

NEW SPECIES OF THYASIRIDAE (BIVALVIA) FROM CHEMOSYNTHETIC COMMUNITIES IN THE ATLANTIC OCEAN

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Abstract A new genus and two new species of Thyasiridae are described from deep-water chemosynthetic communities in the Atlantic Ocean. *Spinaxinus sentosus* n. gen., n. sp. is distinguished by both shell shape and periostracal characters and bears little resemblance to other known thyasirids. It was collected from the organic cargo of the sunken ship, "Francois Vieljeux" and this remains the only record of this species. *Thyasira southwardae* n. sp. was collected from the Logatchev hydrothermal site and is morphologically similar to *T. sarsi*, *T. oleophila* and *T. methanophila* all known to be associated with chemosynthetic sites.

Key words Thyasiridae, new genus, new species, Atlantic Ocean, Deep-sea, Chemosynthetic communities.

INTRODUCTION

It has now been widely established that the larger Thyasiridae (genera *Thyasira sensu lato*, *Parathyasira*, *Conchocele* and *Maorithyas*) are chemosymbiotic (Dufour 2005). However, relatively few Recent species are associated with chemosynthetic environments such as hydrothermal vents, methane seeps or whale falls. Those that are include all species of *Conchocele* (Kamenev, Nadtochy & Kuznetsov 2001; Okutani 2002), *Thyasira methanophila* (Oliver & Sellanes 2005), *T. oleophila* (Clarke 1989), *Maorithyas hadalis* (Okutani, Fujikura & Kojima. 1999), *Parathyasira kaireia* (Okutani, Fujikura & Kojima. 1999), *Thyasira sarsi* (Philippi, 1845) (Dando, Bussmann, Niven, O'Hara, Schaljohann & Taylor 1994) and an un-named species of *Maorithyas* (Lewis & Marshall 1996). These account for around 8% of the known Thyasiridae.

Undescribed species of Thyasiridae from chemosynthetic environments are reported in literature and this paper revisits some of these taxa, describes the species and attempts to place them in a systematic context within the Thyasiridae. Unfortunately, the tissues of many of the specimens available either are now incomplete or poorly preserved, thus restricting this paper to a primarily conchological approach.

The first of these was reported by Dando, Southward, Southward, Dixon, Crawford & Crawford (1992) from the cargo ship "Francois Vieljeux" that sank off Vigo in 1160m of water in 1979. She was carrying a mixed cargo that

included sacks of beans and sunflower seeds along with bales of sisal twine. Exploration of this ship began in 1991 during which a number of chemosynthetic organisms were collected, including the vestiminiferan, *Lamellibranchiata*, mussels of the genus *Idas* and a thyasirid bivalve. A full account of the salvage of the wreck can be found in Crawford (1999).

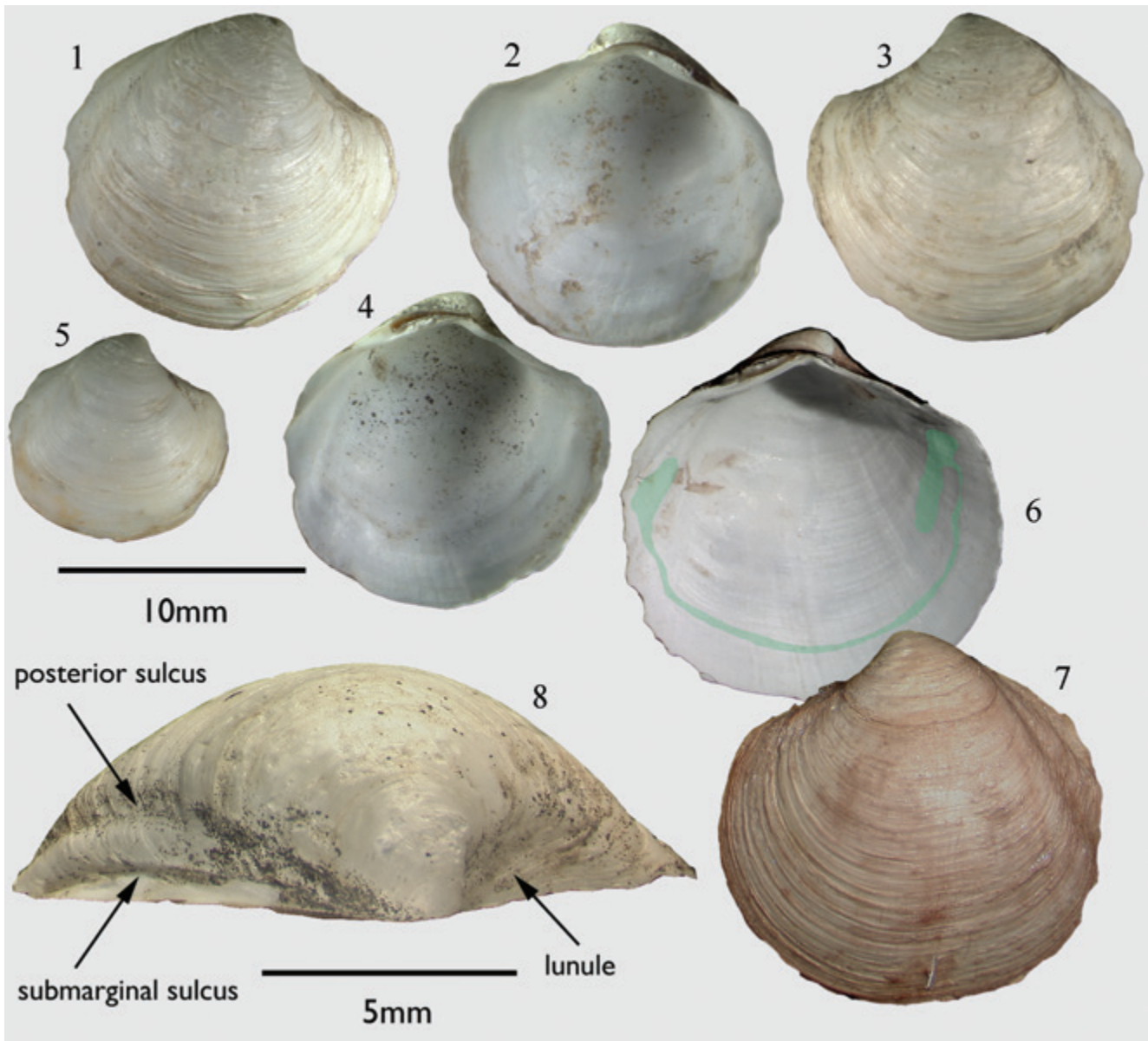
The second report was of two species of *Parathyasira* taken from the Logatchev hydrothermal site by the submersible DSRV 'Alvin' at 3038m (Southward, Gebruk, Kennedy, Southward & Chevaldonné 2001). These specimens were taken along with a species of *Calyptogena* and *Bathymodiolus*, both taxa being typical of hydrothermal sites.

MATERIALS

The specimens from the wreck of the Francois Vieljeux came from the collections of the National Museum of Wales and Natural History Museum London and were originally donated by Dr Eve Southward, Marine Biological Association, Plymouth.

The material from the Logatchev Vent site, originally studied by Dr Southward, was made available by Dr Elena Krylova, PP Shirshov Institute of Oceanology.

Comparative materials of *Thyasira sarsi* and *T. methanophila* came from the collections of the National Museum of Wales and those of *T. oleophila* were made available by Dr Janet Voight of the Field Museum of Natural History, Chicago.



Figures 1-8 *Thyasira southwardae* n.sp., Logatchev Vent site, Mid-Atlantic Ridge, 3038m Figs 1-4 Holotype ZMMU Ld-29999 Figs 5-7 Paratypes NMW.Z. 2006.6.1 Fig.6 with artificially coloured pallial and adductor scars Fig. 8 dorsal view of left valve of holotype.

SYSTEMATICS

Bivalvia: Veneroida
Thyasiridae

Genus *Thyasira* Leach ms in Lamarck, 1818

Type species *Tellina flexuosa* Montagu, 1803

INSTITUTIONAL ABBREVIATIONS
BM(NH) Natural History Museum, London
FMNH Field Museum of Natural History,
Chicago
NMW.Z National Museum of Wales, Zoology
ZMMU Zoological Museum, Moscow University

Definition Fragile shells, ovate to ovate-polygonal in outline with a posterior sulcus; escutcheon variably expressed, absent to deep, with or without an auricle producing

a submarginal sulcus. Hinge teeth lacking or as a single "cardinal" tubercle, ligament sunken. Anterior adductor scar elongate, posterior adductor scar ovate, pallial line entire. Ctenidium with two demibranchs, lateral body pouches large and multilobed, foot vermiform, heel obsolete, toe developed.

Thyasira southwardae n. sp.

Figures 1-8, 25

Thyasira (*Parathyasira*) sp; Southward, Gebruk, Kennedy et al, 2001: p.658, Fig. 1C, lower pair.

Holotype 1 complete shell, Logatchev Vent site, Dive 3133 DSRV 'Alvin', Anya's Garden, Atlantic Ocean, 14°45.189'N; 44°58.829'W; 3038m; 27 July 1997; Zoological Museum of Moscow University ZMMU Ld-29999

Paratypes 1 complete shell as holotype. 1 left valve as holotype. National Museum of Wales, NMW.Z.2006.6.1.

Measurements of T. southwardae n. sp.

Length	Height	Single valve breadth	Lunule length	Escutcheon length
H 13.44	13.17	4.84	4.21	9.05
P 9.15	8.43	3.07	2.84	5.51
P 16.70	15.90	5.54	6.23	10.86

Description Shell to 16.7mm in length. Thin, fragile. Moderately inflated, (length : breadth of both valves 1.4 :1 to 1.5:1). Equivalve. Equilateral, outline subcircular, length slightly greater than height, umbos prominent; posterior dorsal margin almost straight and sloping to meet weakly bisinuate posterior margin; ventral and anterior margins forming a continuous broad sweeping curve; lunule margin strongly in-curved. Lunule large, subcordate, demarcated by a distinct ridge. Escutcheon narrow and long, as a submarginal sulcus with a low auricle running its entire length. Posterior sulcus shallow but distinct. Ligament sunken, visible externally, long about two-thirds the length of the auricle. Hinge teeth absent, slight swelling beneath umbos discernable. Adductor scars unequal, anterior over twice

the length of posterior. Pallial line entire. Shell white; periostracum thin, pale straw coloured with concentric wrinkles and irregular creasing (Fig. 25).

Anatomy Soft tissues were not preserved but Eve Southward has made available video images of the living animal taken at the time of collection (Fig. 16). These show the ctenidia to consist of both demibranchs and these are markedly inflated and pink in colour. The foot is long and vermiform and the lateral body pouches are multilobed rather greyish in colour with darker specks on the tips of the lobes. Southward, Gebruk, Kennedy *et al.* (2001), noted the presence of abundant symbiotic bacteria in the ctenidial filaments.

Habitat Soft sediment at a hydrothermal site at approximately 3040m water depth, in association with *Bathymodiolus* and *Calyptogena* (Gebruk, Chevalloné, Shank, Vrijenhoek & Lutz 2000).

Distribution Known only from the Logatchev hydrothermal vent site.

Derivation of name southwardae named for Dr Eve Southward for her work with the Thyasiridae and for her help in making material available to us.

Species comparisons Of all the known Atlantic species *T. southwardae* most closely resembles *T. sarsi* (Philippi, 1845) (Fig. 9) in that they have similar outlines, have distinct but weak posterior sulci and that the auricle is long and extends the length of the escutcheon. *Thyasira sarsi* differs in having a smaller and less impressed lunule, a weaker posterior sulcus and in the periostracum having a dense pustular microsculpture (Fig. 26), which gives an overall matt sheen appearance at low magnification. *Thyasira oleophila* (Figs 10) is a large species with a relatively heavy shell and is more oblique in outline having a long, steeply sloping escutcheon margin. The resilifer is also relatively longer and the submarginal sulcus less developed. As with *T. sarsi*, the periostracum is pustulose but more coarse and obvious at low magnifications (8x) (Fig. 11). *Thyasira oleophila* is known only from the Louisiana cold seeps in the Gulf of Mexico.

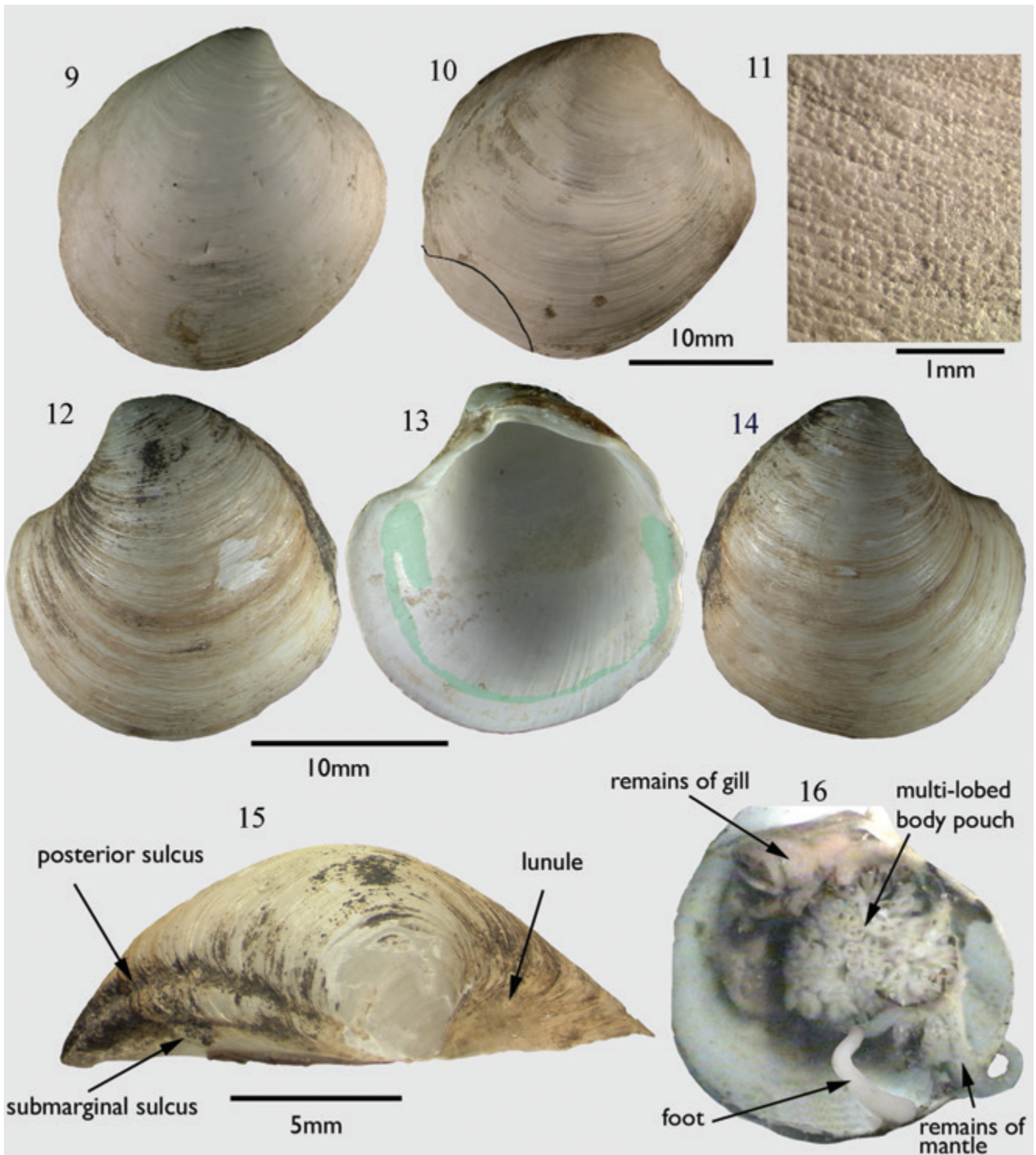


Fig. 9 *Thyasira sarsi* Philippi, Norway, NMW.1955.158.11538 **Fig. 10** *Thyasira oleophila* Clarke, Off Louisiana, Gulf of Mexico, FMNH 307755 **Fig. 11** *T. oleophila* surface sculpture **Figures 12-15** *Thyasira southwardae* var. Logatchev Vent site, Mid-Atlantic Ridge, 3038m, NMW.Z. 2006.6.2 **Fig. 16** Video image of live specimen of *T. southwardae*; ctenidium partly excised.

Thyasira southwardae var.
Figures 12-15

Thyasira (*Parathyasira*) sp; Southward, Gebruk, Kennedy et al, 2001: p.658, Fig. 1C, upper pair.

Material 1 complete shell as holotype. National Museum of Wales, NMW.Z.2006. 6. 2.

Measurements of T. southwardae var

Length	Height	Single valve breadth	Lunule length	Escutcheon length
16.80	17.49	6.29	5.83	11.41

Description This shell is similar to *T. southwardae* except that is relatively more inflated and is slightly higher than long. The posterior slope is very long and the bisinuate condition although present is obscure. Similarly the submarginal and posterior sulci are present but indistinct. The lunule is large and demarcated as in *T. southwardae*. The sculpture and periostracum are also as in *T. southwardae*.

Southward, Gebruk, Kennedy et al, (2001) believed that two species were present in the Logatchev material and it is easy to see why this conclusion was reached. However, Oliver & Sellanes (2005) noted considerable variation in *T. methanophila* and there is the possibility that this shell is a gerontic specimen of *T. southwardae*. As only a single shell exists, we are not willing to give it separate status at this time.

Genus *Spinaxinus* n. gen.

Type species: *Spinaxinus sentosus* n. sp.

Definition Thyasirid of moderate size, shell equivalve, subequilateral, beaks behind midline. Outline roundly subovate, anteriorly expanded, posterior subtruncate, posterior sulcus weak. Escutcheon long, narrow, deeply cleft. Lunule large, flattened, slightly sunken. Ligament large, deeply sunken. Hinge teeth absent. Periostracum minutely spinose. Ctenidium with both demibranchs, lateral body pouches multi-lobed, foot vermiform.

Remarks It is widely recognised that the current definitions of the genera of the Thyasiridae are poor and inadequately reflect the diversity of shell form and anatomy (Payne & Allen 1991; Oliver & Killeen 2002; Oliver & Sellanes 2005; Oliver & Levin 2006). Molecular data (JD Taylor pers. comm.) and gill structure (Dufour 2005) suggest a broad but not conclusive split in the family into larger chemosymbiotic taxa with sulcate shells and paired demibranchs and minute taxa with non-sulcate shells and ctenidia reduced to one demibranch.

Spinaxinus is moderately large for a thyasirid and has a ctenidium with two demibranchs thus removing from further consideration those genera with small shells and a single demibranch.

Those nominal genera with two demibranchs include *Thyasira*, *Parathyasira* Iredale 1930, *Prothyasira* Iredale, 1930, *Maorithyas* Fleming 1950, *Conchocele* Gabb 1866 and *Axinus* Sowerby 1821. The lack of a strong posterior sulcus in *Spinaxinus* distinguishes it from *Thyasira*, *Prothyasira* and *Conchocele*.

The genus *Parathyasira* has been applied to many species, but based on the type species *P. resupina* Iredale 1930, this genus should be used only for shells that are pyriform to polygonal in outline, with a flattened posterior area.

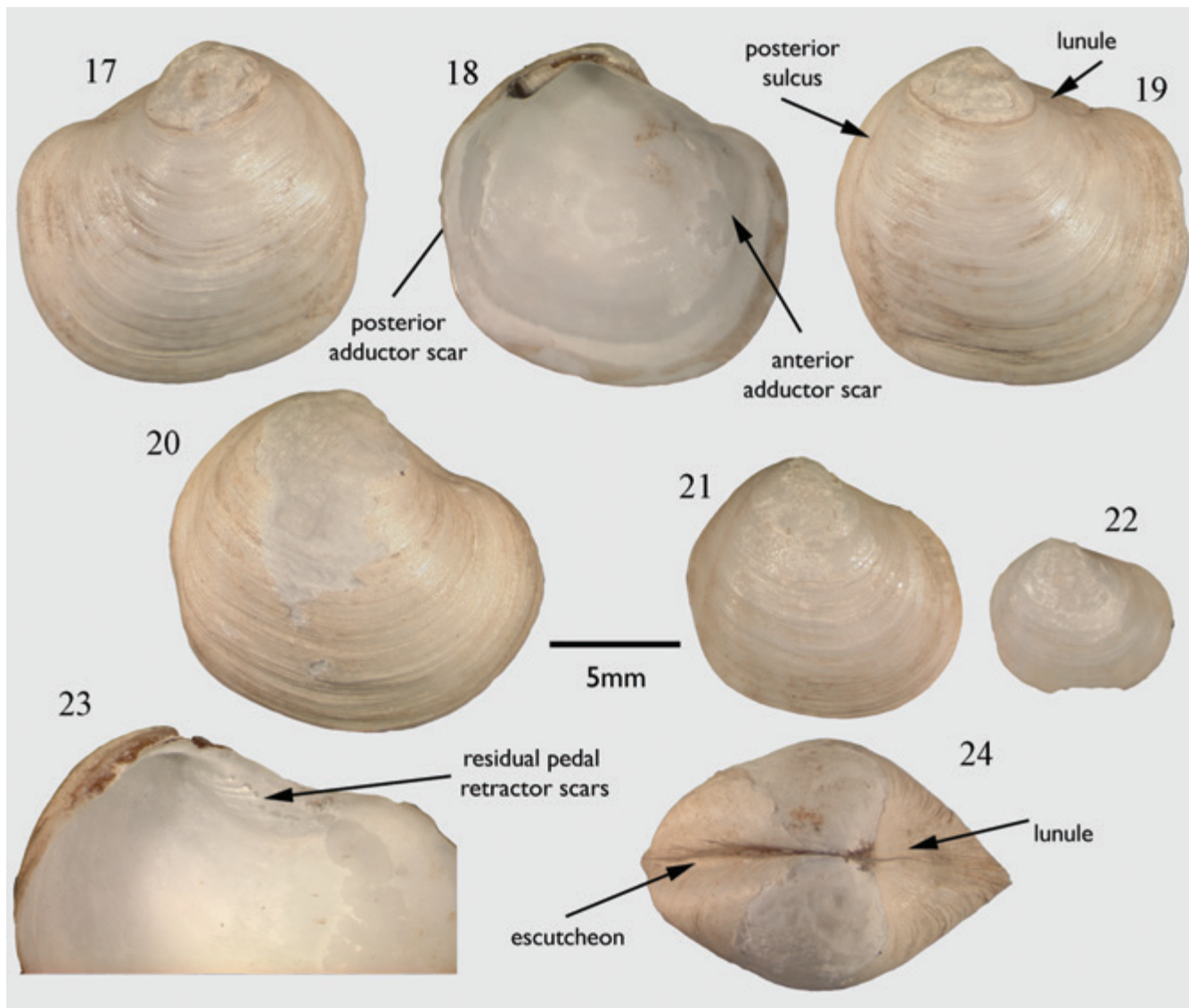
The shell of *Spinaxinus* is more reminiscent of those taxa placed in *Maorithyas* but the anterior expansion is not present in the type species of *Maorithyas*, *M. marama* Fleming 1950. There is some similarity with *Axinus* in the large lunule and anterior expansion, but *Axinus* shells are angulate and the anatomical characters of the mantle are not present in *Spinaxinus*. From all other genera, *Spinaxinus* differs in the presence of the spinose periostracum.

We conclude that the shell characters are sufficiently different to warrant the erection of a new genus, but it is unfortunate that there is no molecular data to indicate its relationships.

Spinaxinus sentosus n. sp.

Figures 17-24, 29-32

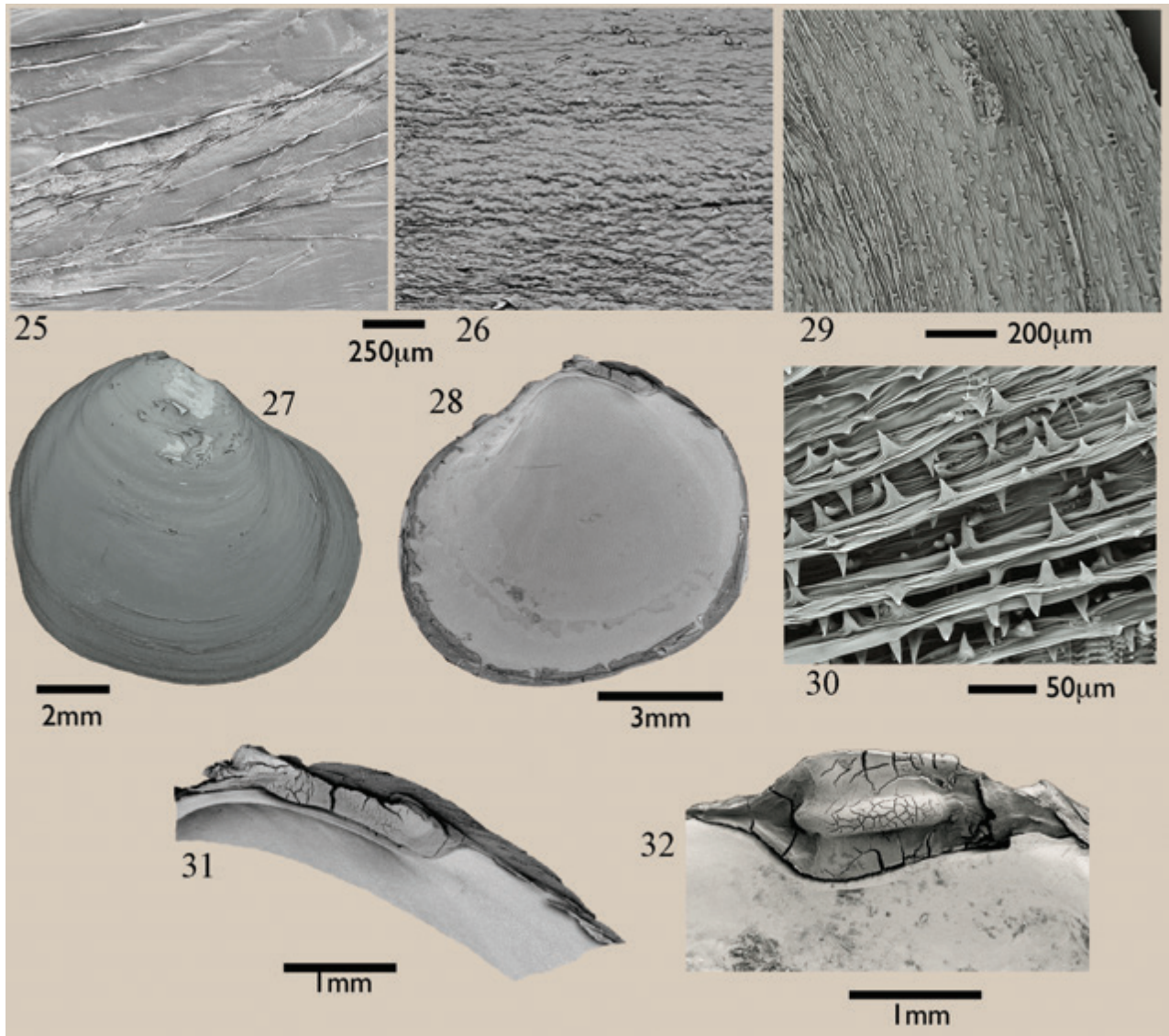
Holotype A complete shell, Cargo hold of the sunken ship "Francois Vieljeux", approx. 30 miles west of Vigo, Spain, 42°7.95'N 9°26.95'W; 1160m, 1992. NMW.Z.2002.108.1



Figures 17-24 *Spinaxinus sentosus* n. gen., n. sp. Wreck of the Francois Vieljeux, off Vigo, Spain, 1160m **Figs 17-19** Holotype, NMW.Z. 2002.108.1 **Figs 20-22** growth series, paratypes, NMW.Z. 2002.108.2 **Fig.23** internal view of a left valve to show pedal retractor muscle scars **Fig. 24** dorsal view.

Measurements of S. sentosus n. sp.

	Length	Height	Single valve breadth	Lunule length	Escutcheon length	Anterior length
Holotype	13.48	13.33	4.27	3.86	6.57	8.83
Paratype	14.25	13.25	3.77	4.25	4.75	6.70
Paratype	13.63	12.50	4.27	4.25	5.76	8.50
Paratype	14.63	12.75	5.14	4.38	5.75	9.00
Paratype	10.25	9.25	2.70	3.00	2.30	6.38
Paratype	10.80	10.40	3.05	3.25	3.90	5.63
Paratype	6.25	5.76	1.84	2.40	2.50	3.50
Paratype	16.54	16.85	5.18	4.50	6.32	9.75



Figures 25-32 Scanning electron micrographs of shells and shell structures. **Fig. 25** *Thyasira southwardae* n. sp., periostracum **Fig. 26** *Thyasira sarsi*, periostracum **Figures 27-32** *Spinaxinus sentosus* n. gen, n.sp. **Fig. 27** external of right valve **Fig. 28** internal of right valve **Figs 29-30** periostracum; **Figs 31-32** ligament.

Paratypes 7 shells, as holotype, NMW.Z.2002.108.2 and BM(NH).

Description Shell to 16.5 mm in length. Thin, fragile. Tumidity increasing with size, length: tumidity ratio 1.6:1 to 1.8:1. Equivalve. Slightly inequilateral with beaks just behind the midline. Outline broadly subovate somewhat expanded anteriorly; posterior dorsal margin curved and sloping steeply to meet the short subtruncate posterior margin; ventral and anterior margins forming a continuous broad sweeping curve; lunule margin relatively long and slightly sunken.

Lunule large, subcordate, impressed. Escutcheon very narrow, shallow with steep edges and no auricle. Posterior sinus weak. Ligament deeply sunken and scarcely visible externally, short but wide and set on a prominent resilifer with a distinct median calcified zone (Figs 31-32). Hinge teeth absent. Adductor scars unequal, anterior twice the length of posterior and not separated from pallial line. Pallial line entire, broad with undulating outer edge. A linear series of small deeply impressed scars is present in most shells on the inner surface of the lunule; these may be relicts of the attachment points of the anterior pedal retractor muscles. Shell white, mostly

eroded over the umbo; periostracum straw coloured with concentric wrinkles bearing minute thorn shaped projections (Figs 29-30).

Anatomy The soft tissues were poorly preserved but the following gross characters were discernable. The mantle edge is simple with no projections. The foot is vermiform with a demarcated toe but with no heel. The ctenidia consist of both demibranchs the outer about half the size of the inner. The filaments appear to be fine and very numerous. The lateral pouches are large and are multi-lobed; the lobes are relatively few in number and large.

Habitat Known only from the cargo of the sunken ship, specimens were retrieved from salvage cargo of sisal bales mixed with castor beans and sunflower seeds.

Derivation of name *sentosus* from the Latin *sentis*, a thorn, and pertaining to the character of the periostracum.

Species comparisons The deep-water thyasirid fauna of the N. Atlantic was extensively studied by Payne & Allen (1991) but none of the species contained in their paper are at all similar to *Spinaxinus sentosus*. We have also considered the taxa described and cited by (Dall 1901) but none warrant further comparison.

DISCUSSION

Thyasira southwardae has strong conchological similarities to *T. sarsi* and *T. oleophila* from the Atlantic and to *T. methanophila* from the south-west Pacific. *Thyasira sarsi* and *T. methanophila* have also been shown to be close at the molecular level (John Taylor pers. comm.). All are closely associated with chemosynthetic sites and may form a natural group that at some time may require separate nomenclatural identity from *Thyasira sensu stricto*.

Spinaxinus sentosus, on the other hand, has little conchological similarity to any other thyasirid and remains an enigma. Despite the extensive deep sea sampling throughout the Atlantic this species has never been found in a natural habitat. Its co-occurrence with a vestiminiferan tubeworm strongly suggests that it is part of a

chemosynthetic community and may therefore have originated in a cold seep environment. In closest proximity are the cold seeps and mud volcanoes in the Gulf of Cadiz off S. Portugal and Morocco (Pinheiro, Ivanov, Sautkin, Akhmanov, Magalhaes, Volkonskaya, Monteiro, Somoza, Gardner, Hamouni & Cunha 2003), from which a few thyasirids have been found. We have examined specimens from the mud volcanoes in the Gulf of Cadiz, but these are bisinuate and of the *T. sarsi* type (Rodrigues & Oliver in prep). Chemosynthetic communities are also known from the eastern Mediterranean (Olu-Le Roy, Sibuet, Fiala-Médioni, Gofas, Salas, Mariotti, Foucher & Woodside, 2004) but the bivalves, including *Thyasira striata* Sturany, 1896, are small and, the above, is a typical *Thyasira* species. In 2003 another sunken ship, the SS 'Persia', was discovered to hold a population of vestiminiferan worms living on the rotting organic cargo but unlike the 'Francois Vieljeux' no bivalves were recorded (Hughes & Crawford 2005).

The evidence from this study suggests that thyasirids associated with chemosynthetic sites do not constitute a single phylogenetic group. This is supported by the presence of *Conchocele* species at cold seeps and with the occurrence of *Axinus* at a warm spring site in the Cascadia Basin (Voight & Grehan 2000; Oliver & Holmes in press)

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