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# A note on the identity of *Acrosterigma suluanum* Vidal, 1999 (Bivalvia, Cardiidae)

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*Acrosterigma suluanum* Vidal, 1999, was described based on much worn material from Sulu Archipelago, Philippines and Japan, collected more than a century ago. Due to the find of fresh and live Japanese material, additional morphological data are provided, a redescription is given and new distribution data are recorded. Additionally, its occurrence in Japanese Pleistocene deposits is documented.

Key words: Cardiidae, *Acrosterigma*, distribution, Japan, Philippines.



## Introduction

Vidal (1999), in his revision of the genus *Acrosterigma* Dall, 1900, assigned the following taxa in a species-group that occurs in deep water of the Indo-West Pacific: *A. uniornatum* Vidal, 1999; *A. profundum* Vidal, 1999; *A. amirante* Vidal, 1999 and *A. suluanum* Vidal, 1999. One fossil species is included: *A. paulayi* Vidal, 1999. Later on, *A. suduirauti* Vidal & ter Poorten, 2007 was added.

One of the most apparent distinguishing features separating this species-group from other *Acrosterigma* taxa are the long, thin, regularly obliquely placed scales on the radial ribs of the posterior slope of the shell.

The description of *A. suluanum* is based on much worn, almost completely discoloured loose valves, sampled more than a century ago, from the Philippines and Japan. The state of preservation does not unequivocally allow inclusion in the Recent fauna. Until recently, the species is only known from its type material, which is mostly juvenile, including the holotype. A short time ago, well preserved complete specimens from Japan have become available, enabling to supplement morphological, morphometrical, ecological and biogeographical data. Thanks to the recognition of fossil material from the Pleistocene of Japan, palaeogeographical data are given.

## Material and methods

The material from this study originates from the following collections: MNHN, USNM, ZMUC and JJTP (see below). The height is measured along an axis perpendicular to the hinge, and the length is the greatest distance between the anterior and posterior ends, parallel to the hinge line. Following Vidal (1999), angle A (Fig. 1f) is formed by two lines joining the laterals to the main cardinal in the right valve, measured in Photoshop and based on a high resolution scan of the interior of the shell. Ratio D (Fig. 1f) measures the asymmetry of the hinge; it is determined by dividing the length of the line from the tip of the umbo to the tip of the posterior lateral by the corresponding dis-

tance from the umbo to the tip of the anterior lateral. Shell shapes have been compared according to the orientation of the nymphs, following the method of Hylleberg (2014).

Acronyms of institutions and repositories: JJTP, Colln J.J. ter Poorten, Hilversum, The Netherlands; MNHN, Museum national d'Histoire naturelle, Paris, France; USNM, Smithsonian Institution, Washington DC, U.S.A.; ZMUC, Zoological Museum University of Copenhagen, Denmark.

Abbreviations: juv., juvenile; H, height; L, length; p.v., paired valves; s.v., single valve(s); LV, left valve(s); RV, right valve(s).

## Systematic part

Family Cardiidae Lamarck, 1809
Subfamily Trachycardiinae Stewart, 1930

### *Acrosterigma* Dall, 1900

*Acrosterigma* Dall, 1900: 1073, 1090 (as a section of *Trachycardium*). Type species by original designation: *Cardium dalli* Heilprin, 1887; Caloosahatchee Formation, Pliocene, Florida, U.S.A.

### *Acrosterigma suluanum* Vidal, 1999 (Figs 1-2, 7-11)



*Vasticardium arenicola* (Reeve, 1845) – Kuroda et al., 1971: 398-399, 619, pl. 89 figs 1-2
*Acrosterigma arenicola* (Reeve, 1845) – Yamashita et al., 1998: 12, pl. 7 fig. 7a-b
*Acrosterigma suluanum* Vidal, 1999: 298, figs 8d-f
*Acrosterigma suluanum* Vidal, 1999 – Hylleberg, 2004: 794-795, 880, unnumbered figs, 'syntype' [= paratype 1]
NOT: *Vasticardium arenicola* (Reeve) – Kira, 1962: 157, pl. 56 fig. 10 [= *Arcosterigma maculosum* (W. Wood, 1815)]

Type locality. — Philippines, Sulu Archipelago, N of Tawitawi Island, Languyan Point, 439 m ['Albatross' Expedition, USBF stn 5577, 23.09.1909].

Type repository: USNM 299435, holotype.

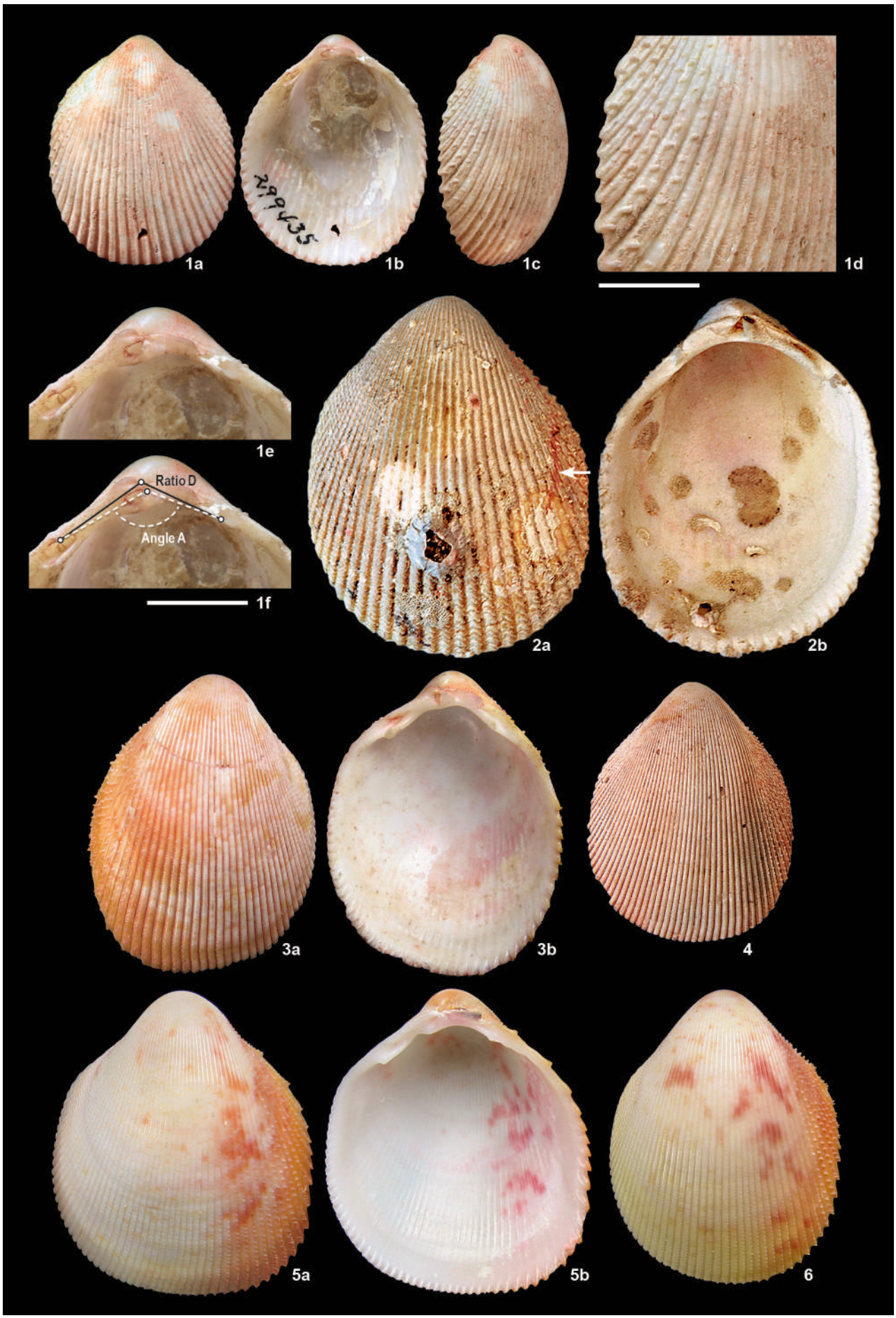
Description (modified after Vidal, 1999). — Shell medium sized (H up to 46 mm), ovoid, weakly truncated posteriorly, almost equilateral to moderately inequilateral, moderately elongated (mean L/H = 0.82, n = 17), tumid (mean W/L = 0.80, n = 18) and rather solid. Lunule small, rather imperfectly delineated, its umbonal margin raised, slightly larger in the right valve. Hinge almost symmetrical (ratio D = 1.02, n = 9) and moderately angled (angle A = 130°, n = 13). On the right valve, cardinals slightly more than usually fused at base. Mean radial rib number 44.9, range 41-48 (n = 16).

Rib morphology: on the posterior quarter of the shell, interstices very narrow, ribs very flat with an axial furrow separating two zones of similar width. Slightly elongated, tubercular, oblique scales on posterior part encroaching upon anterior zone, straddling axial furrow. On the median-posterior quarter ribs become flatly triangular and asymmetrical, then rounded. In the juvenile stage, scales disappear and are replaced posteriorly with numerous very thin short ridges or tubercles, situated at base of rib, touching interstice. In the adult stage, thin, oblique scales remain present, more close-set towards the shell margin. On the median-anterior quarter, large scales are present on the posterior flanks, superimposed on fine short ridges or tubercles; a similar fine beading but thinner and more tubercular appears also at base of anterior flank of ribs. On the anterior quarter, the fine beading of both sides disappears and posterior large scales proceed to top and anterior flank of ribs, forming free curved top-ridges, which are not imbricated.

Exterior colour consisting of a cream to yellowish background with orange to reddish-brown splashes, posterior quarter with deep red-brown commarginally arranged blotches, coinciding with the radial ribs; interstices lemon-yellow on posterior slope. Interior white with light orange or pink umbonal cavity and commarginally undulating pink stripes. The animal has a dirty white, rather slender foot.

Distribution and ecology. — The distribution is imperfectly known with records from the Philippines, Taiwan and Japan (Fig. 12). However, all samples, ex-

**Figs 1-2**. *Acrosterigma suluanum* Vidal, 1999. **1a-f**, Philippines, Sulu Archipelago, N of Tawitawi Island, Languyan Point, 439 m, R/V Albatross, USBF stn 5577, 23.09.1909. USNM 299435, holotype, H 25.4 mm (a: RV exterior, b: RV interior, c: posterior slope of RV, d: detail of posterior slope, e: hinge of RV, f: construction of Ratio D and Angle A). **2a-b**, Japan, off Sunasaki [Hokkaido, Hakodate ca. 42°N, 140°E], dredge, 150-35 m, F.I.S. Endeavour. Leg. Th. Mortensen, 12.04.1914. ZMUC, paratype 1, H 43.6 mm (a: LV exterior, b: LV interior). **Figs 3-4**. *Acrosterigma profundum* Vidal, 1999. **3a-b**, N of New Caledonia, Passe de Poum, 20°16'S, 163°52'E, BATHUS 4, stn DW 894, 245-268 m. Leg. Bouchet, Métivier, Richer de Forges, 03.08.1994. MNHN-IM-2000-9788, holotype, H 36.7 mm (a: RV exterior, b: RV interior). **4**, N of New Caledonia, Passe de Poum, 20°16'S, 163°52'E, BATHUS 4, stn DW 896, 315-350 m. Leg. Bouchet, Métivier, Richer de Forges, 03.08.1994. MNHN-IM-2000-9790, paratype 2, H 30.0 mm, LV exterior. **Figs 5-6**. *Acrosterigma suduirauti* Vidal & ter Poorten, 2007. **5a-b**, Philippines, Panglao Island, 140 m. MNHN-IM-2000-9689, holotype, H 37.8 mm (a: LV exterior, b: RV interior). **6**, Philippines, Bohol, Balicasag Island, tangle nets, 80-150 m, 10.2006. JJTP 3220, H 34.8 mm, LV exterior. Scale bars: 5 mm.


1a
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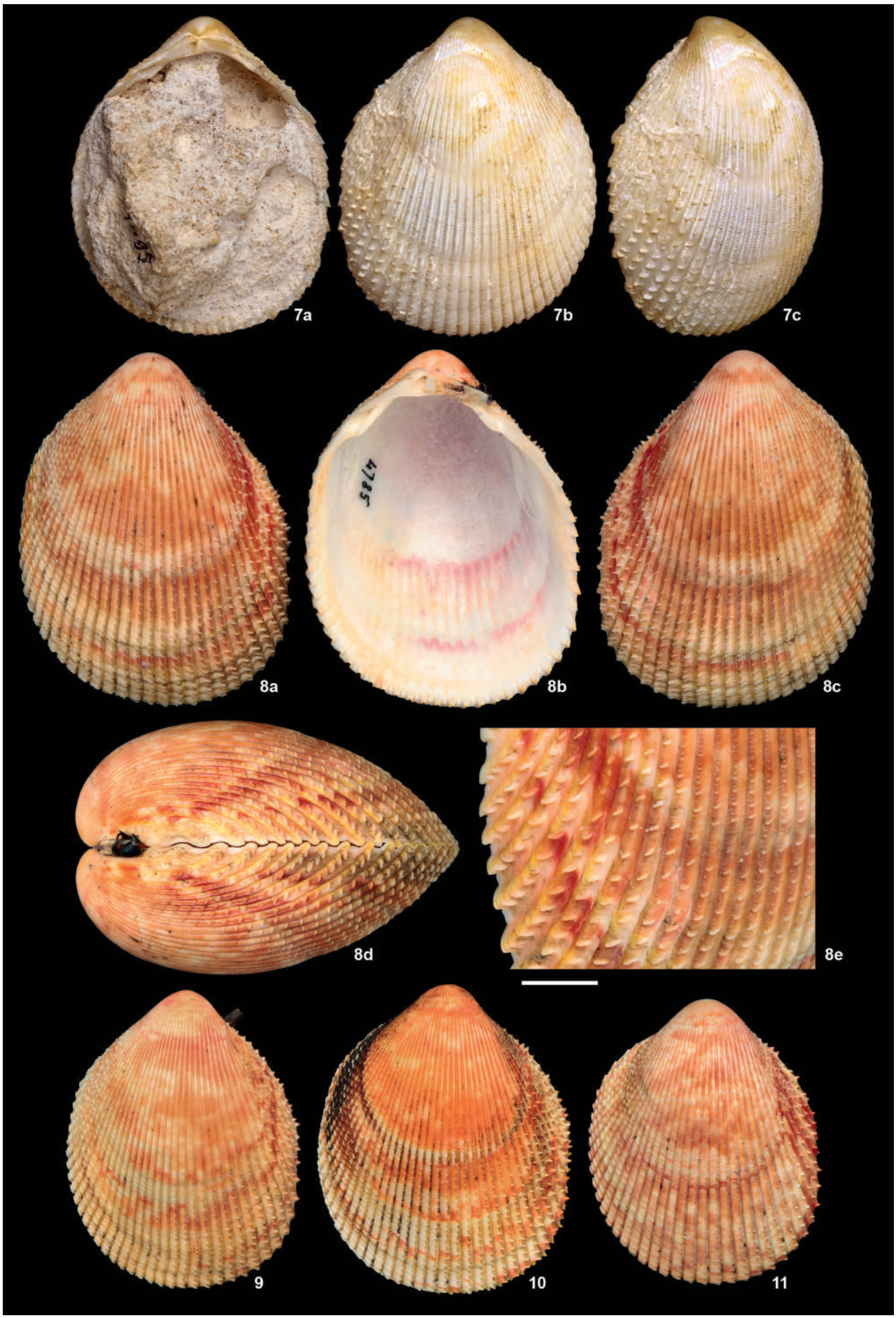
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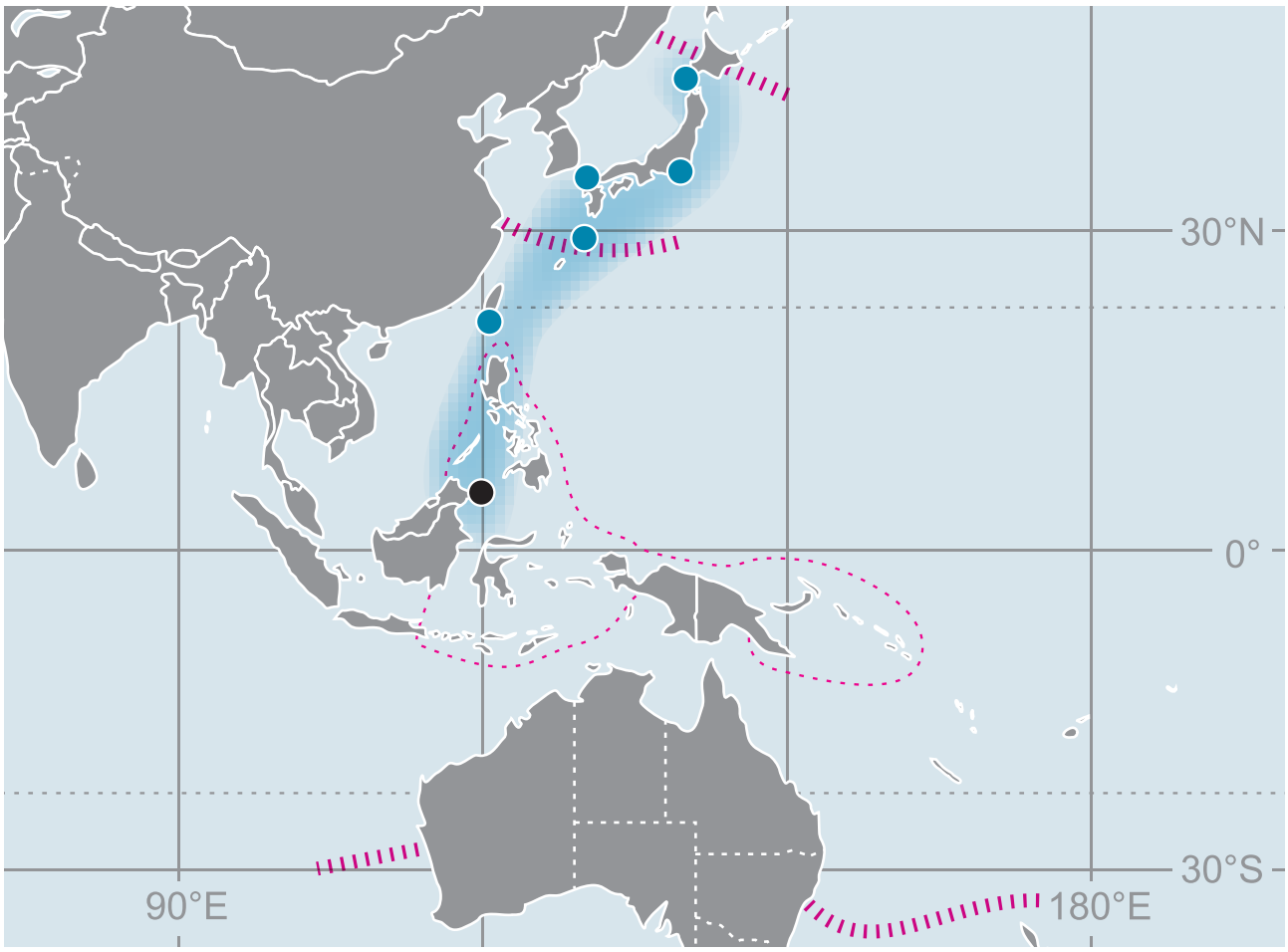




**Fig. 12.** Central Indo-West Pacific distribution of *Acrosterigma suluanum* Vidal, 1999, as currently known. Coral Triangle indicated with red dotted line. Borders of Indo-Pacific and Japanese fauna province with red striped line. Black circle representing the type locality.

cept for the Japanese Sagami Nada shells, are much worn and may not reflect the current distribution. The only live record is from a depth of 67-70 m in a sand-gravel bottom (Fig. 13); the deepest dead record is 439 m (USNM 299435, holotype).

Remarks. — The recently discovered Japanese specimens (JJTP 4785, Figs 8-11) closely match the holotype of *Acrosterigma suluanum* (Fig. 1a-f). Although the latter is a worn juvenile valve, shell shape, rib number (Table 1), rib sculpture and raised margin of the lunule all closely match. The holotype appears to be devoid of colour, the faint traces of reddish pigmentation seem to be the result of the shell being soaked in a reddish fluid rather than remnants of the actual shell coloration. The colour pattern on fresh shells is quite distinctive, consisting of a pattern of loosely commarginally arranged reddish blotches and splashes on a pale yellowish background. On the posterior slope these blotches are of a deeper red (Fig. 8e), strongly contrasting with the background. Within this species group (Vidal, 1999) such a contrasting pattern only occurs in *A. suluanum*. In fact only the rather different *A. punctolineatum* Healy & Lamprell, 1992, living in shallow water of the Central Indo-West Pacific displays a similar contrasting colour pattern on the posterior slope. In this species, the blotches are of a dark brown colour on a white background. The relative shell shapes have been compared according to the orientation of the nymphs, following the

**Figs 7-11**. *Acrosterigma suluanum* Vidal, 1999. **7a-c**, Japan, Kagoshima Prefecture, Ohshima County, Kikaijima Island, N Shiomichi, a small pond, Ryukyu Limestone, loc. 6 (961010-2). Pleistocene. Leg. A. Matsukuma et al. JJTP 1095, H 35.2 mm (a: RV interior, b: RV exterior, c: posterior slope of RV). **8-11**, Japan, Honshu, Tokyo Metropolis, southernmost of Sagami Nada, Izu Oshima, 67-70 m, sand gravel bottom. Leg. H. Takashige, 11.2016. JJTP 4785. **8a-e**, H 46.0 mm (a: LV exterior, b: RV interior, c: RV exterior, d: posterior view, e: detail of posterior slope). **9**, H 38.3 mm, LV exterior. **10**, H 39.8 mm, LV exterior. **11**, H 36.4 mm, LV exterior. Scale bar: 5 mm.

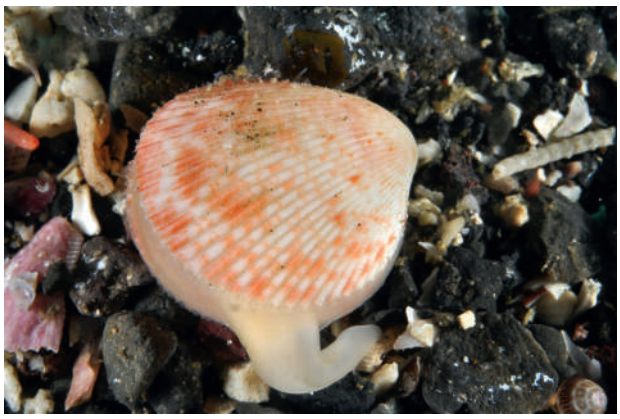

**Fig. 13.** *Acrosterigma suluanum* Vidal, 1999. In situ photo of live juvenile specimen from Japan, Honshu, Tokyo Metropolis, southernmost of Sagami Nada, Izu Oshima, depth 67-70 m, sand-gravel bottom. Photo: Hiroshi Takashige.

method of Hylleberg (2014). Shapes range from nearly perfect drop shape (AK = 43%, LB = 46%. JJTP 1095/2) to oblique-oval shape (AK = 24%, LB = 55%. JJTP 4785/1, 4785/2) with a wide range of intermediates (Fig. 14). It appears that this variation in obliqueness is of intraspecific value and related to age, as larger shells tend to be more oblique (Fig. 15). Additional material from localities throughout the distribution range is needed for a better founded opinion.
According to Hylleberg (2009) the locality of paratypes 1-3 ('Sunasaki') is situated near Hakodate, circa 42°N, 140°E, which is SW Hokkaido: an extremely northern locality for a species of which the holotype is pure tropical. On the other hand, the sampling data of Th. Mortensen are reliable, as he was extremely careful (e-mail J. Hylleberg, 01.04.2017). On the worn paratype 1, traces of the deep red-brown colour are still visible (Fig. 2a, arrow).
Yamashita et al. (1998) described the molluscan fossils of the Pleistocene Ryukyu Limestone of Kikaijima Island, southwestern Japan. The limestone formation has a thickness of max. 30 m, contains remains of Foraminifera, calcareous algae, corals, brachiopods, echinoids and molluscs. The molluscan assemblage consists of molluscs living mainly in the upper subtidal zone, less than 20 m, and mainly living in tropical to warm-temperate waters. The five cardiids dealt with Yamashita et al. (1998) are all tropical extant species. One of these, identified as *Acrosterigma arenicola* (Reeve, 1845), represents *A. suluanum*. A Ryukyu Limestone Formation valve is depicted herein (Fig. 7a-c, identification confirmed by the late J. Vidal, 03.2002).
*Cardium arenicolum* Reeve, 1845, and *Cardium multistriatum* G.B. Sowerby I in Broderip & G.B. Sowerby I, 1833, are generally considered junior synonyms of *A. maculosum* (W. Wood, 1815) although two morphologic groups can be recognized with, however, many intermediate forms (Vidal, 1999). The '*arenicola*' form has relatively large shells (H up to 53 mm), is more asymmetrical and truncated and has less numerous ribs (41-50). This form occurs in China and Japan.
*Acrosterigma suluanum* can easily be differentiated by the more elaborate and complex rib sculpture, with thin oblique scales on the posterior part of the shell, by the higher W/L ratio (0.80 vs. 0.71), the wider hinge angle (angle A 130° vs. 115°) and by the more intense coloration, especially on the posterior slope.
In fact *Acrosterigma profundum* Vidal, 1999 (Figs 3-4) and *A. suduirauti* Vidal & ter Poorten, 2007 (Figs 5-6) are more closely related. However, both species have a higher rib number (55-65), finer oblique scales that are largely lacking on the median part and the latter has a more quadrate and thinner shell. In addition, both species lack the distinctive, contrasting colour pattern present on the posterior slope of *A. suluanum*.

Material examined. — **Japan**. Japan, off Sunasaki [Hokkaido, Hakodate ca. 42°N, 140°E], dredge, 150–35 m, F.I.S. Endeavour; Th. Mortensen leg. 12.04.1914 (ZMUC, paratypes 1-3, all worn s.v.). Honshu, Tokyo Metropolis, southernmost of Sagami Nada, Izu Oshima, 67-70 m, sand gravel bottom; H. Takashige leg. 11.2016 (JJTP 4785, 5 p.v., fresh). Korea Strait, 10 km NE of Okinoshima, 34°20'N, 130°10'E, 113 m, F.I.S. Endeavour; Th. Mortensen leg. 18.05.2014 (ZMUC, paratypes 4-5, both worn s.v.). Kagoshima Prefecture, Ohshima County, Kikaijima Island, N Shiomichi, a small pond, Ryukyu Limestone, loc. 6 (961010-2); Pleistocene; A. Matsukuma et al. leg. (JJTP 1095, 2 s.v.).
**Taiwan**. Bashi Channel, 21°54.8'N, 120°36.2'E, 305 m, N.O. Fisher Researcher 1; P. Bouchet, B. Richer de Forges-IRD & Chan leg. 07.2000. TAIWAN 2000 Exp., stn DW36 (MNHN-IM-2014-6024, 3 s.v., worn and blue-grey discoloured).
**Philippines**. Sulu Archipelago, N of Tawitawi Island, Languyan Point, 439 m, R/V Albatross, USBF stn 5577, 23.09.1909 (USNM 299435, holotype, 1 s.v., worn and juv.).

**Fig. 14.** Morphometrical characteristics of *Acrosterigma suluanum* Vidal, 1999. Comparison of the relative shell shapes according to the orientation of the nymphs, following the method of Hylleberg (2014). Repositories, registration numbers and sizes indicated in the shells; type material in colour.

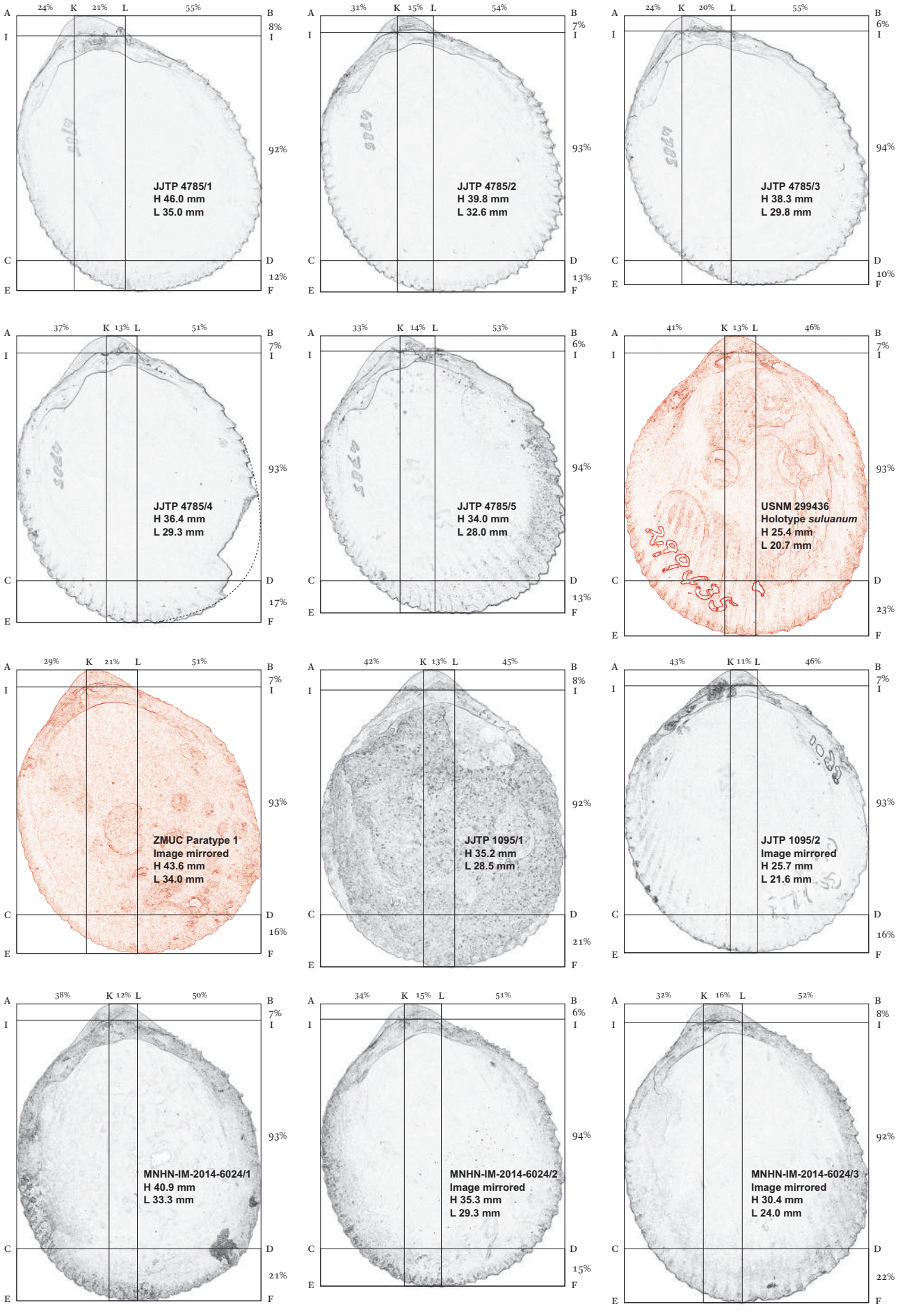
JJTP 4785/1
H 46.0 mm
L 35.0 mm
JJTP 4785/2
H 39.8 mm
L 32.6 mm
JJTP 4785/3
H 38.3 mm
L 29.8 mm
JJTP 4785/4
H 36.4 mm
L 29.3 mm
JJTP 4785/5
H 34.0 mm
L 28.0 mm
USNM 299436
Holotype *suluanum*
H 25.4 mm
L 20.7 mm
ZMUC Paratype 1
Image mirrored
H 43.6 mm
L 34.0 mm
JJTP 1095/1
H 35.2 mm
L 28.5 mm
JJTP 1095/2
Image mirrored
H 25.7 mm
L 21.6 mm
MNHN-IM-2014-6024/1
H 40.9 mm
L 33.3 mm
MNHN-IM-2014-6024/2
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Image mirrored
H 30.4 mm
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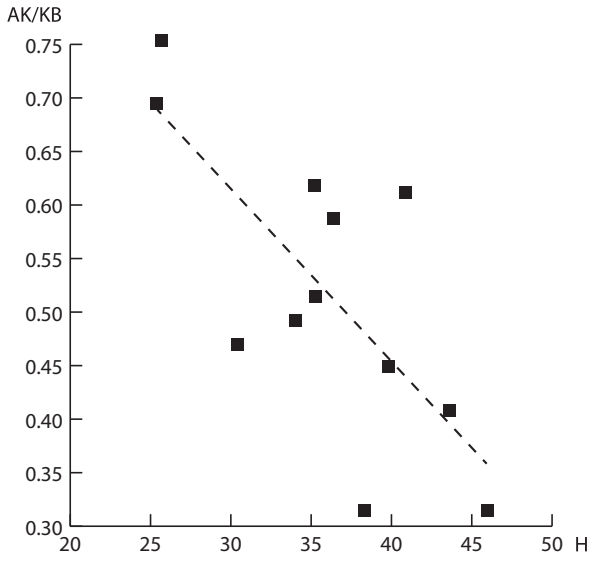


**Fig. 15.** Scatter diagram showing relation shell height (horizontal axis) and degree of obliqueness (vertical axis) for *Acrosterigma suluanum* Vidal, 1999, based on AK/KB values of Fig. 14.


## Acknowledgements

Philippe Bouchet (MNHN) is kindly acknowledged for making expedition material available for study and for sending the collection of the late Jacques Vidal as a long-term loan at the disposal of the senior author. Jørgen Hylleberg (ZMUC) kindly sent photos of paratype 1, provided additional information on the Mortensen labels and gave some useful suggestions as reviewer. Ellen Strong (USNM) kindly provided the senior author access to the collections. Hiroshi Takashige (Japan) kindly shared the Japanese material and gave permission to reproduce his photograph of a live specimen. Travel costs of the senior author to the USNM were supported by the U.S. National Science Foundation under awards DEB-0919124 / 0918982 / 0919451.


| Repository | H | L | W | L/H | W/L | D | A° | Ribs |
|---|---|---|---|---|---|---|---|---|
| USNM 299436 Holotype | 25.4 | 20.7 | 14.4 | 0.81 | 0.70 | 0.88 | 130 | 44 |
| ZMUC Paratype 1 | 43.6 | 34.0 | 30.0 | 0.78 | 0.88 | 0.95 | 125 | 44 |
| ZMUC Paratype 2 | 33.3 | 28.6 | 22.0 | 0.86 | 0.77 | ? | 130 | 45 |
| ZMUC Paratype 3 | ? | 27.0 | 24.0 | ? | 0.89 | ? | 130 | 44 |
| ZMUC Paratype 4 | 30.3 | 25.7 | 19.2 | 0.85 | 0.75 | ? | 130 | 45 |
| ZMUC Paratype 5 | 28.5 | 23.8 | 19.0 | 0.84 | 0.80 | ? | 130 | 41 |
| MNHN-IM-2014-6024/1 | 40.9 | 33.3 | 27.0 | 0.81 | 0.81 | 1.00 | 134 | 47 |
| MNHN-IM-2014-6024/2 | 35.3 | 29.3 | 23.4 | 0.83 | 0.80 | ? | ? | 46 |
| MNHN-IM-2014-6024/3 | 30.4 | 24.0 | 17.4 | 0.79 | 0.73 | ? | ? | 45 |
| JJTP 1095/1 | 35.2 | 28.5 | 24.0 | 0.81 | 0.84 | 0.89 | 131 | 45 |
| JJTP 1095/2 | 25.7 | 21.6 | 16.0 | 0.84 | 0.74 | ? | ? | 43 |
| JJTP 4785/1 | 46.0 | 35.0 | 30.6 | 0.76 | 0.87 | 1.11 | 122 | 45 |
| JJTP 4785/2 | 39.8 | 32.6 | 25.4 | 0.82 | 0.78 | 0.95 | 132 | 48 |
| JJTP 4785/3 | 38.3 | 29.8 | 25.3 | 0.78 | 0.85 | 1.16 | 127 | 47 |
| JJTP 4785/4 | 36.4 | 29.3 | 25.7 | 0.80 | 0.88 | 1.04 | 133 | 44 |
| JJTP 4785/5 | 34.0 | 28.0 | 21.8 | 0.82 | 0.78 | 1.16 | 131 | 45 |
| Kuroda et al. (1971: fig. 1) | 37.8 | 31.6 | 25.5 | 0.84 | 0.81 | ? | ? | ? |
| Kuroda et al. (1971: fig. 2) | 31.6 | 27.2 | 20.8 | 0.86 | 0.76 | ? | ? | ? |
| **Mean values** | | | | **0.82** | **0.80** | **1.02** | **129.62** | **44.88** |
| Number of shells measured | | | | n= 17 | n= 18 | n= 9 | n= 13 | n= 16 |

**Table 1.** Measurements of *Acrosterigma suluanum* Vidal, 1999. Paratypes measurements based on Vidal (1999). Extrapolated data indicated in brackets.

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