

BEAUFORTIA

INSTITUTE FOR SYSTEMATICS AND POPULATION BIOLOGY
(ZOOLOGICAL MUSEUM) UNIVERSITY OF AMSTERDAM

Vol. 48, Nr. 3

July 23, 1998

ASTHENOSOMA MARISRUBRI N.SP. (ECHINODERMATA, ECHINOIDEA) FROM THE RED SEA

STEVEN WEINBERG * & CHANTAL DE RIDDER **

* *École Européenne de Luxembourg, 23 Boulevard Konrad Adenauer, L-1115 Luxembourg, Luxembourg*
** *Laboratoire de Biologie Marine (CP160/15), Université Libre de Bruxelles, 50 Avenue F.D. Roosevelt, B-1050 Bruxelles, Belgium*

Key words: Echinodermata, echinoid, *Asthenosoma*, new species, Red Sea

ABSTRACT

Indopacific echinoids of the genus *Asthenosoma* that have hitherto been described as *A. varium* actually belong to two distinct species that are geographically separated. Animals of the eastern population, extending from Sri Lanka to Hawaii and centered around the Indonesian Archipelago and the Philippines are *A. varium* Grube, 1868. The new species, *A. marisrubri*, is so far known only from the northern Red Sea. The two species can be clearly distinguished by the distribution and the nature of the aboral spines and by the lack of tridactylous pedicellariae with blunt massive valves in *A. marisrubri* n.sp.

RÉSUMÉ

Les échinides indopacifiques du genre *Asthenosoma*, décrits jusqu'à présent sous le nom *A. varium*, appartiennent en réalité à deux espèces distinctes et séparées géographiquement. Les individus de la population orientale, qui s'étend du Sri Lanka jusqu'à Hawaii et se concentre autour de l'Archipel Indonésien et des Philippines, appartiennent à l'espèce *A. varium* Grube, 1868, tandis que l'espèce nouvelle *A. marisrubri* n'est connue, jusqu'à présent, que de la partie septentrionale de la mer Rouge. On peut distinguer les deux espèces sur les critères suivants: la nature et la distribution des piquants aboraux et l'absence de pédicellaires tridactyles à valves trapues et émoussées chez *A. marisrubri* n.sp.

INTRODUCTION

In 1928, an Echinothuriid echinoid was collected by R.P. Dollfus in the shallow reefs of the Red Sea (Gulf of Suez) and was identified as

Asthenosoma varium by Mortensen (1935). Subsequently, this species has been reported several times in the Red Sea either in scientific literature (Clark, 1966; Tortonese, 1977; Dollfus & Roman, 1981; Fishelson, 1991) or in field guides for

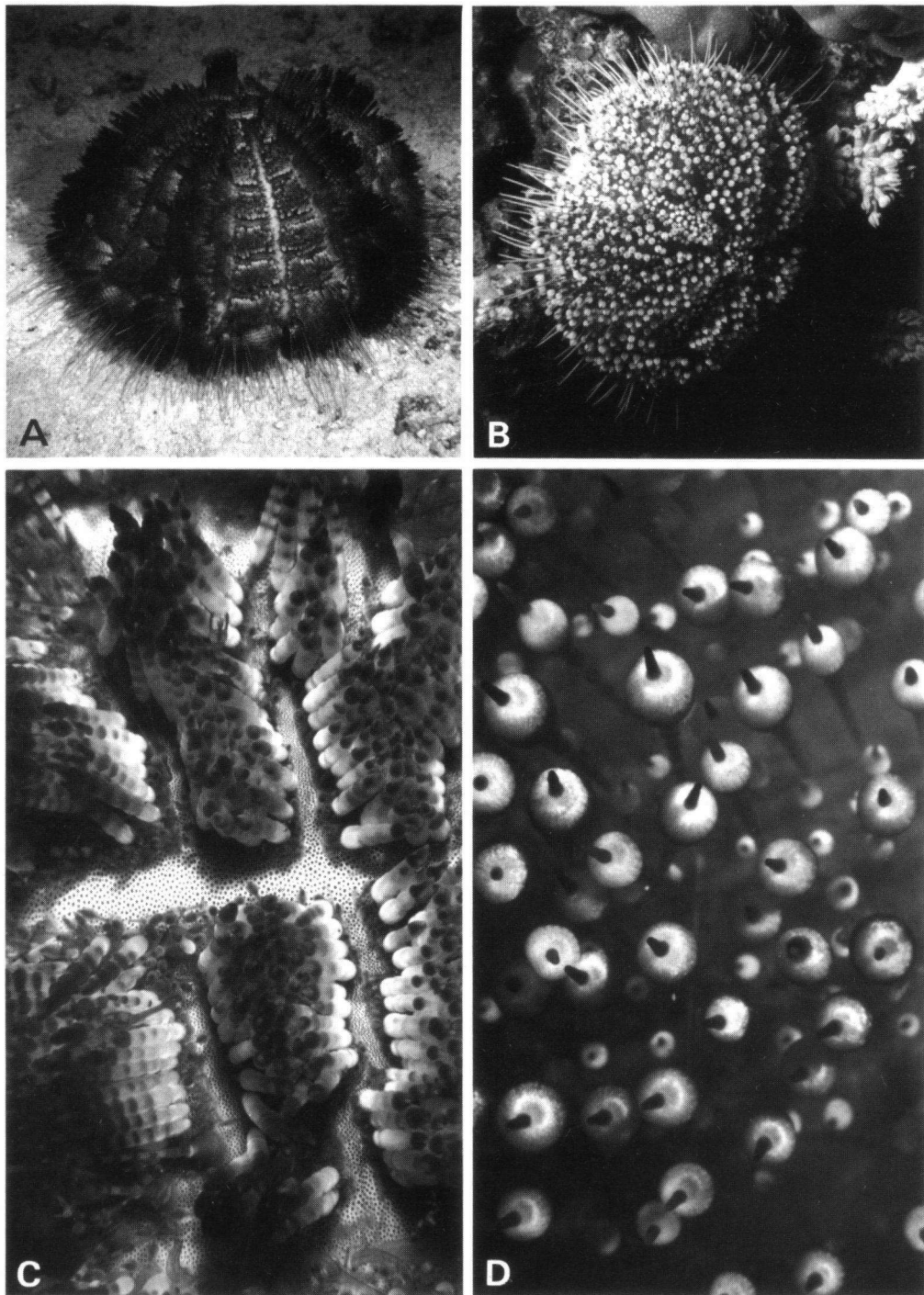


Fig. 1. *In-situ* pictures of *A. varium* and *A. marisrubri* n.sp. A. *Asthenosoma varium* at 8 m depth, Donggala (Sulawesi, Indonesia). (Underwater picture by Steven Weinberg); B. *Asthenosoma marisrubri* n.sp. at 15 m depth, Hurghada (Egypt, Red Sea). The long, incurved primary spines from the oral side form a “skirt” around the ambitus of the animal, secondary spines cover the aboral side. (Underwater picture by John Neuschwander); C. Detail of the aboral spines of *A. varium*. Note the naked zones around the patches of secondary spines which are invested by a thick skin-sheath showing typical constrictions and dark-and-light banding. (Underwater picture by Steven Weinberg); D. Detail of the aboral spines of *A. marisrubri* n.sp. Note the conspicuous canopy of pearl-like swellings, presumably poison glands, of the secondary spines. (Underwater picture by Steven Weinberg)

divers and in other "popular scientific" publications (see e.g.: Darom, 1976; George & George, 1979; Vine, 1986; Schmid & Paschke, 1987; De Wilde & Paccalet, 1990; Baumeister, 1993; Atiya, 1994; Pitkin, 1994).

A. varium was first described from the Sea of China (most likely the Philippines) by Grube (1868). Since Grube, it has been regularly reported in the central Indo-Pacific, from the Philippines and the Indonesian Archipelago eastward to Formosa and Japan and southward to Australia and New Caledonia (Agassiz, 1873; Ludwig, 1880; Agassiz, 1881; de Loriol, 1893, 1895; Döderlein, 1902; Döderlein, 1911; Clark, 1925; Mortensen 1935; Clark & Rowe 1971; De Ridder, 1986; Colin & Arneson 1995).

Recently, one of us (Weinberg, 1996) observed that live individuals of "*A. varium*" look strikingly different in the Red Sea and in the Indo-Pacific region, the most evident differences being the morphology and the arrangement of the aboral spines (Fig.1). This has led us to examine specimens from the Red Sea more carefully. The Red Sea specimens prove to be a hitherto undescribed species: *Asthenosoma marisrubri* n.sp. This new species is described here, and the characters which distinguish it from the species *A. varium* are given, as well as a key to the species of *Asthenosoma*.

MATERIAL AND METHODS

Eleven specimens of *Asthenosoma marisrubri* n.sp. were examined, one of them has been chosen as holotype, the ten others are paratypes.

Four specimens (holotype and 3 paratypes) are in the Zoölogisch Museum, Universiteit van Amsterdam (Amsterdam, The Netherlands) (ZMA): Vech.E 9365 (Holotype) (alcohol), locality: Shab Umm Ush, Hurghada (Egypt, Red Sea), depth: 4.5 m, coll. Paul Kieffer, 22/09/1996, leg. Romain Duprel ; Vech.E 9366 (Paratype) (alcohol), locality: Gulf of Aqaba (Jordanian, Red Sea), coll./leg. Rita Ghalayini, 1996 ; Vech.E 9366 (2 Paratypes) (alcohol), locality: Marsa Shagra, 50 km north of Marsa Alam (Egypt, Red Sea), depth: 10 m., coll. John Neuschwander, January 1997.

Two paratype specimens are in the Zoological Museum, Tel-Aviv University (Tel-Aviv,

Israel) (ZMTAU): EC 25123 (alcohol), locality: Eilat, Gulf of Aqaba (Israel, Red Sea), coll. J.U. Gitai, 1964, identified as *A. varium* ; NS 5091 (alcohol), locality: Eilat, Gulf of Aqaba (Israel, Red Sea), coll. D. Popper, 1968, identified as *A. varium*.

One paratype specimen is in the Zoological Museum, Hebrew University (Jerusalem, Israel) (HUJ): ECHI 343 (alcohol), locality: Eilat, Gulf of Eilat (Israel, Red Sea), coll. F.D. Por, 14/12/1969.

Four paratype specimens are in the Muséum National d'Histoire Naturelle (Paris, France) (MNHN): 6-9. EC ES 8376 (dry, badly preserved), locality: Gulf of Suez, stn 18 (28°4'-28°94' N, 33°28'-33°35' E, Red Sea), depth: 60-70 m, coll./leg. R.Ph. Dollfus, 26/12/1928.

In addition, ten specimens of *Asthenosoma varium* Grube 1868 from the Indo-Pacific region were also examined. These are the type specimen (only some spines and pedicellariae left) from the China Sea, described by Grube (1868) (leg. Salmin) and held in the Wladyslaw Rydzewski Museum of Natural History, Wroclaw University (Wroclaw, Poland) (MNHW): 487; the two specimens (alcohol) from Ambon described by de Loriol (1893) (coll. Bedot & Pictet) now in the Muséum d'Histoire Naturelle de la Ville de Genève (Geneva, Switzerland) (MHNG): E. 3/88; the two specimens (alcohol) from the Formosa Sea described by Ludwig (1880) in the Zoologisches Museum (Hamburg, Germany) (ZMH): E3 ; two specimens (alcohol) from East Sumatra, Java Sea and one (alcohol) from Sumbawa, in the Zoölogisch Museum, Universiteit van Amsterdam (Amsterdam, Netherlands) (ZMA): EC.E.4488 and EC.E.4489; one specimen (dried) from New Caledonia, in the Muséum National d'Histoire Naturelle (Paris, France) (MNHN): E.C.ES.8297; one specimen (alcohol) from southwest Sulawesi, Indonesia collected by Dr. Bert Hoeksema and in the Nationaal Natuurhistorisch Museum (Leiden, Netherlands) (NNM): Echinodermata 06050.

For scanning electron microscope (SEM) observations, pedicellariae and spines (fixed in 70 % ethanol) were dehydrated in graded ethanol and dried by the critical point method using CO₂ as transition fluid. The skeleton of pedicellariae and

spines was prepared by dissolving the tissues with sodium hypochlorite. Detached ossicles were then washed in distilled water and air-dried. Whole spines and pedicellariae or the ossicles were mounted on aluminium stubs, coated with gold in a sputter coater and observed with a JEOL JSM-35-C and an ISI DS-130 scanning electron microscope.

The maximum length and maximum width of the valves have been measured either directly with an eyepiece micrometer or on SEM pictures for the most abundant tridactylous pedicellariae, i.e., the pedicellariae with long, narrow and keeled valves (type 1) and the pedicellariae with blunt massive valves (type 3); their description is given in the results. For *A. marisrubri*, type 1 pedicellariae were collected on the holotype ZMA/V.ech.E 9365 and on the paratypes ZMA/V.ech.E 9366, ZMTAU/EC 25123 and HUIJ/ECHI 343. For *A. varium*, type 1 and type 3 pedicellariae were collected on the type specimen MNHW/487 and on specimens MHNG/E.3/88, ZMH/E3, ZMA/EC.E.4488, ZMA/EC.E.4489EC and NNM/Echinodermata 06050.

RESULTS

FEATURES OF THE GENUS ASTHENOSOMA GRUBE 1868

Asthenosoma varium Grube 1868 is the type species of the genus. The original description of the species by Grube was brief; more detailed descriptions were given later, mainly by Ludwig (1880), Agassiz (1881), de Loriol (1893) and Doederlein (1902). A precise diagnosis of the genus is given by A. Agassiz & H.L. Clark (1909) and by Mortensen (1935). However, a few features given in these descriptions are specific to *A. varium* and consequently do not concern all the species belonging to the genus. Therefore we propose a revised diagnosis largely based on that given by Mortensen (1935), but omitting the specific features of *A. varium*.

Asthenosoma belongs to the family Echinothuriidae and to the subfamily Asthenosominae (= Echinothuriinae in Fell, 1966). The characters of these taxonomic groups are given in Mortensen (1935). We will only recall here the distinctive

features of Asthenosominae: trigeminate ambulacra, non-crenulate tubercles, oral primary spines terminating in a hoof, not club-shaped and not skin-clad. The characters of the genus *Asthenosoma* can be summarized in the following way.

THE CORONA SKELETAL PLATES

1. Ambulacra

Each primary ambulacral plate is associated with two included ambulacral plates (i.e., plates having no contact with the ambulacra edges), and each plate bears one pore pair. Pores occur in three dense series both on oral and aboral sides. On the aboral side, the pores are in horizontal series. On the oral side, they form typical arcs of three plates close to the peristome but toward the ambitus they become horizontally arranged.

2. Interambulacra

Large tubercles (primary tubercles) are present only on the oral side (ambulacra and interambulacra); they continue a little above the ambitus, and then totally disappear. Their areoles are not deepened, but they are large: they necessitate a widening of the plates off the areoles. This causes: (1) the outlines of the plates to be more or less conspicuously sinuate, (2) the alternating position of the tubercles in successive plates. In larger specimens, there may be as many as five primary tubercles in a horizontal series on the interambulacral plates; on the ambulacral plates, there are no more than two to three tubercles, and some of the plates may be devoid of primary tubercles. Smaller tubercles (called here secondary and miliary tubercles) occur both on the oral and aboral sides (ambulacra and interambulacra). On the aboral side, the arrangement of the secondary tubercles on the plates is one of the species discriminant features.

3. Apical system

Genital and ocular plates are in contact with the periproct (monocyclic arrangement). Madreporic pores are limited or not to the madreporite.

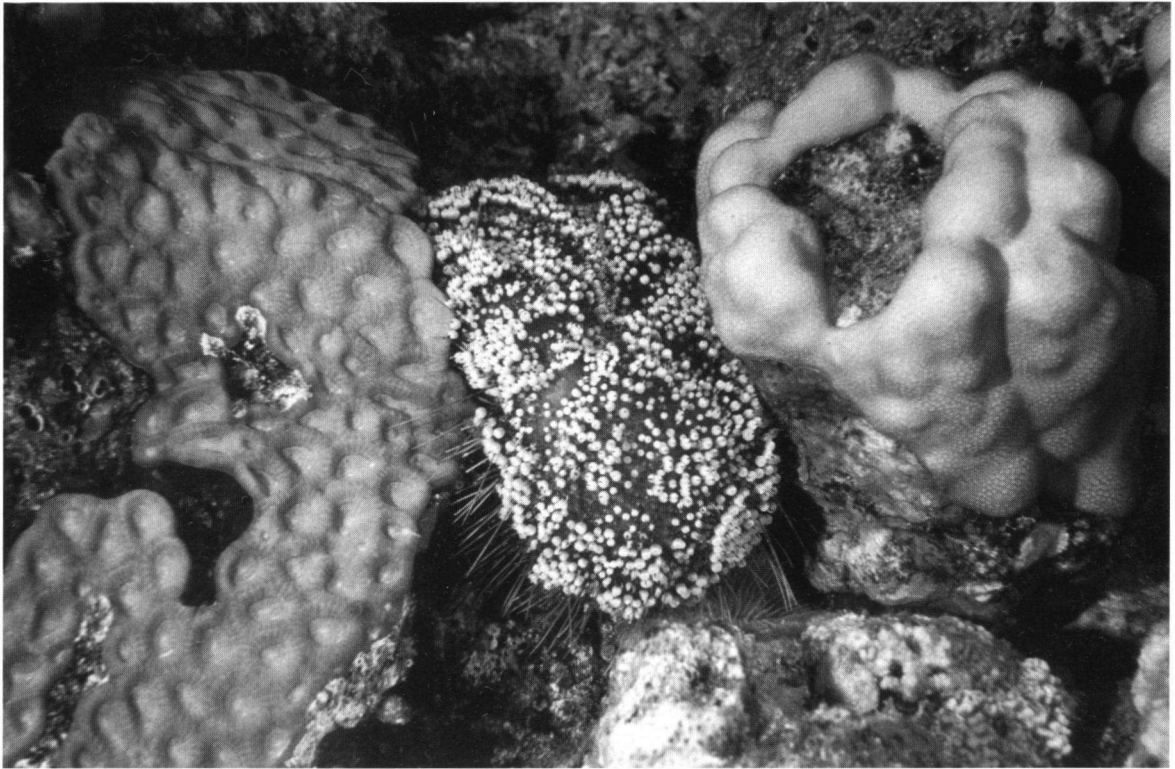


Fig. 2. *In-situ* picture of *A. marisrubri* n.sp. (near Safaga, Egypt, Red Sea; 10 m depth). Notice the flexibility of the test: the echinoid has wedged itself between two coral heads. (Underwater picture by Steven Weinberg)

THE APPENDAGES

1. Spines

The spines corresponding to the primary tubercles (primary spines), are the largest (in length and diameter), they are slightly curved, finely serrated and oral spines have an apex terminating in a slender hoof. The spines corresponding to the secondary tubercles are of three types: (a) slightly curved spatulated spines, (b) spines invested by a thick skin-sheath which is more or less distinctly annularly constricted and banded with dark and light colors, (c) spines with an apical, large spherical swelling (a poison gland). Spines of type a occur on the peristomial membrane, spines of types b and c occur both on the oral and the aboral sides but they are most developed on the aboral side. The respective development and arrangement of type a and type b spines are species discriminant features. The military tubercles (the smallest tubercles) correspond to the attachment of very small spines and pedi-

cellariae. The military spines show no particular features.

2. Pedicellariae

Only tridactylous and trifoliate forms do occur. The tridactylous may be of different types: (a) a large type, with narrow valves joining only in their distal part -the edge forming there some coarse teeth -, (b) a short, massive type with broad valves, joining in their distal half, -their edges are coarsely dentate in the joining part -, (c) a short, slender type with narrow valves and a median longitudinal crest along the inner face of the valve. The occurrence and/or the relative abundance of these pedicellariae types vary according to the species *A. varium*, *A. intermedium*, *A. ijimai* and *A. marisrubri*. However, in *A. dilatatum*, the only pedicellariae typically belong to a fourth type: a short, massive type, with broad leaf-shaped valves that are joined along their whole length.

3. Sphaeridia

The sphaeridia occur on the inner side of the included ambulacral plates, from the peristome to at least above the ambitus.

4. Tube-feet

On the oral side, the tube feet have well-developed sucking disks; on the aboral side, the distal ends of the tube feet are simply conical (sucking disk absent).

On the whole, species of *Asthenosoma* are large, beautifully coloured tropical echinothurids with a flexible test (Fig.2), occurring from the ebb-zone to a depth of ca. 100 m. They are the only littoral forms among Recent echinothurids.

***Asthenosoma marisrubri* n.sp.**

GENERAL FEATURES

This species has a circular outline when flattened in alcohol, with a relatively vertical ambitus. Living animals have usually a hemispherical shape forming a regular dome, but they can deform themselves when moving through narrow spaces between coral heads or rocks. The ambitus diameter of the alcohol preserved holotype

and paratype specimens varies from 85 to 150 mm (Table 1). When compared to the interambulacral areas, the ambulacral areas have a higher number of plates (primary ambulacral plates) in all the specimens (Table 1). This is comparable to the data given for *A. varium* and *A. urens* by Doederlein (1902), for *A. dilatatum* by Mortensen (1935) and for *A. intermedium* by H.L. Clark (1938). It is however perplexingly contrary to what is reported for *A. varium* and *A. ijimai* in Mortensen (1935). Observed at the ambitus, the ambulacra are narrower than the interambulacra (ambulacra ca. 2/3 of the interambulacra). All the tubercles are perforated. The distribution of the primary and secondary tubercles is mentioned in the following description of the corona skeletal plates; the miliary tubercles show no particular features.

THE CORONA SKELETAL PLATES (FIG.3A)

1. Ambulacra

The ambulacral plates are narrow, their edges are straight or slightly sinuous when at the level of a primary tubercle. Both on the oral and aboral faces, naked spaces are lacking. However, on the oral side, the perradial membranous suture may be slightly widened at the ambitus. Each

Table 1. Size features of the holotype and paratype specimens.

Specimen	Diameter (mm)			Number of plates			
	Ambitus	Peristome	Apical system	oral face		aboral face	
				A	IA	A	IA
ZMTAU-EC25123	85	ca. 19	ca. 17	27-29	22-25	35-37	28-31
ZMTAU-NS5091	95	ca. 23	ca. 18	23-26	19-22	43-46	31-33
ZMA-V.ech.E9366	105	ca. 22	ca. 20	-	-	-	-
ZMA-V.ech.E9365	115	ca. 24	ca. 20	30-33	23-25	45-48	28-32
HUJ-ECHI343	150	ca. 25	ca. 20	27-30	21-23	41-45	30-33

A: ambulacra, IA: interambulacra.

ZMA-V.ech.E9365 = Holotype

For specimen ZMA-V.ech.E9366, the test has not been denuded and consequently the number of plates is not given (the specimen has been kept as intact as possible in order to preserve most appendages in place).

Measurements were not realised on ZMA-V.ech.E9367 and MNHN-EcEs8376 because they are too badly preserved.

primary ambulacral plate has two included ambulacral plates and every plate bears one pore pair. In each ambulacral column, pore pairs are equidistant and are transversally in line in the adradial mid part of the column. They subsequently form three meridional series on both adradial sides of an ambulacrum. Oral and aboral sides differ by their tuberculation. On the oral side, primary tubercles (0-2) occur in the interporiferous zone; the primary tubercles increase in diameter and in number from the peristome towards the ambitus. The general pattern of their distribution is as follows: near the peristome, one primary tubercle every second plate and further upwards on each plate; some plates may bear two tubercles. Tubercles on successive plates have an alternating position. Secondary tubercles are transversally in line throughout the plate. On the aboral side, the primary tubercles are lacking (they disappear a little above the ambitus) and the secondary tubercles are slightly larger than these on the oral face. As a whole, the secondary tubercles have rather a uniform distribution. In the apical region of the corona, the secondary tubercles (1-4) form a transversal series on each plate and are restricted to the interporiferous zone; towards the ambitus, they increase in number, occurring both in the poriferous and interporiferous zones and are uniformly distributed along the plate without forming regular transversal series.

2. Interambulacra

The interambulacral plates are 1.5 to 2 times the width of the ambulacral plates. Their edges are straight, slightly adorally curved in the vicinity of the interradial membranous suture. Close to the apical system, they are V-shaped with the point directed toward the apex. As for the ambulacra, the oral and aboral sides differ in their tuberculation. On the oral side, 1-4 primary tubercles occur on each plate. One tubercle is located close to the adradial edge of each plate from the peristome edge to the ambitus. A second tubercle may occur lateral to the first one, every second plate. These adradial tubercles have an alternating position in successive plates; they form meridional series that run parallel along the adradial membranous suture and extend a little above the ambitus. Primary tubercles also occur

in the interradial mid part of the plate: there is one tubercle generally every two plates close to the peristome and one on every plate at mid distance from the ambitus; in this area, a second tubercle may occur lateral to the first one, every second plate. These perradial tubercles have an alternating position on successive plates.

Secondary tubercles are scattered between the primaries and are often transversely in line. On the aboral side, the primary tubercles are lacking: as in the ambulacra, they disappear a little above the ambitus. The secondary tubercles are regularly distributed all over the interambulacral plates. Naked areas may occur along the interradial suture, but they are little developed. As a whole, membranous sutures are more conspicuous (wider) in the interambulacra than in the ambulacra.

THE PERISTOME

The peristome is entirely covered by imbricating plates. These correspond to ambulacral and interambulacral plates which are incorporated on the peristomial membrane. The ambulacral plates bear pores pairs which are meridionally in line from the corona up to the mouth.

Gills are well-developed, but the gill slits are shallow.

THE APICAL SYSTEM

The apical system is monocyclic. All plates are rather triangular in shape, with the genital plates being larger. The membranous junctions are well-developed and often cover the periphery of the plates. The madreporite is conspicuous, being the largest and the most prominent plate. Pores only occur on the madreporite. Small tubercles (1-2 / plate) are present on the periproctal plates; the latter are small, well-separated from each other, and with a sinuous outline. The central anus is surrounded by a fold formed by the periproctal membrane.

THE APPENDAGES

1. Spines

Primary spines correspond to a single morphological type: they are slightly curved (on the oral

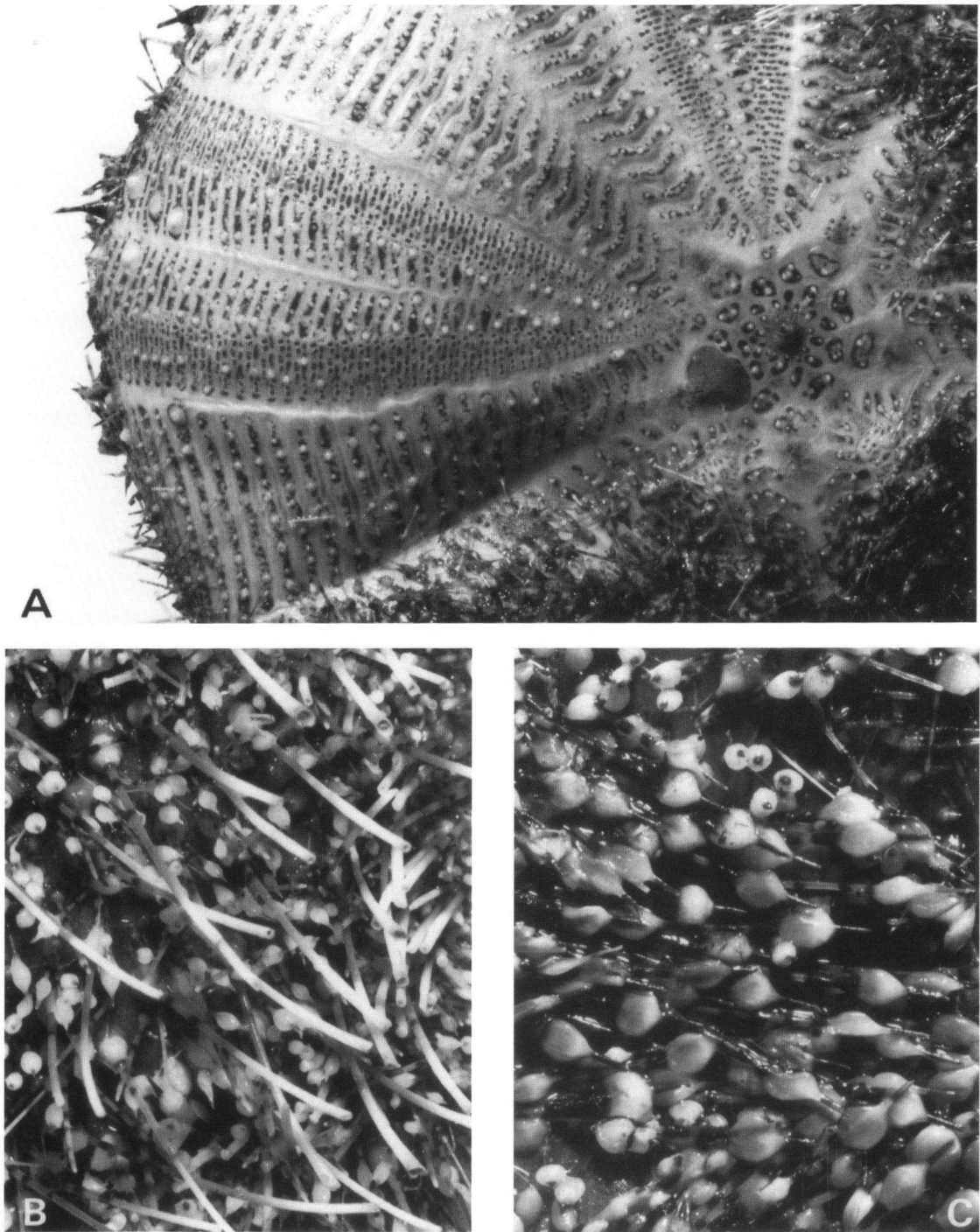


Fig. 3. *A. marisubri* n.sp., A. Detailed view of the aboral face of the holotype (ZMA: V.ech.E 9365) showing the naked test; B. Detailed view of the oral face of the paratype (ZMA: V.ech.E 9366) showing the primary "hoof" spines and the secondary spines with the apical swelling; C. Detailed view of the aboral face of the paratype (ZMA: V.ech.E 9366) showing the secondary spines with the apical swelling.

side) or straight (at the ambitus) with a cylindrical hollowed shaft ending in a distal hoof; this hoof is not enlarged and is even sometimes narrower than the shaft (Figs. 3B, 4). Primaries occur on the oral side as well as along and a little above the ambitus. The primaries are of very uniform size all over the oral face (10-15 mm, holotype specimen), but they increase in length at the level of the ambitus and on the aboral side (20-25 mm, holotype specimen); there, the primaries extend well over the coating of secondary spines.

Secondary spines belong to two morphological types: (1) spines invested in a narrow epidermal bag with a very conspicuous apical swelling forming a sphere (most presumably a poison gland: divers have reported an extremely painful burning sensation when these sea urchins are touched) which is supported by a very sharp skeletal point (Figs. 3C, 5), (2) slightly curved spines with a slightly spatulated distal end. Type 1 spines abundantly occur both on the oral and the aboral sides. On the oral side, they are much

shorter (ca 6 mm, holotype specimen) than on the aboral side (ca 20 mm, holotype specimen). On the aboral side, these tallest secondaries form a regular canopy typically characterized by the spherical apex of the spines. Type 2 spines (7-9 mm) are confined to the peristome.

2. Pedicellariae

Two main types of tridactylous pedicellariae occur: (1) a large type ("type 1"), with long narrow valves that join only in their distal part - the edge forming there five coarse teeth (Fig.6), (2) a short type ("type 2") with relatively broad and flat valves that join distally and along 1/3 to 2/3 of their length (Fig.7). On type 1 pedicellariae, a keel occurs medially on the outer face of the valves. On type 2, there is a crest running along the inner face of the valve (from the septum separating the musculature of the pedicellariae up to the distal extremity of the valve); this crest typically bears several large sharp spines. Trifoliate pedicellariae are numerous, with broad and short valves.

KEY TO THE SPECIES OF THE GENUS ASTHENOSOMA

Five species are referred to the genus *Asthenosoma*: *Asthenosoma varium* Grube, *Asthenosoma ijimai* Yoshiwara, *Asthenosoma dilatatum* Mortensen, *Asthenosoma intermedium* H.L. Clark, *Asthenosoma marisrubri* n.sp. The key proposed hereafter, is based on the distinctive features given by Mortensen (1935) for *A. varium*, *A. ijimai* and *A. dilatatum*, by H.L. Clark (1938) for *A. intermedium* and by this paper for *A. marisrubri*. We think, however, that a closer look at living and well preserved specimens of comparable size (age) should be made in the future, in order to ascertain the validity of the species *A. ijimai*, *A. dilatatum* and *A. intermedium*.

- | | |
|---|--|
| <p>1.- Tridactylous pedicellariae of 2-3 different types, one with narrow valves and a median longitudinal crest along the inner face of the valve; none simply with broad leaf-shaped valves joined along their whole length and without an inner median longitudinal cost....2</p> <p>- Tridactylous pedicellariae of one type only, with broad leaf-shaped valves, joined along their whole length and without an inner median longitudinal crest<i>A. dilatatum</i></p> | <p>- On the aboral side, predominant and taller spines are invested in a skin sheath which is only swollen distally forming a very conspicuous spherical extremity (probably a poison gland). They regularly cover the entire aboral side; naked spines are inconspicuous or absent <i>A. marisrubri</i></p> |
| <p>2.- On the aboral side, predominant and taller spines are invested by a thick skin-sheath, more or less distinctly annularly constricted and banded with dark and light colours; their distal extremity is not swollen as a sphere. These spines are grouped in rectangular patches that are well separated by naked areas. Smaller spines also invested in a skin sheath but with a distal spherical swelling (probably a poison gland) are mostly located along the margins of the naked areas 3</p> | <p>3.- On the oral side, primary spines are usually ringed. Pedicellariae of the massive type with broad valves are present or absent. Madreporic pores confined to the madreporite4</p> <p>- On the oral side, primary spines are not ringed. Pedicellariae of the massive type with broad valves are absent. Madreporic pores extending over the adjoining periproctal plates <i>A. ijimai</i></p> |
| <p>4.- Pedicellariae of the massive type with broad valves present. (Indo-Pacific) <i>A. varium</i></p> <p>- Pedicellariae of the massive type with broad valves absent. (Great Barrier Reef) <i>A. intermedium</i></p> | |

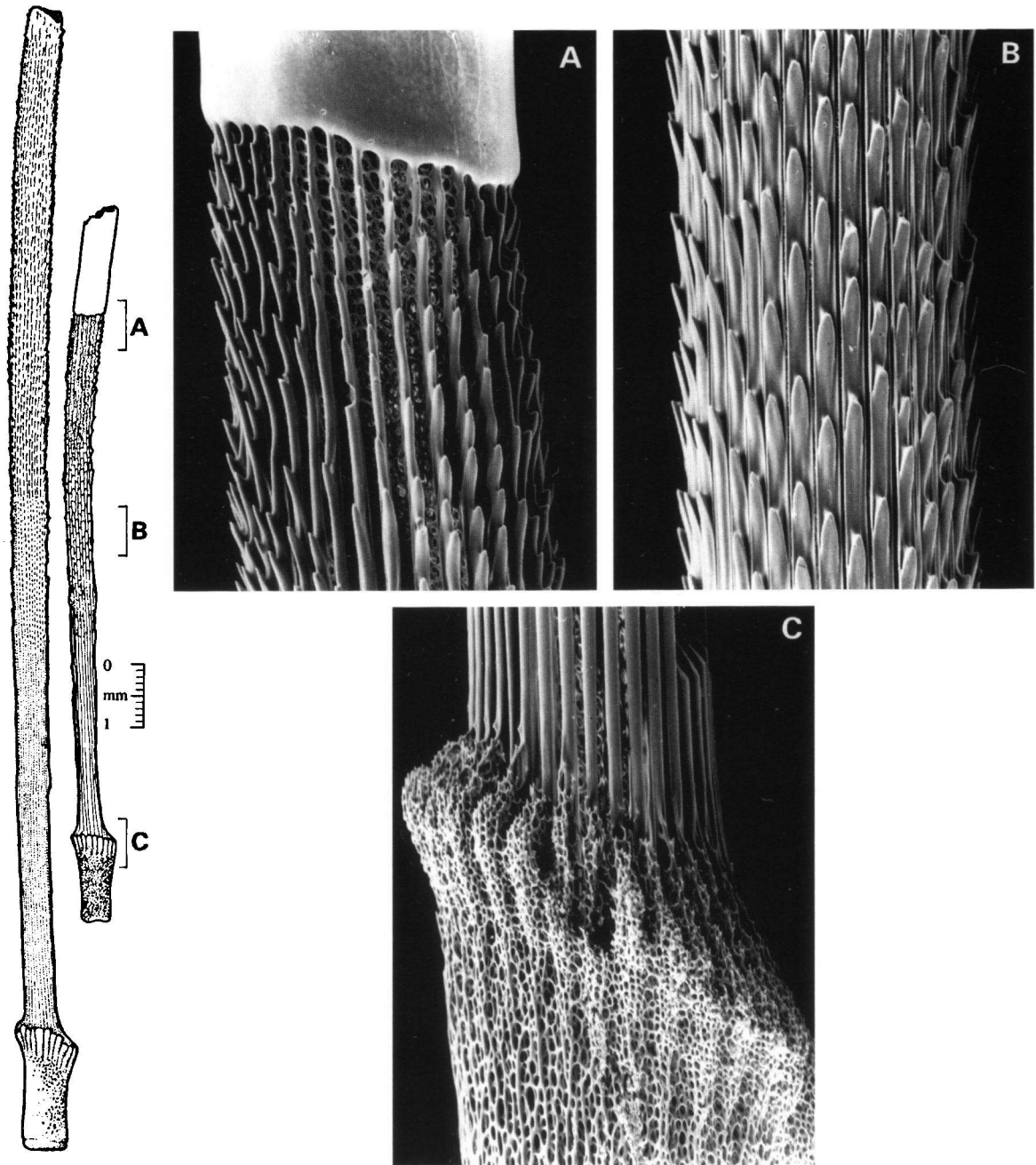


Fig. 4. Primary "hoof" spines of *A. marisrubri* n.sp. SEM pictures A-C correspond to the zones shown in the drawing of whole spines.

DISTINCTIVE FEATURES OF *ASTHENOSOMA VARIUM* GRUBE 1868 AND *ASTHENOSOMA MARISRUBRI* N.SP.

The original description of *Asthenosoma varium* by Grube (1868) was based on a single specimen deposited in the Natural History Museum of the

University of Breslau. During the turmoil of World War II and the siege of the fortress of Breslau by the Soviet Army, German soldiers took up positions in the museum and in order to assure freedom of movement, several collections were thrown out of the windows in the yard. Subsequently, one wing of the museum building

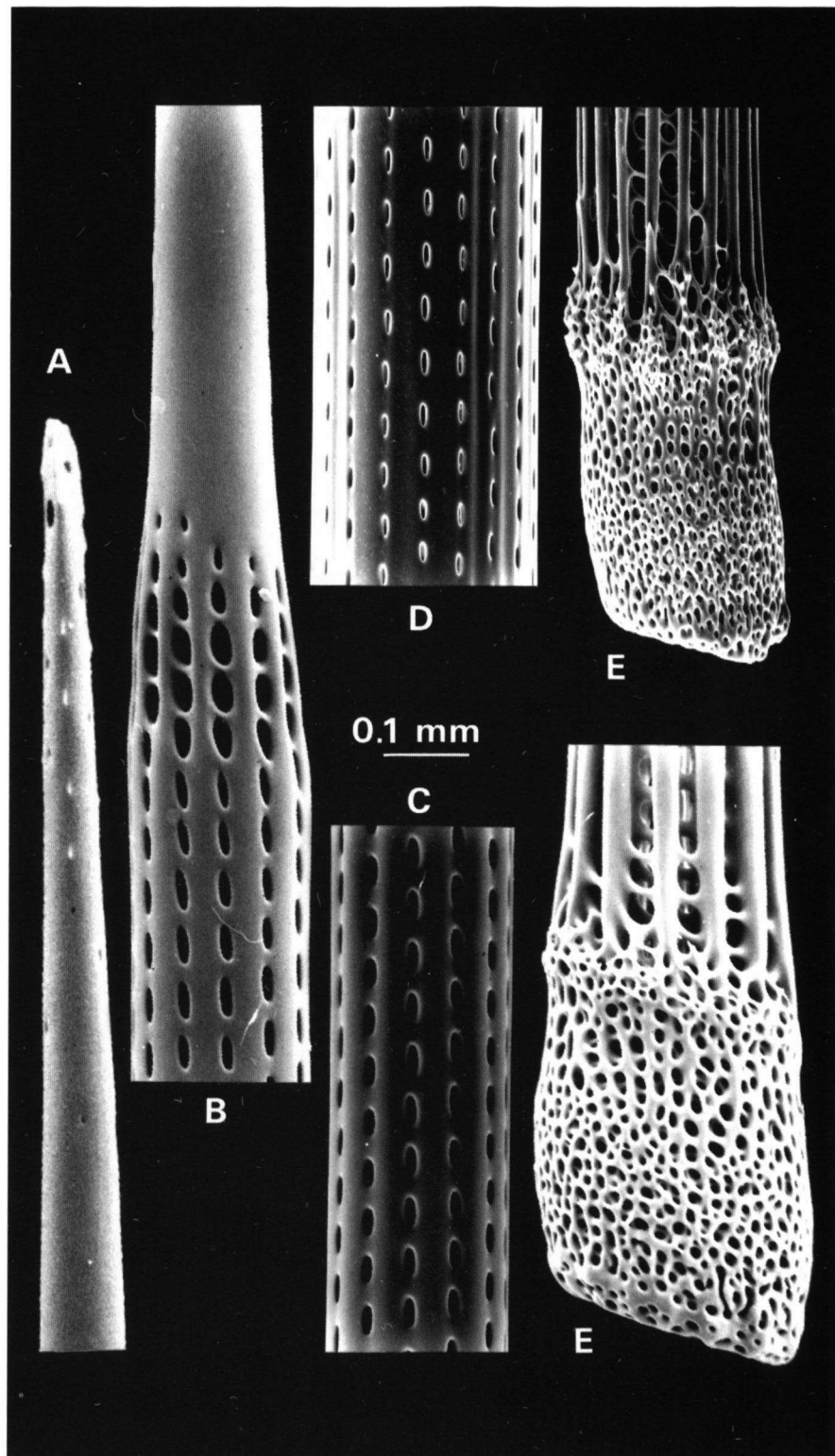
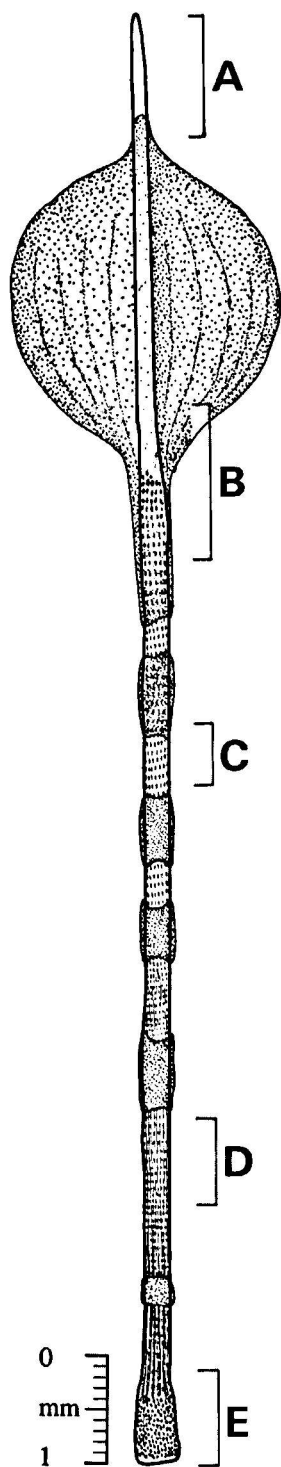


Fig. 5. Secondary spines of *A. marisrubri* n.sp. These spines are invested in a narrow epidermal bag that is only very conspicuous apically where it forms a spherical swelling. SEM pictures A-E correspond to the zones shown in the drawing of whole spine.

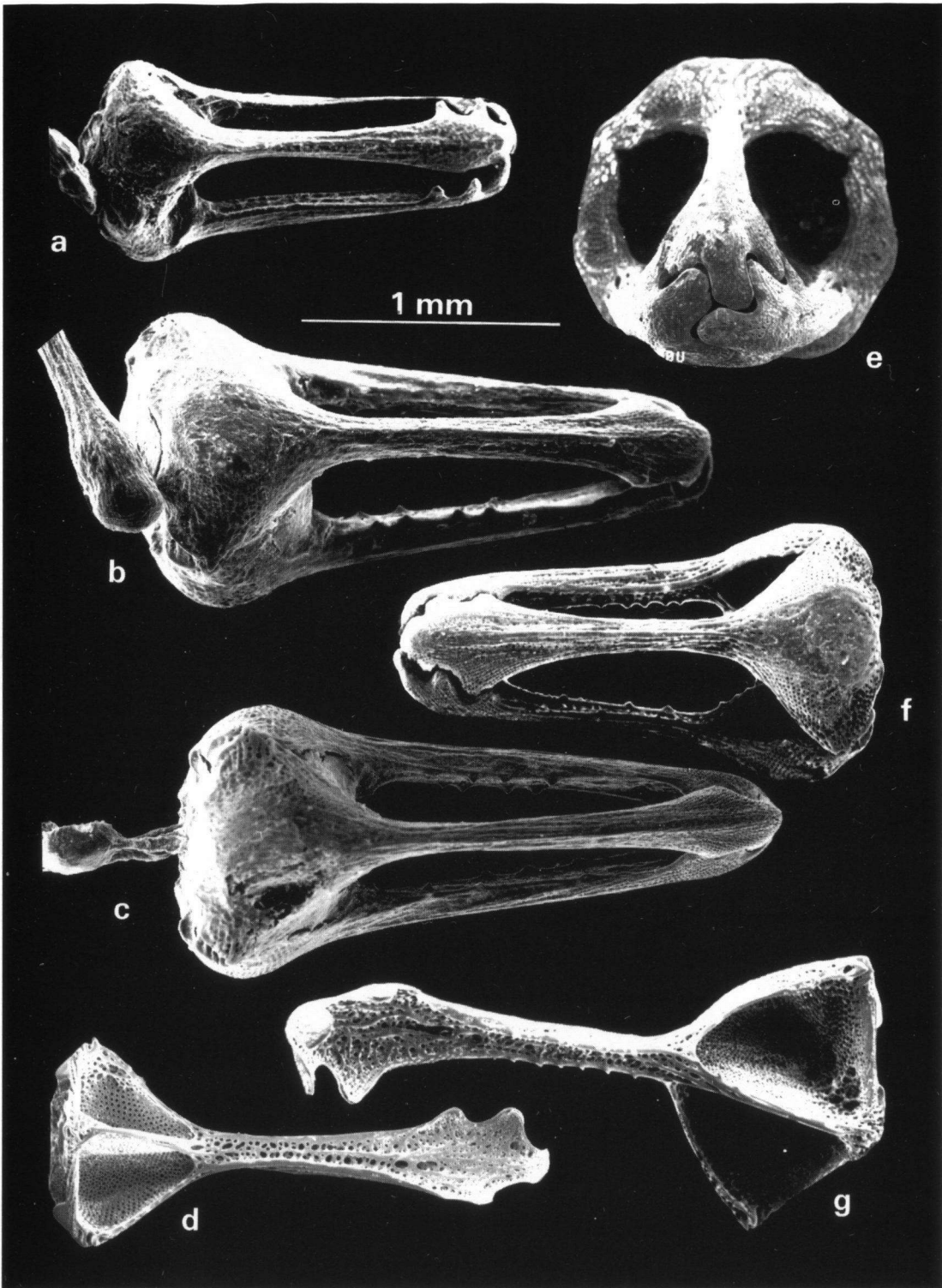


Fig. 6. *A. marisrubri* n.sp., SEM views of type 1 tridactylous pedicellariae; a, b, c, f : the three-jaws head (lateral views); e : apex of the head; d, g : inner face of a valve (frontal view).

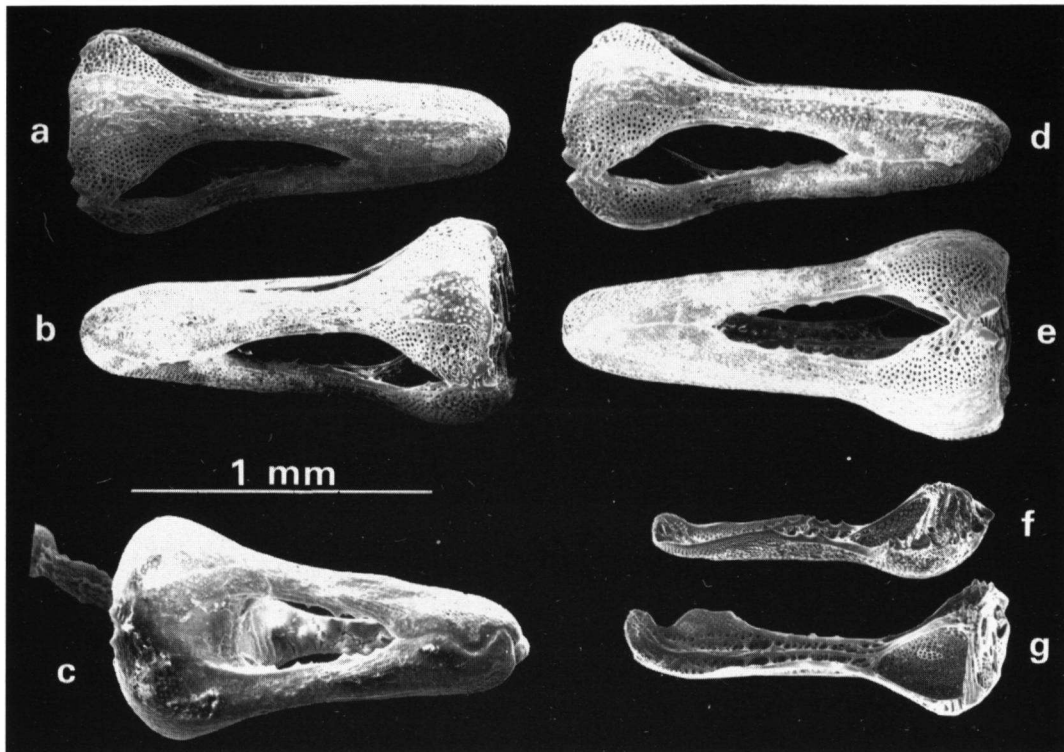


Fig. 7. *A. marisrubri* n.sp., SEM views of type 2 tridactylous pedicellariae; a, b, c, d, e : the three-jaws head (lateral views); f, g : inner face of a valve (lateral view).

was bombed and when Red Army soldiers finally conquered the city, they took hold of the remaining alcohol collections in the museum, drank out the liquid and threw the vials with the zoological specimens down the staircase, enjoying the smashing of the glassware (Pax, 1949 ; Wiktor, pers. comm.). When the Poles took possession of the city that has been rebaptized Wroclaw since, only about 50% of the collection remained, much of it in a pitiful state. Mrs. Jadwiga Wiktor has spent many years saving what could be saved, and today the remnants of the ancient collections are well preserved and catalogued (Wiktor, 1992). Unfortunately, the type of *Asthenosoma varium* only consists of some spines and pedicellariae; the complete animal seems to be lost forever. We therefore examined also the specimens that were described shortly after Grube's, by Ludwig (1880) and de Loriol (1893, 1895).

Detailed descriptions of *A. varium* were performed by Mortensen (1935) and by previous authors as Ludwig (1880), Agassiz (1881), de Loriol (1893) and Doederlein (1902). The follow-

ing features allow to distinguish *A. varium* from *A. marisrubri* n.sp. They are schematically summarized in Fig.8.

ABORAL SPINES

In *A. varium*, the aboral predominant spines (in size and number) are invested by a thick skin-sheath which is more or less distinctly annularly constricted and banded with dark and light colors; These spines are distributed according a patchy pattern: they form rectangular patches that are meridionally in line and particularly conspicuous in the interambulacra; the patches of spines are well separated from each other by naked areas (Figs. 1A and 1C). Small spines with a small apical swelling (presumably a poison gland) only occur along the rim of the patches, thus along the naked areas.

In *A. marisrubri*, the aboral predominant spines (in size and number) are invested in a thin epidermal bag with a very conspicuous apical swelling forming a sphere (most presumably a

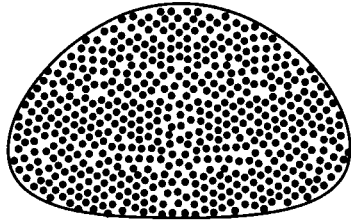
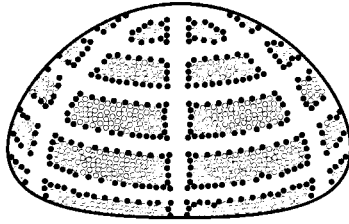
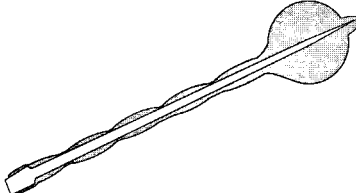

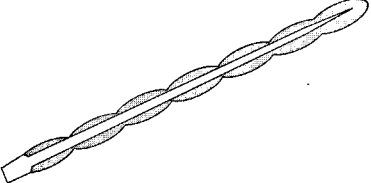
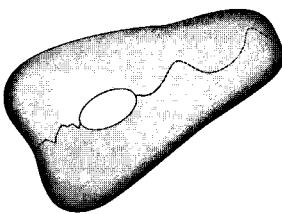
	<i>Asthenosoma marisrubri</i>	<i>Asthenosoma varium</i>
DISTRIBUTION OF THE ABORAL SPINES	 regular	 rectangular patches separated by naked areas
SPINES WITH A DISTAL SPHERICAL SWELLING (●)	 large size, all over the aboral surface	 small size, confined to the margins of the naked areas
SPINES INVESTED IN A THICK SKIN BAG (○)	lacking	 large size, grouped in rectangular patches separated by naked areas
MASSIVE TRIDACTYLOUS PEDICELLARIAE (TYPE 3)	lacking	 present

Fig. 8. Comparison of the main features distinguishing *A. marisrubri* n.sp. from *A. varium*.

poison gland). They form a regular canopy typically characterized by the spherical apex of the spines (Figs. 1B, 1D and 5).

PEDICELLARIAE

In *A. varium*, three types of tridactylous pedicellariae occur. They correspond to the types 1 and 2 also observed in *A. marisrubri* (see the above description), i.e. a large form, with long narrow

valves that join only in their distal part -the edge forming there five coarse teeth- (type 1) (Figs. 9A and 10), and a small form with relatively broad and flat valves that join distally and along 2/3 to 1/3 of their length (type 2) (Fig.10). The third type (type 3), present in *A. varium* only, corresponds to a relatively large plump form with massive valves that are joined on more than half of their length (Figs. 9B and 11).

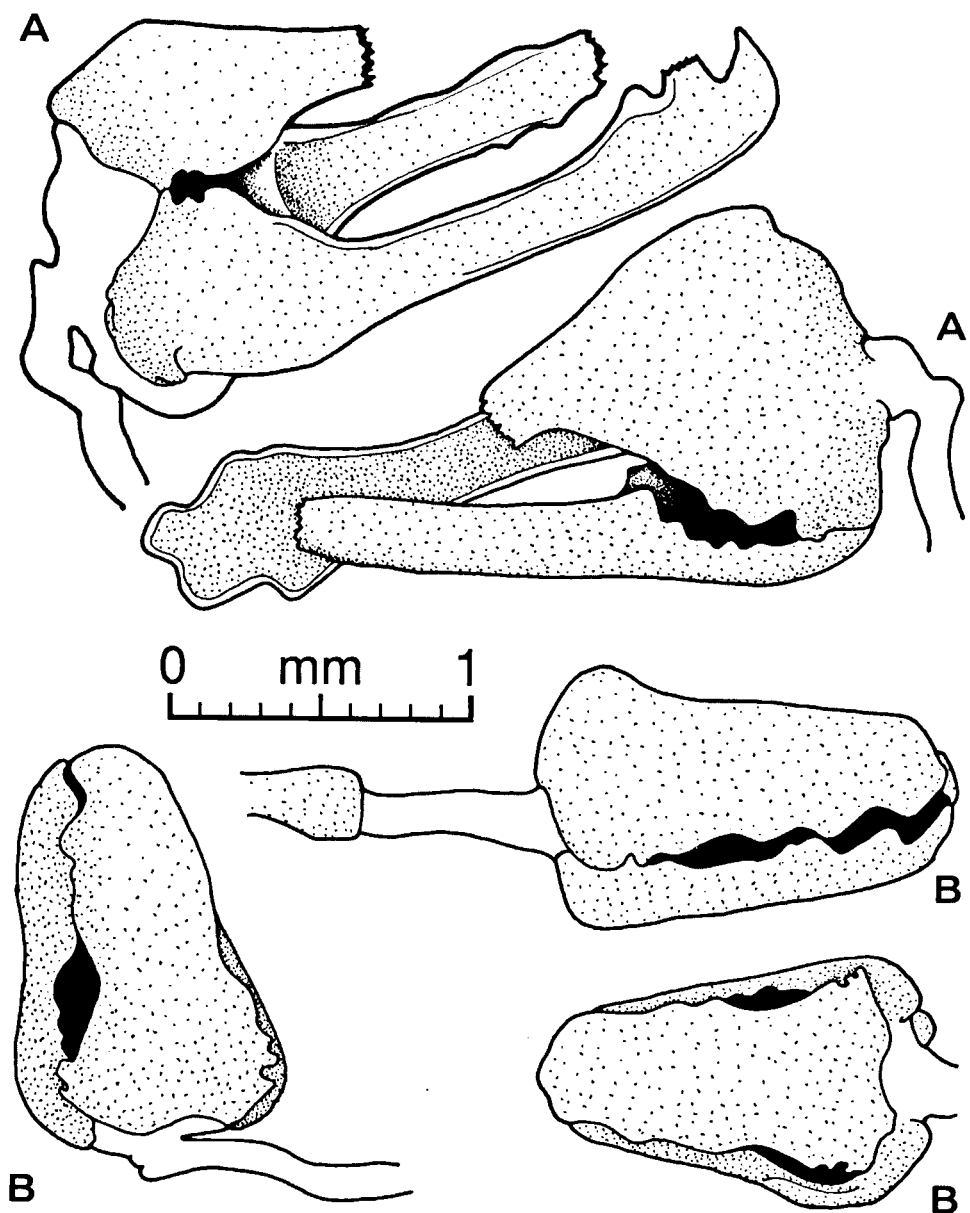


Fig. 9. *A. varium*, drawing of the tridactylous pedicellariae of the type specimen (MNHW: 487). Type 1 (A) and type 3 (B) pedicellariae are illustrated.

The size of type 1 pedicellariae slightly differs in the two species: the length ranges from 2200 μm to 3200 μm (average \approx 2440 μm) in *A. varium* and from 825 μm to 3875 μm (average \approx 2075 μm) in *A. marisrubri*. This is illustrated in Fig. 12.

PRIMARY SPINES (PRIMARIES)

Primary spines (Figs. 3B and 4) are slightly

curved (on the oral side) or straight (at the ambitus) with a cylindrical hollowed shaft ending in a distal hoof. This hoof is not enlarged and is even sometimes narrower than the shaft in *A. marisrubri*, whereas it is funnel-shaped in *A. varium*.

GEOGRAPHICAL DISTRIBUTION

According to existing literature and our own

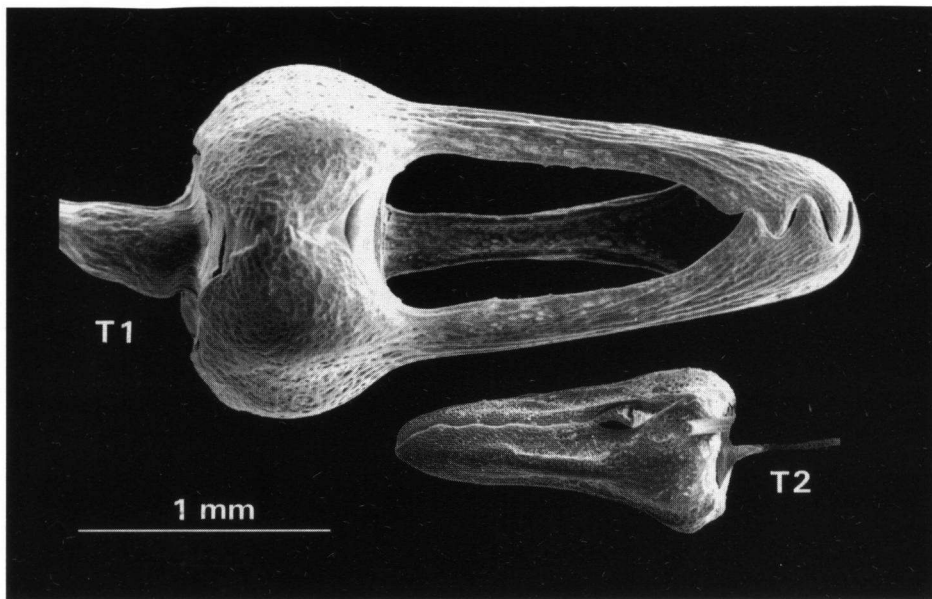


Fig. 10. *A. varium*, SEM views of the head of type 1 (T1) and type 2 (T2) tridactylous pedicellariae.

observations, specimens belonging to the genus *Asthenosoma* have been found in the following locations: northern Red Sea, Maldives, Sri Lanka, Mergui Archipelago (Burma), Singapore, East Sumatra, Java Sea, Sulawesi, Sumbawa, Aru Islands, Ambon, Banda, Jolo, Philippines, Palau, Seaforth Island (Great Barrier Reef, Queensland), New Caledonia, Izu Marine Park, Sagami Bay (Japan), Hawaii (Fig. 13). Recent popular publications such as field guides for divers and books on the underwater world illustrated by underwater pictures reveal that *A. marisrubri* is a common (probably endemic) species in the northern Red Sea, but has so far never been encountered in the Indian or Pacific oceans. Conversely, whereas *A. varium* has been documented several times recently from the Philippines, Indonesia, Micronesia, Japan, Australia and New Caledonia, not one single recent record has reached us from either the Seychelles or the Maldives. *A. varium* must therefore be considered to be a Pacific species, which hardly penetrates into the Indian Ocean. This suggests that both species are well separated and that no geographical overlap occurs.

DISCUSSION

It seems well established that there are two distinct distributions for the the presently studied *Asthenosoma*: *A. marisrubri* n.sp. being centered in the northern Red Sea and *A. varium* Grube 1868 around the western part of the tropical Pacific (Philippines and Indonesia). It would be interesting to gather more data on the geographical distribution of both species: does the population of *A. marisrubri* extend into the southern part of the Red Sea and beyond (southern Arabia, Seychelles, Maldives)? On the other hand, it is still unclear how far *A. varium* extends into the Indian Ocean. Sarasin & Sarasin (1888) described *A. urens* from the harbour of Trincomalee in northeastern Sri Lanka; according to their plate X, this was almost certainly *A. varium*, as decided by Mortensen (1935). This is the westernmost reliable record. *A. varium* was mentioned just once (as *A. urens*) from the Maldives by Bell in 1903, as mentioned in Mortensen (1935). We are sceptical about this record, however, since to our knowledge, in spite of many thousands of underwater pictures being taken in the Maldives during the past two or three decades, not even once has this sea urchin been recorded again in these waters.

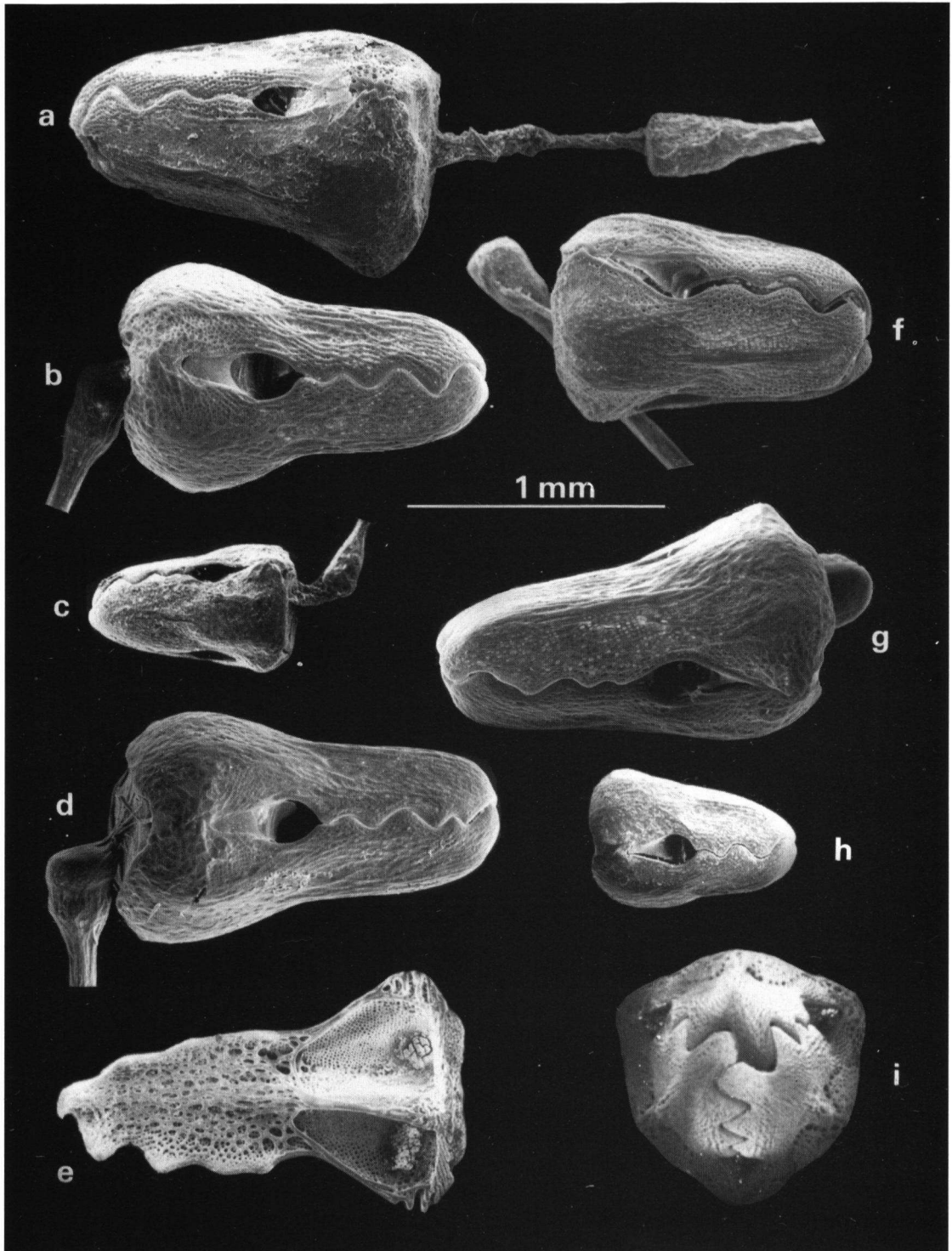


Fig. 11. *A. varium*, SEM views of type 3 tridactylous pedicellariae; a, b, c, d, f, g, h : head of the pedicellaria (lateral views); e : inner face of a valve; i : apex of the head of the pedicellaria.

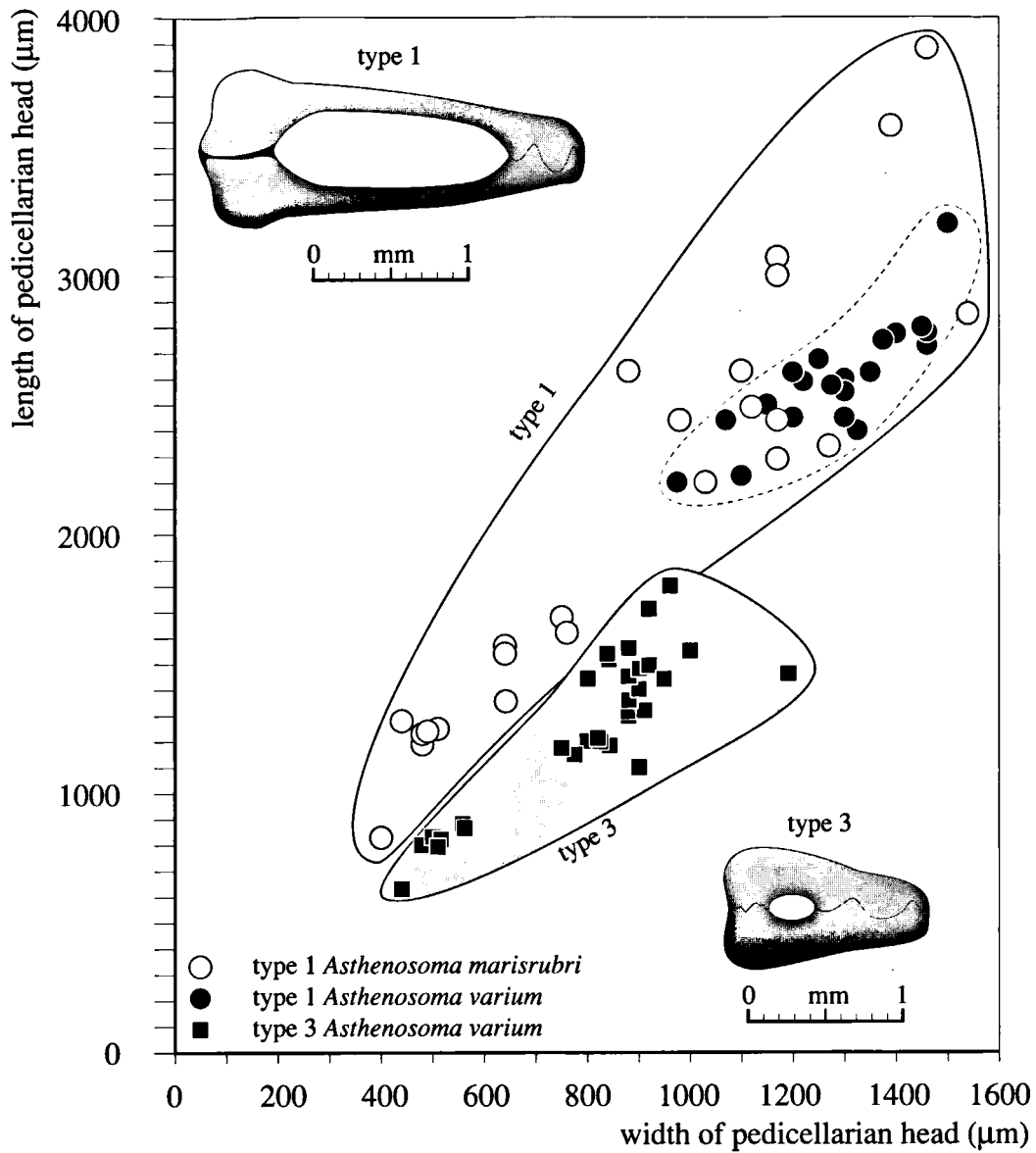


Fig. 12. Size comparison of type 1 and type 3 tridactylous pedicellariae. Type 1 pedicellariae originated from *A. varium* and *A. marisrubri* n.sp., type 3 pedicellariae from *A. varium*.

As mentioned above, we do not feel very comfortable about the status of the species *Asthenosoma yimai* Yoshiwara 1897, *Asthenosoma dilatatum* Mortensen 1935 and *Asthenosoma intermedium* H.L. Clark 1938, which might well turn out to be junior synonyms of *Asthenosoma varium* Grube 1868. In order to test this assumption, however, more material from different localities and of comparable sizes is needed. We hope to be able to carry out this comparison in the future.

ACKNOWLEDGEMENTS

The following persons are acknowledged for collecting specimens of *Asthenosoma marisrubri* in the Red Sea: Paul Kieffer & Romain Duprel (Luxembourg), Rita Ghalayini (Amman, Jordan), John Neuschwander (Eindhoven, The Netherlands). The latter is also acknowledged for supplying an underwater picture of *Asthenosoma marisrubri* (Fig. 1b). Léo and Michel Barkate (Strasbourg, France) filmed and observed speci-

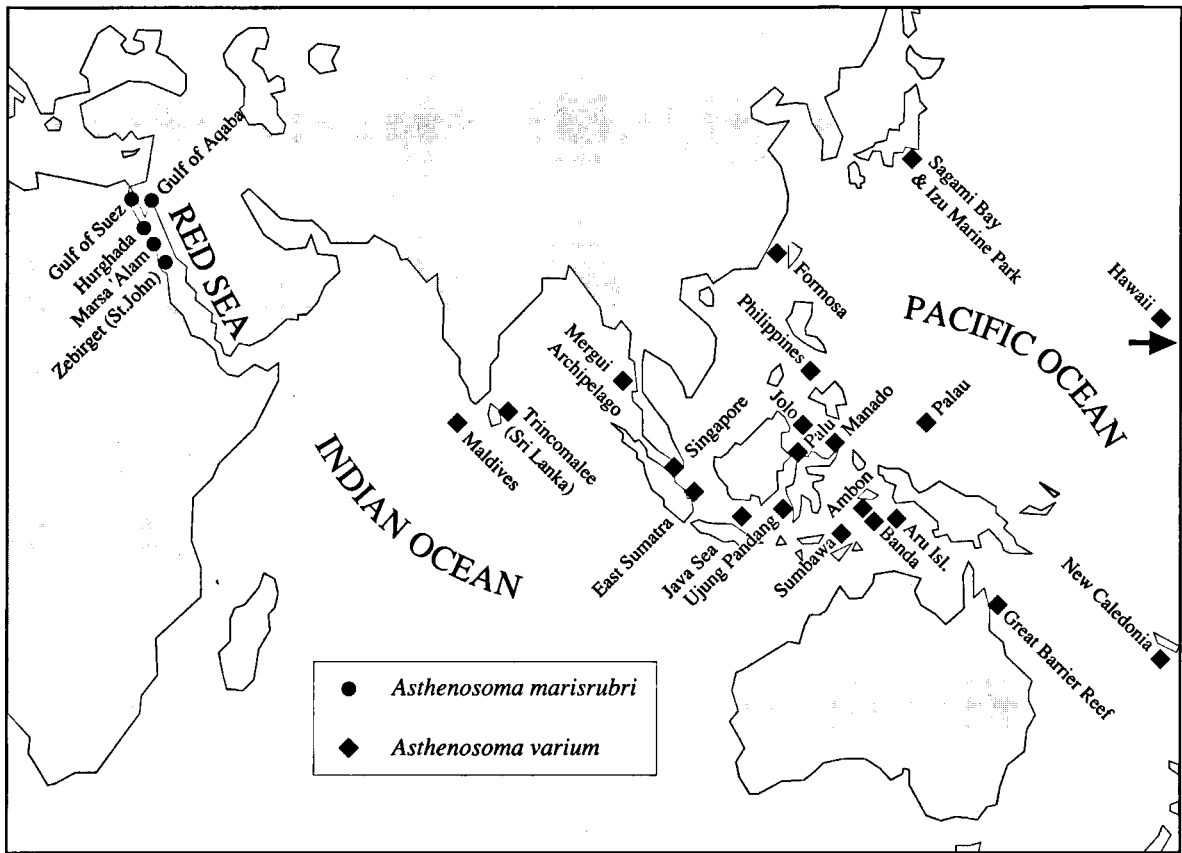


Fig.13. Presently known geographical distribution areas of *A.varium* Grube, 1868 and *A. marisrubri* n.sp.

mens of *A. marisrubri* in the northern Red Sea as far south as the St. John's islands, so far the southernmost record of the species. Dr. Bert Hoeksema collected a specimen of *A. varium* from Sulawesi (Indonesia) that enabled us to have recent material for comparison. In his search for Grube's (almost) lost type of *Asthenosoma varium*, the senior author received the help, the hospitality and the kindness of the following persons from the Wladyslaw Rydzewski Museum of Natural History, Wroclaw University (Wroclaw, Poland): Dr. Beata Pokryszko, Mrs. Jadwiga Wiktor and Miss Renata Brasinska. The following persons are acknowledged for kindly sending us material on loan: Dr. Nadia Améziiane-Cominardi (Muséum National d'Histoire Naturelle, Paris, France), Dr. Yehuda Benayahu and Mr. Alex Schlagman (Dept.of Zoology, Tel Aviv University, Israel), Dr. Nechama Ben Eliahu (Zoological Museum, Hebrew University of Jerusalem, Israel), Dr. Maya Best (Nationaal Natuurhistorisch Museum, Leiden, The Netherlands), Mrs.

Joke Bleeker (Zoölogisch Museum, Universiteit van Amsterdam, The Netherlands), Dr. Hilke Ruhberg (Zoologisches Museum der Universität Hamburg, Germany), Dr. Claude Vaucher (Muséum d'Histoire Naturelle, Genève, Switzerland). Special thanks are extended to Dr. Stefan Zlot and Mrs. Alexandra Breukink for carefully conveying the Geneva specimens. The senior author also wishes to thank Mr. Dirk Platvoet and Mr. Jan Vermeulen from the Zoölogisch Museum of Amsterdam for enabling him to make use of their institution's scanning electron microscope. Contribution of the CIBIM.

REFERENCES

- AGASSIZ, A., 1873. Revision of the echini. III. In: Illustrated catalogue of the Museum of Comparative Zoology n° 7. Harvard Univ. Press, Cambridge: 381-629
- AGASSIZ, A., 1881. Report on the Echinoidea dredged by H.M.S. Challenger during the years 1873-1876. Rep. sci. Res. Voy. H.M.S. Challenger, Zool., **3** (9): 1-321.

- AGASSIZ, A. & H.L. CLARK, 1909. Hawaiian and other Pacific echini. The Echinothuriidae. Mem. Mus. Comp. Zool. Harvard, **34** (3): 137-204.
- ATIYA, F.S., 1994. The Red Sea in Egypt. Part II. Invertebrates. Atiya publ., 6th of October City (Egypt): 297 pp.
- BAUMEISTER, W., 1993. Farbatlas Meeresfauna. Rotes Meer, Indischer Ozean (Malediven). Niedere Tiere. Ullmer Verlag, Stuttgart (Germany) : 320 pp.
- BELL, F.J., 1903. The actinogonidiate echinoderms of the Maldive and Laccadive islands. In: J.S. Gardiner ed.: Fauna and Flora of the Maldive and Laccadive Archipelagoes, **1** (3): 223-233.
- CLARK, A.M., 1966. Echinoderms from the Red Sea. Part 2. Crinoids, Ophiuroids, Echinoids and more Asteroids. Sea Fish.Res.Stat.Haifa, (B), **41**: 26-58.
- CLARK, A.M. & F.W.E. ROWE, 1971. Monograph of shallow-water Indo-West Pacific Echinoderms. Trustees of the British Museum (Natural History) London (Great Britain): 238 pp.
- CLARK, H.L., 1925. A catalogue of the recent sea-urchins in the collection of the British Museum (Nat. Hist.), London: 250 pp.
- CLARK, H.L., 1938. Echinoderms from Australia. An account of collections made in 1929 and 1932. Mem. Mus. comp. Zool. Harvard College, **55** (I-VIII): 1-596.
- COLIN, P.L. & C. ARNESON, 1995. Tropical Pacific Invertebrates. Coral Reef Press Publications, Beverley Hills (USA): viii + 296 pp.
- DAROM (MASRY), D., 1976. The Red Sea. Sadan Publishing House, Tel-Aviv (Israel) : 105 pp.
- DE RIDDER, C., 1986. Les échinidés. In : Guille, A., P. Laboute & J.-L. Menou, eds.: Guide des étoiles de mer, oursins et autres échinodermes du lagon de Nouvelle Calédonie. Éditions de l'ORSTOM. Coll. Faune tropicale, **25**: 15-53.
- DE WILDE, S. & Y. PACCALET, 1990. Secrets de corail. Éditions Atlas, Paris (France): 110 pp.
- DÖDERLEIN, L., 1902. Bericht über die von Herrn Professor Semon bei Amboina und Thursday Island gesammelten Echinoidea. Jena. Denkschrift., **8** : 43-84 (685-726).
- DÖDERLEIN, L., 1911. Über Echinoidea von den Aru-Inseln. Abh. Senckenberg. Naturf. Ges., **34**: 243.
- DOLLFUS, R.-P. & J. ROMAN, 1981. Les échinides de la mer Rouge. Comité des Travaux historiques et scientifiques, Ministère des Universités, Bibliothèque Nationale, Paris (France): 145 pp.
- FELL, B.H., 1966. Diadematacea. In: J. Wyatt Durham et al., eds.: Treatise on invertebrate paleontology, part U. Echinodermata, **3**: 340-366.
- FISHIELSON, L., ed., 1991. Plants and animals of the land of Israel. Vol.4. Aquatic life. (in Hebrew). Ministry of Defense/The publishing House, Society for Protection of Nature, Israel: 342 pp.
- GEORGE, J.D. & J.J. GEORGE, 1979. Marine Life. An illustrated encyclopedia of Invertebrates in the sea. Harrap, London (Great Britain): 288 pp.
- GRUBE, A.E., 1868. Über *Asthenosoma varium* n.sp. und einige andere Seeigel des Breslauer Zoologischen Museums. Jber. schl. Ges. vaterl. Cult., Breslau, **45** (1867): 42-44.
- LORIOU, P. DE, 1893. Échinodermes de la Baie d'Amboine. Rev. Suisse Zool., **1**: 364-367.
- LORIOU, P. DE, 1895. Supplément aux Échinodermes de la Baie d'Amboine. Rev. Suisse Zool., **3** (3): 365-366.
- LUDWIG, H., 1880. Über *Asthenosoma varium* Grube und über ein neues Organ bei den Cidariden. Z. wiss. Zool., **34**: 70-86
- MORTENSEN, T., 1935. A Monograph of the Echinoidea. Vol. II. C.A.Reitzel publ., Copenhagen (Denmark): 647 pp.
- PAX, F., 1949. Erinnerungen an die Wanderjahre eines Schlesiers. Koleopterol. Zeitschr., **1** (1): 53-66.
- PITKIN, L., 1995. The living Sea - A photographic exploration of life in the sea. Fountain Press, Kingston-upon-Thames (Great Britain): 192 pp.
- SARASIN, P. & F. SARASIN, 1888. Ueber die Anatomie der Echinothuriden und die Phylogenie der Echinodermen. Ergebnisse naturwissenschaftlicher Forschungen auf Ceylon, I. C.W.Kreidel's Verlag (Wiesbaden): 83-154.
- SCHMID, P. & D. PASCHKE (1987). Underwaterguide Red Sea : Invertebrates. Verlag Stephanie Naglschmid, Stuttgart (Germany): 167 pp.
- TORTONESE, E., 1977. Report on the Echinoderms from the Gulf of Aqaba (Red Sea). Monitore zool. Ital., (Suppl.) **9** (12): 273-290.
- VINE, P., 1986. Red Sea Invertebrates. Immel Publishing, London (Great Britain): 224 pp.
- WEINBERG, S., 1996. Découvrir la Mer Rouge et l'océan Indien. Éditions Nathan, Paris (France): 415 pp.
- WIKTOR, J., 1992. Type specimens of invertebrates (excluding insects) in the Wladyslaw Rydzewski Museum of Natural History Wroclaw University. Acta Universitatis Wratislaviensis, **1124** (Prace Zoologiczne 23): 137-155.

Received: december 18, 1997