Six *T. squamosina* syntypes were collected in the Gulf of Aqaba, in Dahab (4 specimens) and in Sharm el Sheikh (2 specimens). The seventh and largest specimen originated in the southern Red Sea at Kamaran Island, off Yemen. Altogether Sturany studied 7 *squamosina* specimens ranging in size from 102 to 190 mm.

Almost 30 Pola specimens conform to *T. maxima*. More than 30 Pola specimens conform to *T.* cf. *squamosa*. Contrary to the situation nowadays, *T.* cf. *squamosa* was around 1900 the most commonly collected *Tridacna* in the Red Sea.

Results

Unfortunately, many authors including ROSEWATER (1965) and ZUSCHIN & OLIVER (2003) as well as ROA-QUIAOIT et al. (2008) and very recent works of RUSMORE-VILLAUME (2008) and KNOP (2009) have overlooked Sturany's publication. Only OLIVER (1992) mentioned his paper and he assigned Sturany's *T. rudis* Rve. to *T. squamosa* LAMARCK, 1819.

Sturany sorted the well over 60 tridacnids collected by the Pola expedition and recognized 3 taxa. Two Red Sea species – *T. maxima* and *T.* cf. *squamosa* – were found commonly in various lots with approximately 30 specimens each, one species in just 3 lots with 7 specimens. This is in accordance with modern findings.

STURANY (1899) briefly described the nov. var. *T. elongata squamosina*: hingegen

eine Varietät besonders hervorzuheben, die systematisch zur Tr. squamosa Lm. hinüberführt. Diese mit squamosina nov. var. zu bezeichnende Form liegt von den Localitäten 12, 14 und 43 in mehreren Exemplaren vor " He pointed out the characteristic " gegen den Unterrand blättrig aufgestellte Querschuppen der Rippen "

ROA-QUIAOIT (2005: table 9) elaborated precisely the characteristics of *T. costata* – shell asymmetrical, hinge length < half shell length, scutes crowded and well spaced, wide byssal orifice, and 5–6 deeply triangular radial folds (Table 1).

A close morphological comparison of Sturany's *T. squamosina* with the newly described *T. costata* left no doubt that these two species are identical. This assessement was confirmed by J. J. ter Poorten, a well known cardioid specialist. In addition, two of Sturany's three collecting stations conform to the type locality of *T. costata* in the Gulf of Aqaba.

Although *Tridacna squamosina* STURANY, 1899 was not found cited in other publications, Sturany's species was validly proposed and is recognizably characterized. Seven syntypes are unambiguously available. Sturany's name is not preoccupied.

Consequently, a lectotype of *T. squamosina* is herein designated and *T. costata* formally synonymized.

With respect to the description of the habitat, spawning, genetics of *T. squamosina* and comparisons with other species of *Tridacna*, the works of ROA-QUIAOIT et al. (2008) and especially the thesis of ROA-QUIAOIT (2005) provide an excellent overview. These aspects are not discussed in this article.

However, two facts merit being added. More than 100 years ago *T. squamosina* was also the species least commonly collected. The locality of station 43 further indicates that *T. squamosina* may be found throughout the Red Sea and not just in its northern part.

Taxonomy

Tridacna squamosina STURANY, 1899

(Figs. 1–6)

Tridacna elongata var. *squamosina* STURANY, 1899: 283

Tridacna nov. sp. ROA-QUIAOIT, 2005: 67, 72, 75–77 (with an extended characterization of nov. sp. and a comparison of the other Red Sea species)

Tridacna costata ROA-QUIAOIT, KOCHZIUS, JANTZEN, AL-ZIBDAH & RICHTER in RICHTER, ROA-QUIAOIT, JANTZEN, AL-ZIBDAH & KOCHZIUS, 2008: 1349–1354 (**syn. nov.**)

Type material. Lectotype (Figs. 1–6) selected herein: largest specimen selected from the material Sturany described as *Tridacna elongata* var. *squamosina*. – Red Sea, Yemen, Kamaran Island, ca. 15°17' N; 42° 37' E, shallow water, Pola expedition leg. F. Steindachner & F. Siebenrock 1.-3. Nov. 1897 [Loc. 43], (NHMW Moll. 107075); paralectotypes: Egypt, Dahab, shallow water, Pola expedition leg. F. Steindachner & F. Siebenrock 6. Apr. 1896 [Loc. 12] (4 specimens, NHMW Moll. 107076; Figs. 7, 10); Egypt, Sharm el Sheikh [Sherm Sheik], shallow water, Pola expedition leg. F. Steindachner & F. Siebenrock 1. Apr. 1896 [Loc. 14] (2 specimens, NHMW Moll. 107077).

Table 1: Diagnostic criteria in tridacnids after ROA-QUIAOIT (2005) and HUBER (2010)

	T. squamosina	*T. squamosa*	*T. maxima*
Shell symmetry	asymmetrical	symmetrical	asymmetrical
Hinge length	< half shell length	= half shell length	< half shell length
Scutes	crowded, well spaced	large, well spaced	low, crowded
Radial folds	5–6 deeply triangular	4–6 pointed to bluntly rounded	usually 5 sharply triangular
Byssal orifice	wide	narrow	moderate to wide
Mantle patterns	subdued	subdued mottled	colored
Incurrent tentacles	distinct	distinct	indistinct
Maximum size	320 mm (Red Sea)	476 mm (Tonga)	500 mm (India)
Distribution	Red Sea only	Indo-Pacific	Indo-Pacific
Habitat	to 2 m, byssally weakly attached	to 25.5 m, byssally attached	to 32 m, usually embedded

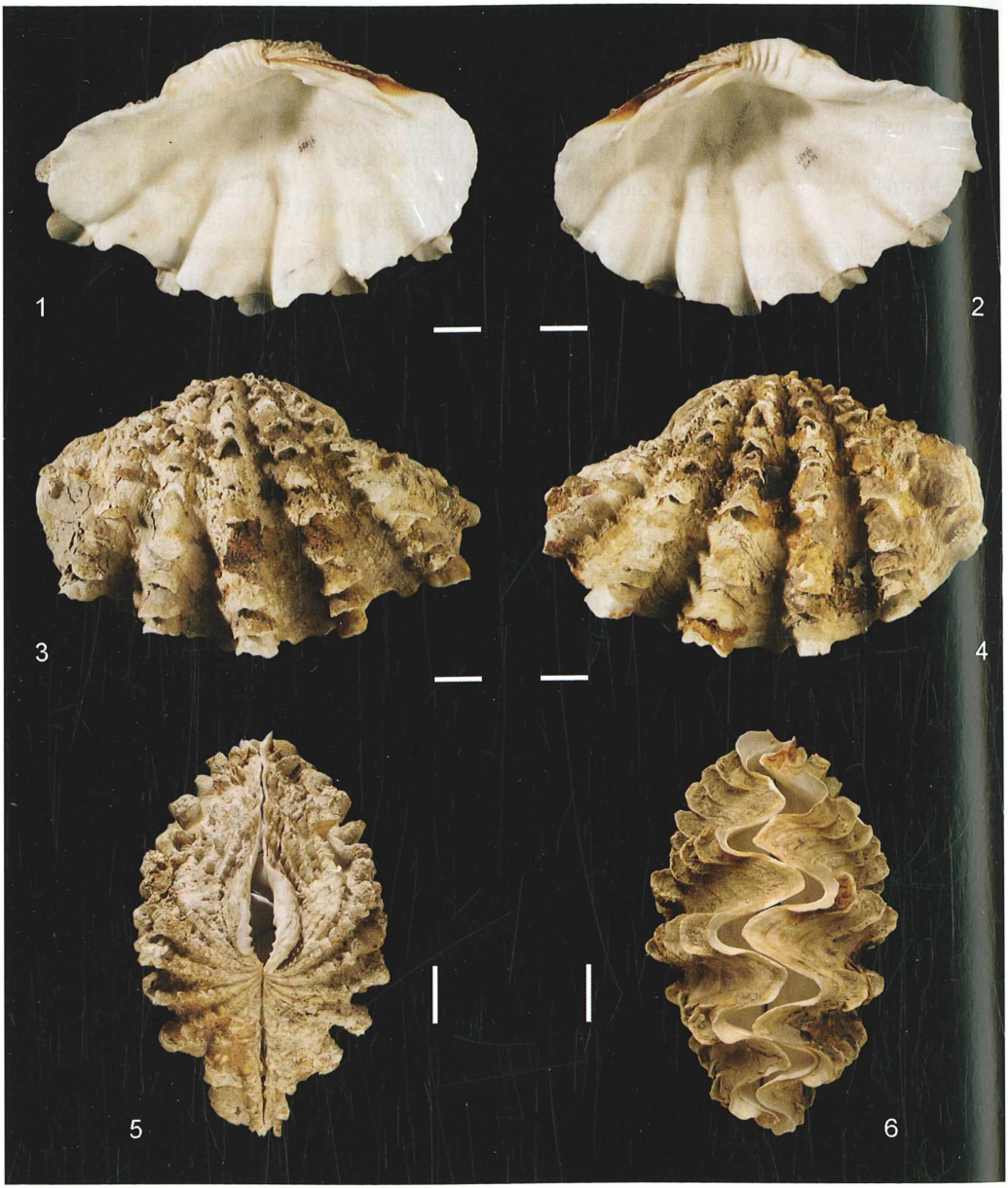
Comparative material. *Tridacna* cf. *squamosa* (Figs. 8, 11) – Red Sea, Egypt, Gulf of Aqaba, Nawibi, Pola expedition leg. F. Steindachner & F. Siebenrock 9.-10. Apr. 1896 [Loc. 10] (NHMW Moll. 38076); *Tridacna maxima* (Figs. 9, 12) – Red Sea, Egypt, Shadwan Island, Pola expedition leg. F. Steindachner & F. Siebenrock 18.-20. Feb. 1896 [Loc. 16] (NHMW Moll. 38077).

Discussion

Earlier workers treated tridacnids as their own superfamily (e.g. KEEN 1969; STAROBOGATOV 1992). However, most modern analyses, including SCHNEIDER (1998), BRALEY & HEALY (1998), SCHNEIDER & FOIGHIL (1999), GIRIBET et al. (2002) and MATSUMOTO (2003) demonstrate a close relationship between tridacnids and cardiids, either to *Fragum* RÖDING, 1798 or even to *Nemocardium (Keenaea)* HABE, 1951 (MATSUMOTO 2003). Consequently, many modern researchers attribute tridacnids subfamilial status within Cardiidae. From an exclusive phylogenetic point of view, this placement may be favored.

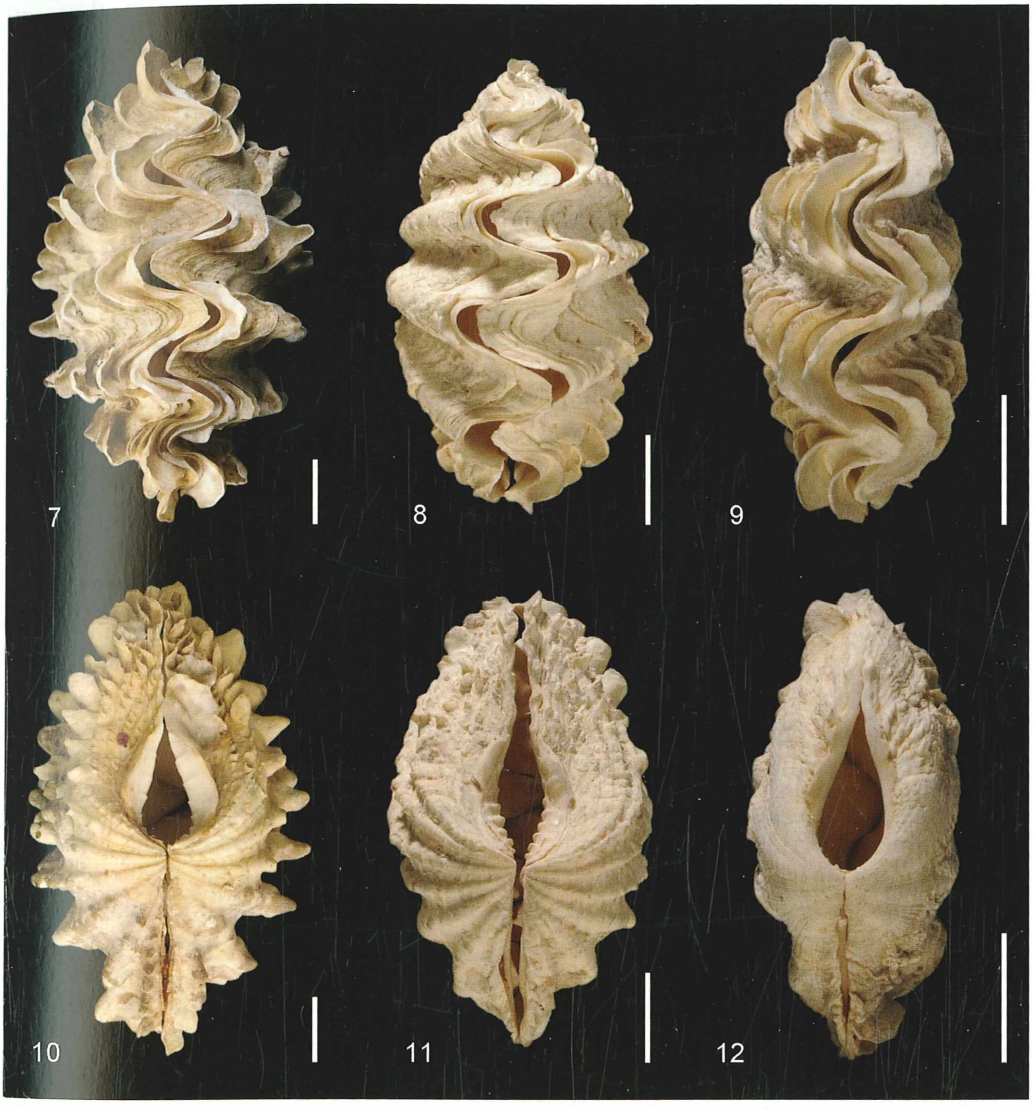
A superfamily Tridacnoidea LAMARCK, 1819 is certainly no longer valid. Tridacnids must be understood as firm portion of Cardioidea LAMARCK, 1809, see BIELER et al. (2010). However, the restricted biogeography of tridacnids, their peculiar habitats and mode of life, their unique anatomy, together with their size and weight nonetheless justifies a special treatment within Cardioidea. As such, a familial treatment as Tridacnidae LAMARCK, 1819 is here preferred and *T. squamosina* is understood as member of this small bivalve family.

IREDALE (1937) started to divide *Tridacna* and proposed five additional genera for Australian and Pacific species. He even created for the most variable tridacnid, *T. maxima*, two distinct genera (i.e. *Vulgodacna* for *T. fossor* and *Sepidacna* for *T. throughtoni*, which today are both considered synonymous to *T. maxima*). But it is doubtful if *Persikima* is genetically distinct from *Tridacna* s.s. (ROA-QUIAOIT 2005; SCHNEIDER & Ó FOIGHIL 1999). In addition, the subgenus *Chametrachea* MÖRCH, 1853 was earlier used by HERRMANNSEN (1846), which is based on *Chama aspera* RUMPHIUS, 1705. Taking further into account the characteristic features of each species and the small number of



Figs. 1–6. *Tridacna squamosina* – lectotype, NHMW Moll. 107075 from Kamaran. 1, right valve inside; 2, left valve inside; 3, right valve outside; 4, left valve outside; 5, byssal orifice; 6, radial folds. Scalebar: 2 cm. Photographs: A. Schumacher.

8 valid tridacnids, a forced differentiation of various subgenera within *Tridacna* adds little benefit. More important are the real differences between species regarding habitats, modes of life, genetics and detailed morphology. This was excellently worked out by ROA-QUIAOIT (2005). Consequently, the subgeneric level is here abandoned and *T. squamosina* is placed as *Tridacna.*



Figs. 7–12. Comparison of the three *Tridacna* species from the Red Sea in the collection of the NHMW; top: radial folds; bottom: byssal orifice. 7, 10, *Tridacna squamosina* – paralectotype, NHMW Moll. 107076a from Dahab; 8, 11, *Tridacna* cf. *squamosa* – NHMW Moll. 38076 from Nawibi; 9, 12, *Tridacna maxima* – NHMW Moll. 38077 from Shadwan. Scalebar: 2 cm. Photographs: A. Schumacher.

STURANY (1899) recognized three Red Sea taxa. He clearly used the monograph of REEVE (1862) on *Tridacna* as an identification guide. He identified *elongata* correctly. Sturany's *elongata* conforms to *T. elongata* LAMARCK, 1819. But in the 1950s and 1960s it was recognized that Lamarck's *elongata* is a junior synonym of *Tridachnes maxima* RÖDING, 1798. *Tridacna maxima* (RÖDING, 1798) is today recognized as valid, earliest name for this widely distributed species.

The second common Red Sea species identified by Sturany was *T. rudis*. REEVE (1862) described *T. rudis* from the Philippines. Indeed, Reeve's pl. 5 fig. 4 a, b, c superficially resembles the material identified by Sturany. Based on Rosewater's treatment of this family, modern authors today accept Reeve's *rudis* as a peculiar form of *maxima*. Consequently, this second species was erroneously identified by Sturany as *rudis*. This was recognized by OLIVER (1992), who identified it as Lamarck's *T. squamosa*, here termed *T.* cf. *squamosa*. It is not excluded that *Tridachnes imbricata* RÖDING, 1798 was the earlier name for Lamarck's famous species. Large portions of the Bolten collection, on which Röding based his *imbricata*, are still to be found in Museum der Natur at Gotha, Germany. However, a critical review of the respective material at Gotha in September 2010 led to the following conclusion: "Overall, due to missing descriptions and specific marks in Röding, due to lack of original numbers and labels, due to the peculiar suppressing and renaming method of Schmidt and finally due to the curational condition of the collection we could not unambiguously identify any Bolten/Röding Bivalve type." (HUBER & TER POORTEN in prep.). Thus, *Tridachnes imbricata* RÖDING, 1798 is best treated as nomen dubium

The third, the least common species was described by Sturany as *squamosina*. ROA-QUIAOIT (2005) stated the closest morphological affmities for *T. costata* are to *T. maxima*. STURANY (1899) came to the same result in considering *squamosina* closer to *elongata* (=*maxima*) than to *squamosa*. From a molecular phylogeny based on mitochondrial 16 rDNA, ROA-QUIAOIT (2005) concluded that *T. costata*'s closest relative is *T. maxima*, whereas lower affinities were found between *T. squamosa* and *T crocea*. For further detailed information on *T. squamosina* we refer to ROA-QUIAOIT et al. (2008 as *T. costata*) and especially to ROA-QUIAOIT (2005 as *T.* nov. sp.).

As such, *Tridacna squamosina* STURANY, 1899 is the 8th member of the genus *Tridacna* within the family Tridacnidae. Currently, it is only known from the Red Sea, likely living throughout. It is the least common of the described three Red Sea tridacnids. The known habitat is very shallow within approximately 5 meters and the maximal size reported is 320 mm.

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