

## A new species of deep-water Holothuroidea (Echinodermata) of the genus *Synallactes* from off western Mexico

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**SUMMARY:** An undescribed species of *Synallactes* was collected during a deep-water benthic fauna survey off the Pacific coast of Mexico in the East Pacific, with the R/V *El Puma*. This new species differs from all the other known *Synallactes* by the presence of huge massive rods in the tube feet, some of them club-shaped. The later ossicle shape is unique among Holothuroidea. This is the first record of a *Synallactes* in the Gulf of California.

**Keywords:** Holothuroidea, *Synallactes* n. sp., club-shaped ossicles, deep water, East Pacific, Mexico.

**RESUMEN:** UNA NUEVA ESPECIE DE AGUAS PROFUNDAS DE HOLOTHUROIDEA (ECHINODERMATA) DEL GÉNERO *SYNALLACTES* DEL PACÍFICO MEXICANO. – Una especie de *Synallactes* no descrita ha sido recolectada durante un programa de estudio de la fauna bentónica de aguas profundas del Pacífico mexicano, en el Pacífico Este, por el B/O “El Puma”. Esta nueva especie difiere de todas las especies de *Synallactes* conocidas por la presencia de barotes muy largos y masivos en los pies ambulacrales, algunos en forma de clava. Esta forma de osículos es única dentro de los Holothuroidea. Esta especie nueva representa el primer registro del género para el golfo de California.

**Palabras claves:** Holothuroidea, *Synallactes* n. sp., osículos en forma de mazo, aguas profundas, Pacífico Este, México.

### INTRODUCTION

The deep-water Holothuroidea of the East Pacific have been studied mainly by Ludwig (1893, 1894) and H.L. Clark (1913, 1920, 1923). In 1988, Maluf compiled the information on central part of the east Pacific holothuroids. This study includes four *Synallactes* species, viz *S. aenigmae* Ludwig, 1893, *S. alexandri* Ludwig, 1893, *S. ishikawa* f. ind. Mitsukuri, 1912 (now considered as a synonym of *S. sagamiensis* Augustin, 1908) and *S. triplax* H.L. Clark, 1920. Only *S. ishikawa* has been collected along the Mexican West coast (Parker, 1964), whereas no *Synallactes* are mentioned in the Gulf of California (Maluf and Br-

usca, 2005). The family Synallactidae has been revised by Solís-Marín (2003), Solís-Marín and Laguarda-Figuera (2004) and Solís-Marín (2005). Including a new species recently described for southern Africa (Thandar, 2008), 24 species of the genus *Synallactes* are recognized as valid. Moreover, Solís-Marín *et al.* (2005) and Honey-Escandón *et al.* (2008) compiled the echinoderm species in the Gulf of California and in western Mexico (excluding the Gulf). Both lists, based exclusively on records verified in Maria Elena Caso Muñoz's collections (Universidad Nacional Autónoma de México, Mexico D.F.) and in the Smithsonian Institution collections (Washington D.C.), include 55 species of Holothuroidea, but no species of *Synallactes*.

During a deep-water benthic fauna survey off the Pacific coast of Mexico, in the East Pacific, material belonging to the genus *Synallactes* was dredged at 1030 m depth in the SW Gulf of California and is the object of the present paper.

MATERIALS AND METHODS

Acronyms and abbreviations. CTD: Conductivity, Temperature, Density. UNAM: Universidad Nacional Autónoma de México. EMU: Regional Collection of Invertebrates, Instituto de Ciencias del Mar y Limnología, UNAM. ICML-UNAM: María Elena Caso Muñoz's Collection, Instituto de Ciencias del Mar y Limnología, UNAM. IG-HOL: General Inventory, Holothuroidea Collection, Royal Belgian Institute of Natural Sciences. TL: Total length.

Samples of Holothuroidea were obtained at depths between 600 and 2250 m on the continental slope of the southern Gulf of California using a benthic sledge (2.35 m width, 0.9 m height) equipped with a modified shrimp net (5.5 cm stretched mesh size). A total of 13 cruises were organized in the Gulf of California and along the west coast of Mexico, south of Banderas Bay, from 1989 to 2008. Positional coordinates for each sampling station were plotted using a GPS navigation system. Depth was measured with a digital recorder. Epibenthic water

temperature and salinity were measured with a Seabird CTD, and dissolved oxygen content was measured with the Winkler method and with a probe attached to the CTD. Holothuroidea were fixed on board with a 4% formaldehyde sea water solution for a few days, washed with tap water and preserved in 70% ethanol.

TAXONOMY

Order ASPIDOCHIROTIDA Grube, 1840  
 Family SYNALLACTIDAE Ludwig, 1894  
 Genus *Synallactes* Ludwig, 1894  
*Synallactes virgulasolida* n. sp.  
 (Figs. 1-3)

*Synallactes alexandri*; Hancey, 2004: 3, Appendix 1-4, Pl. 1, Figs. 1-2, Pl. 2, Figs. 1-4.

*Type locality.* TALUD VIII, Off SE Baja California, Station 16 (25°24'26"N, 110°37'36"W), 18/April/2005, three specimens (TL 50, 60 and 85 mm), benthic sledge, 1030 m depth.

*Type material.* Holotype in Mazatlán, Mexico (EMU-8608); paratype 1 in Brussels, Belgium (IG.31487-HOL 1506); paratype 2, María Elena Caso Muñoz's Collection, in Mexico DF, Mexico (ICML-UNAM 5.171.0).

*Abiotic data.* At the type locality, epibenthic water temperature and dissolved oxygen were, respectively, 5°C and 0.20 ml O<sub>2</sub>/l. Bottom of fine black mud.

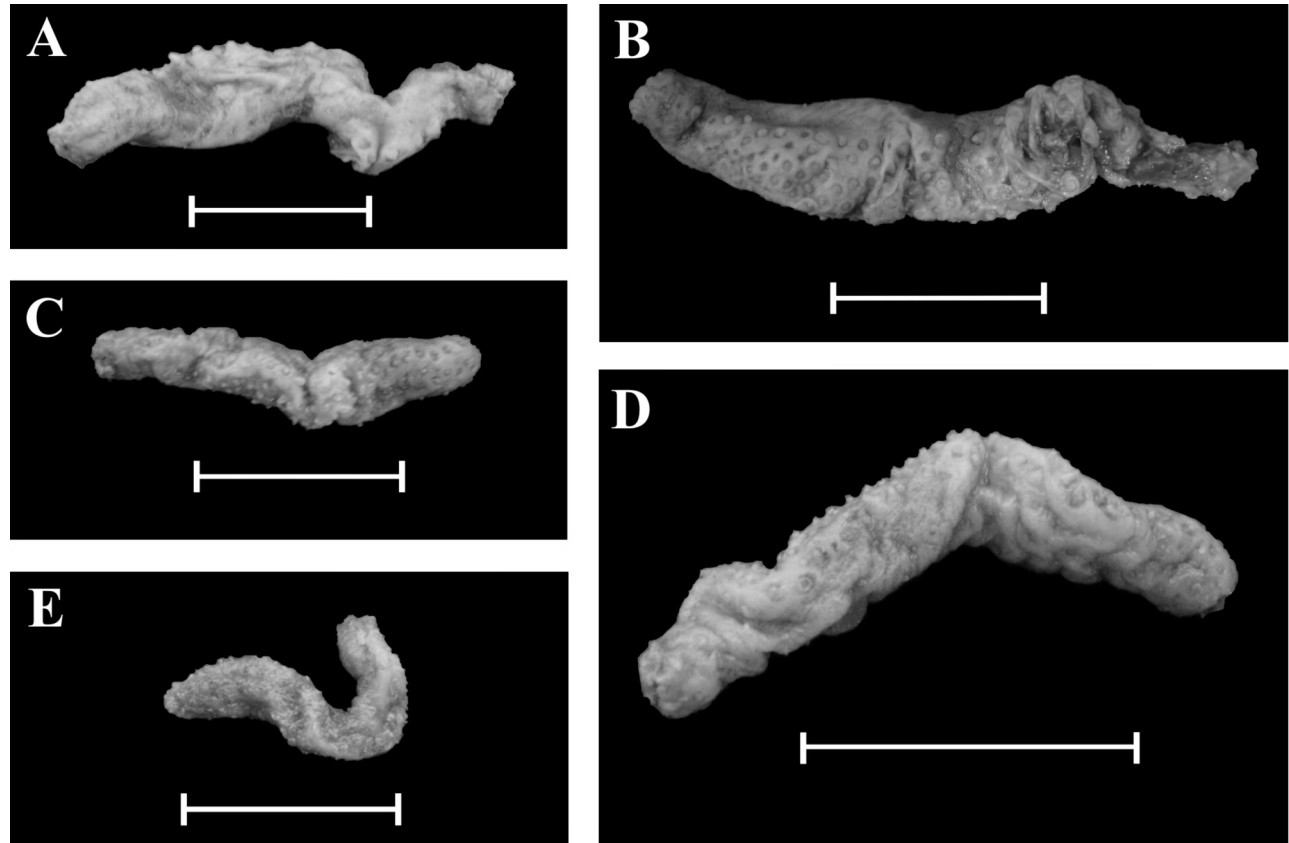


FIG. 1. – *Synallactes virgulasolida* n. sp. A, dorsal view of the holotype; B, ventral view of the holotype; C, general view of paratype 1; D, lateral view of paratype 1; E, general view of paratype 2.

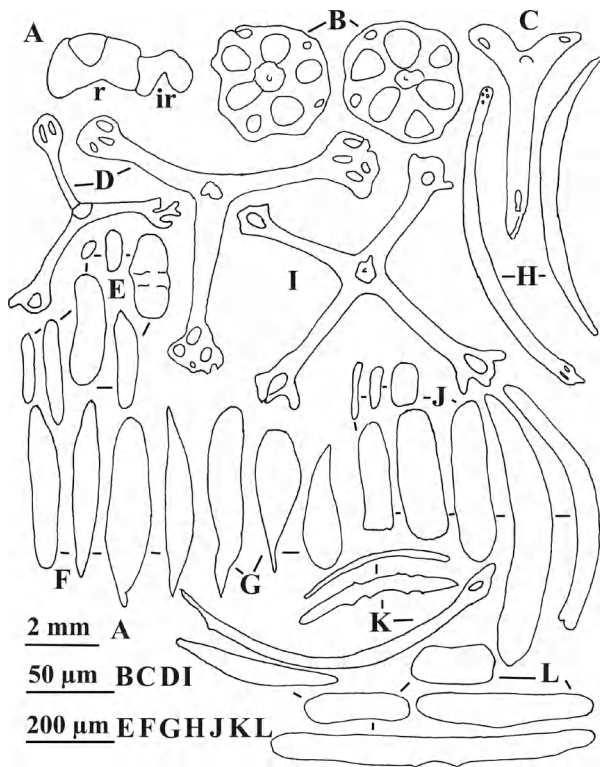


FIG. 2. – *Synallactes virgulasolida* n. sp. A, calcareous ring paratype (r: radial piece; ir: interradial piece); B, tables of ventral body wall (holotype); C, table from ventral body wall, lateral view (holotype); D, cross-shaped ossicles from dorsal body wall (holotype); E, bean-shaped ossicles from ventral tube feet (holotype); F, massive rods of the ventral tube feet (holotype); G, club-shaped ossicles from ventral tube feet (holotype); H, slender rods from the ventral tube feet (holotype); I, cross-shaped ossicles from ventral tube feet (holotype); J, massive rods from ventral tube feet (paratype 1); K, slender rods from ventral tube feet (paratype 1); L, massive rods from ventral tube feet (paratype 2).

**Etymology.** The name of the new species is a combination of the Latin words *virgula* meaning “rod” and *solida* meaning “massive”. It refers to the huge massive rods from the tube feet.

**External anatomy.** Medium size holothurian, cylindrical, slightly tapering posteriorly (Fig. 1A, B, C, E). Body length 50, 60 and 85 mm with a diameter of 5, 10 and 13 mm, respectively. In alcohol, body wall brown-beige with tube feet and tentacles yellow. Mouth ventral surrounded by 18-20 shield shaped tentacles. Tentacles surrounded (mainly dorsally) by a collar of very long papillae which have a hairy aspect because of the pillar of the cross-shaped ossicles protruding outside. Ventral tube feet very large (Fig. 1A, B, D), conical, aligned in 2-3 rows (Fig. 1B). One row of very large tube feet along the limit bivium/trivium (Fig. 1D). Dorsally, numerous cylindrical papillae, spread all over the bivium.

**Internal anatomy.** Calcareous ring well developed, massive (Fig. 2A) in the two small specimens; in

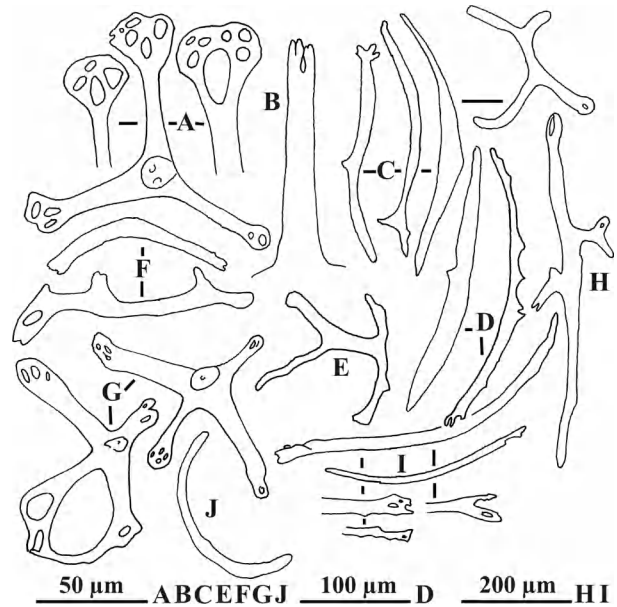


FIG. 3. – *Synallactes virgulasolida* n. sp. A, cross-shaped ossicles from dorsal papillae (holotype); B, central pillar of a cross-shaped ossicles from dorsal papillae (holotype); C, rods from dorsal papillae (holotype); D, E, F, H, rods of the tentacles (holotype); G, cross-shaped ossicles from the tentacles (holotype); I, J, rods of the tentacles (paratype 1).

the largest specimen the calcareous ring is very thin, translucent, made of a meshwork of tubules. No tentacle ampullae. Polian vesicle and madreporic plate not observed. Longitudinal muscles well developed, cylindrical.

**Ossicles.** In the ventral body wall, tables 70-80 µm across, perforated by 7-10 holes (Fig. 2B). One central pillar 105-120 µm high, perforated at the extremity and/or ending in a few short spines (Fig. 2C). On the dorsal body wall a few cross shaped ossicles (Fig. 2D), generally with one central pillar and three arms perforated at their extremities. These cross-shaped ossicles are 120-150 µm across. In the ventral and lateral tube feet of the holotype huge, massive, smooth rods going from granules (80-200 µm long) (Fig. 2E) to massive rods (Fig. 2F) up to 750 µm long. Some of these massive rods are club-shaped (Fig. 2G). In the paratypes same massive rods (Fig. 2J, L) but no club-shaped ossicles were observed. Among the massive rods, long slender rods with perforated extremities (Fig. 2H). Slender rods of the paratype are similar to the one of the holotype (Fig. 2K). In the ventral tube feet, cross-shaped ossicles (Fig. 2I) are present. The end plate of the ventral and lateral tube feet is made of several plates which together measured 450 µm across. The holes of the end plate are very irregular in size and form. In the dorsal papillae, cross-shaped ossicles with 3-4 arms (Fig. 3A, B) together with irregular rods 120-150 µm long (Fig. 3C). In the tentacles, rods (Fig.



3D, E, F), and cross-shaped ossicles (Fig. 3G). Rods densely packed around the shaft of the tentacles, similar in the holotype and paratypes (Fig. 3I, J). They are irregular, 100-750  $\mu\text{m}$  long, smooth or spiny, straight, curved or branched with forked or perforated extremities. A few cross-shaped ossicles located at the base of the tentacles. They are up to 130  $\mu\text{m}$  across with the end of the branches perforated by 2-6 holes. Some branches are fused at their extremities (Fig. 3G).

*Remarks.* The three specimens observed belong without any doubt to the family Synallactidae and the genus *Synallactes*, as defined by Solís-Marín (2003).

*Synallactes virgulasolida* n. sp. is easy to separate from all the other *Synallactes* species by the presence in the ventral and lateral tube feet of massive granules growing up to smooth massive rods, some of them being club-shaped in the largest specimen (holotype). These club-shaped ossicles are up to now unique among sea cucumber ossicles. Granules and bean-shaped ossicles are well known in the genus *Bohadschia* (see Panning, 1944), in some specimens of *Actinopyga* such as *A. mauritiana* (Quoy and Gaimard, 1833) (see Cherbonnier, 1988: Fig. 2A), and in *Neostichopus grammatus* (H.L. Clark, 1923) (see Thandar, 1984: Fig. 40h). But all these granules are much smaller (20-50  $\mu\text{m}$  long) than the ones of *Synallactes virgulasolida* n. sp. Only some *Orphnurgus*, such as *Orphnurgus glaber* Walsh, 1891 (see Hansen, 1975: Fig. 13) have granules up to 450  $\mu\text{m}$  long.

*S. virgulasolida* shows affinities with the two *Synallactes* known from the Central East Pacific (Maluf, 1988), i.e. *Synallactes alexandri* Ludwig, 1893 and *Synallactes aenigma* Ludwig, 1893. *S. virgulasolida* has body wall tables very similar to those of *S. alexandri* (see Ludwig, 1894) and cross-shaped ossicles from the body wall very similar to those of *S. aenigma* (see Ludwig, 1894). Moreover, *S. aenigma* and *S. virgulasolida* have a similar distribution of the tube feet (Ludwig, 1894; H.L. Clark, 1920). Both authors also noted the possible absence of the calcareous ring in the studied specimens of *S. aenigma*. *S. virgulasolida* shows a reduction of the calcareous ring with growing size, which could result in its absence in very large specimens.

The *S. alexandri* mentioned by Haney (2004) shows in the tube feet numerous bean-shaped ossicles identical to those observed in *S. virgulasolida*. Neither Ludwig (1894) in his original description nor Solís-Marín (2003) in the redescription of the type material refer to the presence of these bean-shaped ossicles in the tube feet of *S. alexandri*. These ossicles are so large and so numerous that they cannot be overlooked. They are a good discriminant character which, up to now, has not been observed in any other *Synallactes*, included the species from South Africa recently described by Solís-Marín (2005) and Thandar (2008).

We consider the specimen described by Haney (2004) to be a *Synallactes virgulasolida* and not a *S.*

*alexandri*. Consequently, the distribution of *S. virgulasolida* is extended from the Gulf of California (Mexico) to California (USA), and its depth range is from 500 to 1030 m.

*S. virgulasolida* shows an evolution of its ossicle assemblages with size, as observed in many other sea cucumbers (see among others Massin 1994; Massin *et al.* 2000). The appearance of club-shaped ossicles in large specimens could be interpreted as a discriminant character to erect a new species. DNA analysis will certainly help to solve this problem but the material collected was not preserved for such analysis (material in formalin). However, the club-shaped ossicles are derived from the bean-shaped ossicles and we do not observe a hiatus between the two kinds of ossicle. With the anatomical data at hand we consider the three observed specimens to belong to a single species.

*S. alexandri* and *S. aenigma* have a Central East Pacific distribution (Maluf, 1988) but are not mentioned from the Gulf of California by Maluf and Brusca (2005). The presence of *S. challengerii* along the east coast of North America up to the coast of California is putative and needs to be checked (Solís-Marín, 2003). Indeed, *S. challengerii* is known from sub-Antarctic islands (Théel, 1886; Massin, 1992) and the species described by Lambert (1997) as *S. challengerii* probably represents another species. *Synallactes virgulasolida* is the first *Synallactes* mentioned in the Gulf of California.

As in the case of many species of Mollusks and Crustacea collected in deep water along the west coast of Mexico, at the edge of the Oxygen Minimum Zone (see Hendrickx, 2001; Zamorano *et al.*, 2006), *Synallactes virgulasolida* occurs in severe hypoxic conditions.

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