The southern African stichopodid holothurians, with notes on the changes in spicule composition with age in the endemic *Neostichopus grammatus* (H.L. Clark)

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Four species of stichopodid holothurians, namely the Indo-West Pacific *Stichopus chloronotus* Brandt, *S. variegatus* Semper, *Thelenota anax* H.L. Clark and the endemic *Neostichopus grammatus* (H.L. Clark) occur in the southern African shallow waters (south of 20°S latitude). Besides *T. anax*, which is not present in the material studied, notes are provided on the remaining three species, of which *S. variegatus* is here recorded from this region for the first time. The changes with age in the composition of the body wall spicules of *N. grammatus* are described and it is indicated that the characteristic dumb-bell-shaped deposits of the dorsal papillae, consistent in both juveniles and adults, offer a reliable and easily accessible morphological character in preserved specimens. A key to all four species is provided and their geographic distributions are mapped.

Vier spesies van die stichopodiede Holothuroidea, naamlik, die Indo-Wes Pasifiese *Stichopus chloronotus* Brandt, *S. variegatus* Semper, *Thelenota anax* H.L. Clark en die endemiese *Neostichopus grammatus* (H.L. Clark) kom in die Suider-Afrikaanse vlakwaters voor (suid van 20°S breedtegraad). Behalwe *T. anax* wat nie in die studiemateriaal teenwoordig was nie, word aantekeninge oor die drie oorblywende spesies verskaf. *S. variegatus* word vir die eerste keer in hierdie gebied aangeteken. Die veranderinge wat met veroudering in die samestelling van die spikules in die liggaamswand van *N. grammatus* intree, word bespreek. Daar word ook aangetoon dat die kenmerkende handgewig-vormige afsettings van die dorsale papillae, wat in beide onvolwasse en volwasse diere voorkom, 'n betroubare en maklik waarneembare morfologiese kenmerk in gepreserveerde eksemplare is. Sleutels, sowel as die geografiese verspreiding, word vir al vier spesies gegee.

Introduction

The family Stichopodidae comprises a group of fairly large aspidochirotid holothurians found in practically all tropical-temperate regions of the world, normally occurring in shallow waters in the same habitat as members of the large cosmopolitan genus *Holothuria*. Pawson (1982) recorded six genera in the family but regrettably his list omitted the southern African monotypic genus *Neostichopus* erected by Deichmann as early as 1948. Pawson further considered *Microthele* Brandt as a genus of the family Stichopodidae. In this paper, however, the classification of Rowe (1969) and Clark & Rowe (1971) is followed and *Microthele* is considered a subgenus of *Holothuria*. In any case the record by James & Pearse (1969) of the occurrence in Natal of *Holothuria (Microthele) nobilis* Selenka is dubious. In fact neither Pearson (1910) nor Kalk (1958, 1959) or Macnae & Kalk (1958) record the species from Mozambique. Four stichopodid holothurians are here recorded from southern Africa and additional information is provided on three of the species. Further, a key to all the species is included and their geographic distributions are mapped.

Material

Material for this investigation was obtained on loan from the University of Cape Town (UCT) and the South African Museum (SAM) or procured through several collection trips undertaken by the author or the staff of the Zoology Department of the University of Durban-Westville (UDW).

Methods

The material was studied according to conventional methods outlined by other writers, notably Deichmann (1948) and Rowe & Doty (1977). The spicules were removed with antiformin (see Mahoney 1966) and illustrated with the aid of a camera lucida. For scanning electron micrography, the spicules were washed in two changes of distilled water, passed through two changes of absolute alcohol and transferred together with a little alcohol to a specimen stub, to which they normally stick once the alcohol evaporates. They were then coated and photographed.

Previous records of the species and of the material here examined are expressed in terms of latitude/longitude degree squares. The following symbols denote provinces and depth records. C = Cape Province, M = Mozambique, N = Natal, T = Transkei, i = intertidal, s = shallow (0 – 100 m).

Family Stichopodidae Haeckel

Diagnosis: Generally large holothurians with gonad in two tufts, papillae situated on prominent warts, and body wall spicules usually in the form of tables, either persistent throughout life, accompanied by C-shaped spicules and/or rosettes, or lost early in development to be replaced by minute perforated plates and asymmetrical rods; some species with spicules exclusively in the form of dichotomously branched spiny rods and round to oval miliary granules.

Remarks: Currently about 36 species are classified in this family, of which approximately 20 belong in the genus *Stichopus*. In southern Africa (south of 20°S latitude) four species are known to occur, namely, the endemic *Neostichopus grammatus* (H.L. Clark, 1923) and the Indo-West Pacific *Thelenota anax* H.L. Clark, 1921,

Stichopus chloronotus Brandt, 1835 and *S. variegatus* Semper, 1868.

Genus *Stichopus* Brandt, 1835

Diagnosis: Large stichopodid holothurians, quadrangular in cross section, with thickened lateral flanks; pedicels crowded or in three longitudinal series; papillae situated on large wart-like prominences, either in rows or scattered. Body wall spicules include well-formed tables, usually accompanied by C or S-shaped spicules and/or delicate rosettes.

Type species: *Stichopus (Perideris) chloronotos* Brandt, 1835 (by subsequent designation H.L. Clark, 1922:44).

Remarks: The two southern African species of this genus are well known Indo-West Pacific forms, long known from Mozambique. *S. chloronotus* has not yet been found further south than Inhaca Island while *S. variegatus* is here recorded for the first time from south of 20°S latitude.

Genus *Thelenota* Brandt, 1835

Diagnosis: Large stichopodid holothurians with a single, long, branched polian vesicle; body wall spicules as dichotomously branched, slender rods and minute miliary granules.

Type species: *Trepang ananas* Jaeger, 1833 (by subsequent designation H.L. Clark, 1922:48).

Remarks: The genus *Thelenota* includes only two species, *T. ananas* and *T. anax,* both from the Indo-West Pacific region and distinguished from each other by the colouration and the form of the dorsal papillae. Of the two species only *T. anax* has been recorded from the southern African region.

Genus *Neostichopus* Deichmann, 1948

Diagnosis: See amended species diagnosis.

Type species: *Holothuria grammata* H.L. Clark, 1923 (by original designation Deichmann, 1948:335).

Remarks: This is a monotypic genus represented only by the endemic southern African *N. grammatus* (H.L. Clark).

Key to the southern African species of the family Stichopodidae

1. Spicules of body wall exclusively minute, round to oval miliary granules and dichotomously branched (cross-shaped) spiny rods; tables or minute perforated plates never present..... *Thelenota anax* H.L. Clark.

   Spicules of body wall comprising tables, sometimes severely reduced with age, and C-shaped bodies, rosettes or minute perforated plates and rods; spiny rods and granules absent..... 2

2. Well-developed tables present only in juveniles (< 40 mm long), severely reduced and absent in larger specimens; minute perforated plates replace tables, but become progressively modified with age to form rods, ellipses, spectacles, etc. C-shaped bodies and rosettes absent .... *Neostichopus grammatus* (H.L. Clark).

   Tables well formed, retained throughout life, accompanied by C-shaped bodies and often by rosettes..... genus *Stichopus* 3

3. Tables with somewhat squarish discs (0,025–0,040 mm), usually pierced by four large central and four smaller marginal holes; C-shaped bodies minute (0,025–0,050 mm); rosettes rare or absent; colour in life deep green with papillae tipped with rust or red.... ..... *Stichopus chloronotus* Brandt.

   Tables of moderate size with more or less rounded discs (0,025–0,055 mm) pierced by four large central and numerous (up to 15) smaller marginal holes; C-shaped deposits large (0,06–0,21 mm); rosettes numerous; colour variable, usually a variegated brown to yellowish brown with orange to red-tipped papillae ..... *Stichopus variegatus* Semper.

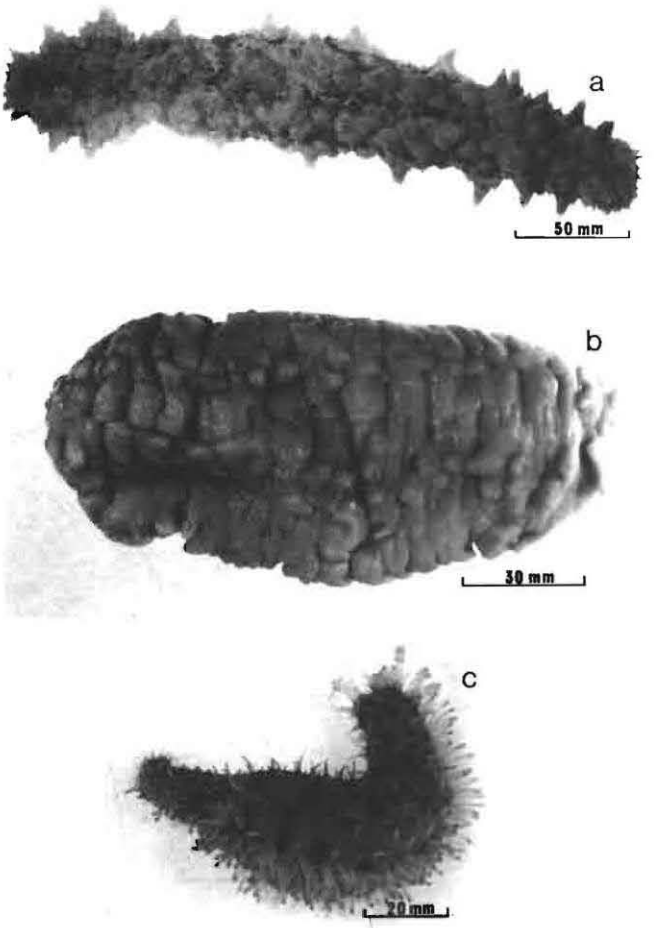

Figure 1 Southern African stichopodid holothurians: (a) *Stichopus variegatus* Semper; (b) *S. chloronotus* Brandt; (c) *Neostichopus grammatus* (H.L. Clark).

Stichopus chloronotus Brandt
(Figures 1b, 2 and 7d–f)

Stichopus (Perideris) chloronotos Brandt, 1835:50.
Stichopus chloronotus Selenka, 1867:315, pl.17, figs. 20–24, pl.18, fig.25; Théel, 1886:159, pl.7, fig.6; Pearson, 1910:172; H.L. Clark, 1922:53, pl.2, figs. 1–10 (refs.); 1923:425; Kalk, 1958:216, 238; 1959:6, 22; Macnae and Kalk, 1958:107, 119, 130; Clark and Rowe, 1971:178 (dist.), pl.27, fig.18; Branch and Branch, 1981:246, 248.
Stichopus cylindricus Haacke, 1880:47.
Stichopus chloronotus* var. *fuscus Pearson, 1903:204.

Diagnosis: Length up to 300 mm when alive; colour in life deep green with reddish to rust-coloured tips to papillae; body wall tables squarish with four large and four small holes; C-shaped deposits small; rosettes rare or more commonly absent.
Type/type locality: Lost/Guam and Lugunor.
Previous southern African records: M(12–15/40/i; 26/32,33/i).
Material examined: M(22/35/i), 3 spec. (UDW).

Description: Largest preserved specimen 112 mm (Figure 1b); colour, in alcohol, greyish white. Anus surrounded by papillae in only one specimen, by naked periproctal membrane in others. Dorsal papillae arise directly from warts arranged in four bands. Table discs (0,025 – 0,040 mm) squarish, with jagged margins (Figure 2b and d). Wart tables (Figure 2g) with discs up to 0,065 mm, spire 0,028–0,042 mm high, terminating in 8–16 teeth. Dorsal tables (Figures 2a and 7d–f) with taller spires. C-shaped spicules (Figures 2c, f and 7d) 0,025–0,050 mm long, larger in the warts.

Local distribution: Known only from Mozambique. Figure 5.
General distribution: Indo-West Pacific but not yet recorded from the Red Sea, Persian Gulf, India and Pakistan.
Habitat: Sand or rock.

Remarks: Regrettably the size and colour of the living specimens were not recorded for it is well known that this species, reported to be over 300 mm in life, contracts drastically and quickly loses its green colouration in alcohol. Although H.L. Clark (1922) and Rowe & Doty (1977) indicate the absence of rosettes in this species, these were confirmed to be present but sparsely distributed in at least one of the present specimens (Figure 2e).

Fisher (1907) also reported their occurrence in his presumably mislabelled specimen (according to H.L. Clark, 1922) from Hawaii and Ludwig (1887) reported their presence in specimens from Sri Lanka. Evidently then, rosettes are either absent or poorly developed in this species.

The present material was collected from Vilanculos, S. Mozambique. Previous records of the species from Mozambique are those of Pearson (1910), H.L. Clark

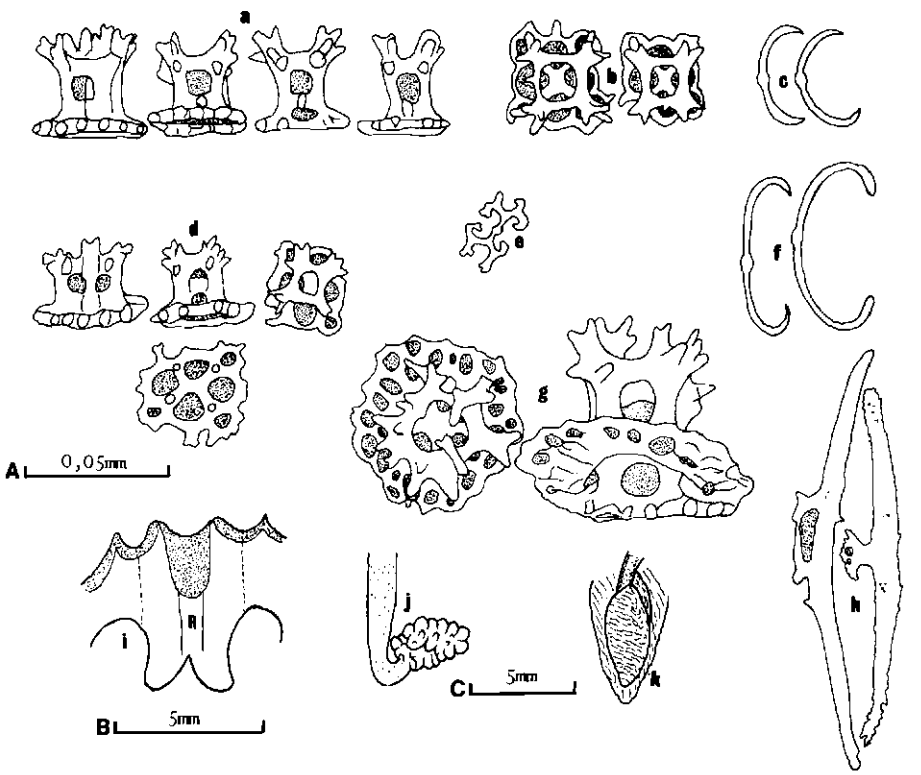

Figure 2 Spicules and other internal structures of *Stichopus chloronotus* Brandt. (a) Tables from dorsal body wall (side view); (b) same (from above); (c) c-shaped spicules from dorsal body wall; (d) tables from ventral body wall; (e) rosette from ventral body wall; (f) large c-shaped spicules from warts; (g) large tables from warts; (h) pedicel rods; (i) part of calcareous ring; (j) polian vesicle (terminal end); (k) madreporite (in dorsal mesentery). R = radial plate. (a–h Scale A; i scale B; j & k scale C)

(1923), Kalk (1958, 1959), Macnae & Kalk (1958) and Branch & Branch (1981).

Stichopus variegatus Semper
(Figures 1a, 3 and 7a–c)

Stichopus variegatus Semper, 1868:73, pls. 16 and 30, fig. 1; Théel, 1886:191; Pearson, 1910:173; H.L. Clark, 1922:67; Clark and Rowe, 1971:178 (dist.), pl.27, fig.2O.
Stichopus naso Haacke, 1880:46.
Stichopus levis Sluiter, 1887:198, pl.1. fig.6.
Stichopus vastus Sluiter, 1887:198, pl.2, figs. 46–48.
Stichopus hirotai Mitsukuri, 1912:161.
?Stichopus oshimae Mitsukuri, 1912:171.

Type/type locality: ?Germany/Phillipine and Navigator Islands.

Diagnosis: Length up to 400 mm when alive; colour in life yellowish brown with bright orange to red tips to papillae; tables of body wall with circular discs, pierced by four large central and numerous small peripheral holes; C-shaped deposits large; rosettes abundant.

Previous southern African record: None.
Material examined: M(22/35/i); N(29/30/i); 7 spec. (UDW).

Description: Largest specimen over 400 mm in life, 210 mm in alcohol (Figure 1a). Live colouration an admixture of dark and light brown, speckled with white. Warts better developed laterally and at both ends. Tables (Figures 3a, b, and 7 a–c) with large discs and small crowns or small discs and large crowns, both types common; disc diameter 0,025–0,055 mm, spire height 0,022–0,040 mm. C- or S-shaped spicules (Figures 3c, e and 7a, b) and rosettes (Figures 3d and 7a–c) few or numerous, the former 0,06–0,21 mm, the latter 0,012–0,035 mm.

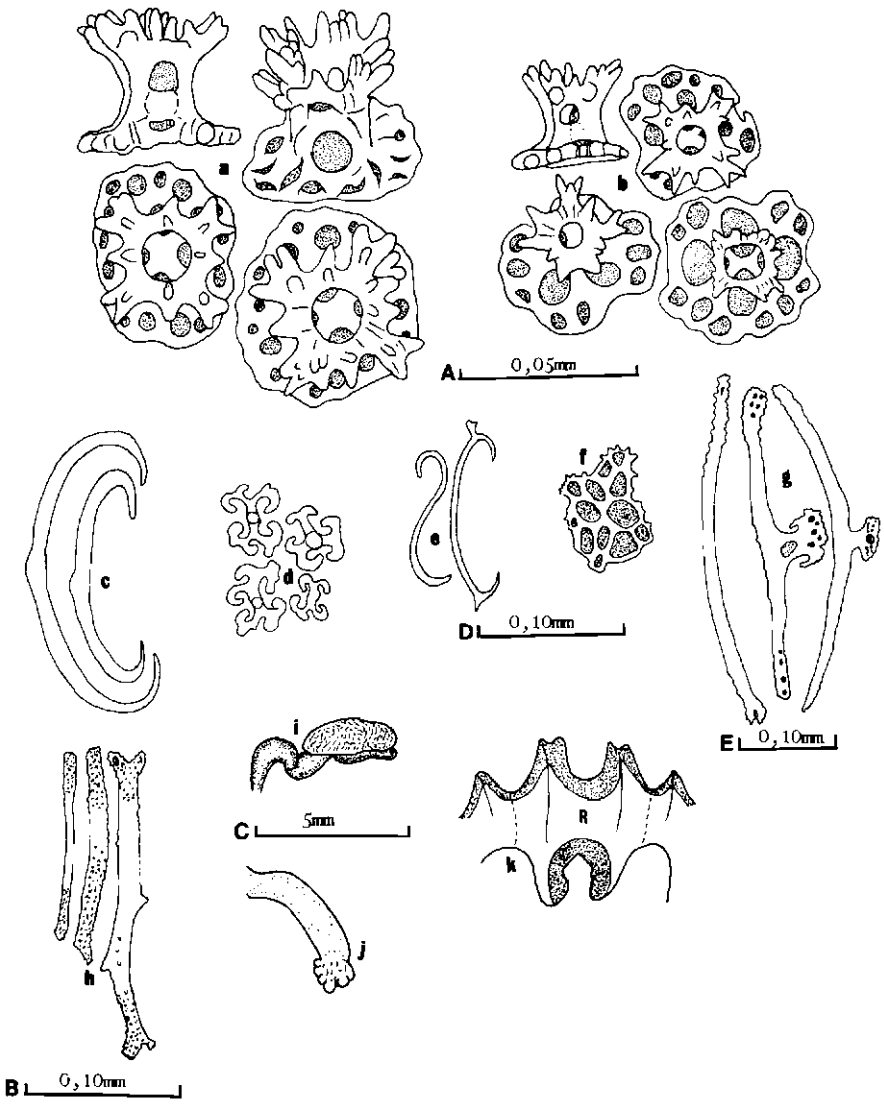

Figure 3 Spicules and other internal structures of *Stichopus variegatus* Semper. (a) Tables from dorsal body wall; (b) same from ventral body wall; (c) c-shaped spicules from dorsal body wall; (d) rosettes from dorsal body wall; (e) c- and s-shaped spicules from collar; (f) plate from wart; (g) pedicel rods; (h) papillae rods; (i) madreporite; (j) polian vesicle (terminal end); (k) part of calcareous ring. R = radial plate. (a–d Scale A; h scale B; i–k scale C; e & f scale D; g scale E).

Local distribution: Mozambique to Natal, as far south as Isipingo. Figure 5.
General distribution: Throughout the Indo-West Pacific region but not yet reported from W. India, Pakistan and Hawaii.
Habitat: Sand, mud, rock or coral.

Remarks: Contrary to the condition in *S. chloronotus*, in *S. variegatus* numerous papillae arise directly from the body independent of the warts. Apart from colour, this character is quite useful in separating local forms of both species on external features alone. Although H.L. Clark (1922) states that the disc diameter of the tables in this species does not exceed 0,05 mm, that of the wart tables in the present material often exceeds 0,07 mm. *S. variegatus* has been recorded from the Querimba Archipelago (N. Mozambique) by Pearson (1910). Its presence as far south as southern Natal is a noteworthy extension of its southern range. It is surprising that the species was not recorded from Inhaca Island by the University of the Witwatersrand survey.

Thelenota anax H.L. Clark

Thelenota anax H.L. Clark, 1921:185, pl.18, fig.3; Clark and Rowe, 1971:178 (dist.); Rowe and Doty, 1977:27, fig. 5f; Cherbonnier, 1979:9, text-fig.5 (A–N).

Diagnosis: Length over 500 mm when alive; colour various shades of mottled browns and creams; dorsal papillae simple, not leaf-like or trilobed; spicules slender, dichotomously branched, spiny rods and numerous round to oval miliary granules.

Type/type locality: Museum of Comparative Zoology (Harvard)/Murray Island.
Material examined: None.
Distribution: Mozambique (Figure 5), N.E. Australia and Guam.

Remarks: The southern African record of this species is that of Cherbonnier (1979), based on a single specimen collected from Glory Islands, Mozambique Channel, at a depth of 25 m.

Neostichopus grammatus (H.L. Clark)
(Figures 1c, 4, 6 and 7g, h)

Holothuria grammata H.L. Clark, 1923:424.
Holothuria (Holothuria) grammata Panning, 1934:34.
Stichopus grammatus syn. nov. Stephenson, Stephenson and du Toit, 1937:363, 381.
?Holothuria curiosa (?) Ludwig, Deichmann, 1948:375 syn. nov. (non *H. curiosa* Ludwig, 1875 = *H. fuscocinerea* Jaeger, 1833).
Neostichopus grammata Stephenson, 1944:348.
Neostichopus grammatus Deichmann, 1948:336, pl.17, figs. 1–17; 1948:265; Branch and Branch, 1981:248, figs.
?Red holothurian Day, Millard and Harrison, 1952:412.

***Diagnosis* (From Deichmann, 1948, amended herein):** Length up to 120 mm, gelatinous when alive, colour usually a shade of red; papillae few; body wall spicules of juveniles (< 40 mm long) exclusively tables, severely reduced and absent in larger individuals; minute perforated plates replace tables but become variously modified with age to form asymmetrical rods, ellipses, etc., large dumb-bell or skittle-shaped deposits in the papillae.

Type/type locality: SAM-A6455, P.F. 918; one mile east of Cove Rock, East London.
Paratype: Museum of Comparative Zoology, Harvard, U.S.A.
Previous records: C(34/19/i to 34/22/i; 33/26/i to 33/27/i); T(32/28/i); N(31/30/i).
Material examined: C(34/19/i to 34/22/i, 34/24/i to 33/27/i); T(32/29/i); N(31/30/i to 29/31/i,s, 28/32/i); 88 spec. (UCT, 13 spec; UDW, 72 spec; SAM, 3 spec.)

Description: Colour in life extremely variable, usually a shade of pink or red but white, cream, yellow, grey or even mottled brown specimens not uncommon. Body wall gelatinous in life. Well relaxed specimens often with a series of longitudinal and transverse ridges, often forming a reticulate pattern on body surface.

Spicules of juveniles (< 40 mm) exclusively tables with either a small disc with 2–4 marginal holes and a low spire (Figures 4d and e) or a large disc with up to 30 marginal holes and a tall spire (Figures 4e, g and 7g); spire of 4(–5) thin pillars, spinose at end, and 1–3 cross bars, terminating in a ring of clustered teeth; disc diameter and spire height 0,025–0,075 mm.

In older specimens tables replaced by minute plates (0,015–0,040 mm) (Figures 4b and 7h), with 2–8 holes and smooth to slightly serrate, knobbed or spinose margins, often thickened at one point. With age plates modified to asymmetrical deposits (0,02–0,03 mm) of diverse form (Figure 4a). Anal spicules plates, rods, corrugated crosses and modified tables with discs up to 0,10 mm (Figure 4f). Pedicels with end plates and other huge vertically disposed oblong plates; papillae with end plates, oblong perforated plates and large dumb-bell or skittle-shaped bodies (Figures 4h and 6); tentacles with curved, spinulated rods (Figure 4i).

Changes in spicule composition with age

In juveniles of *N. grammatus* (up to 40 mm long) the body wall spicules comprise exclusively tables. With age the tables degenerate rapidly to be replaced by minute perforated plates (pseudobuttons of Deichmann, 1948). At first only the spires are affected (Figure 4c) but later the discs as well. However, sometimes a few complete tables may be retained in the anal region and at the bases of papillae of slightly older individuals. The minute perforated plates are of varied form and with 2–8 holes. Initially they are few, accompanying degenerating tables, but later they become numerous and progressively modified with age to form asymmetrical deposits of such varied form that no two appear exactly alike.

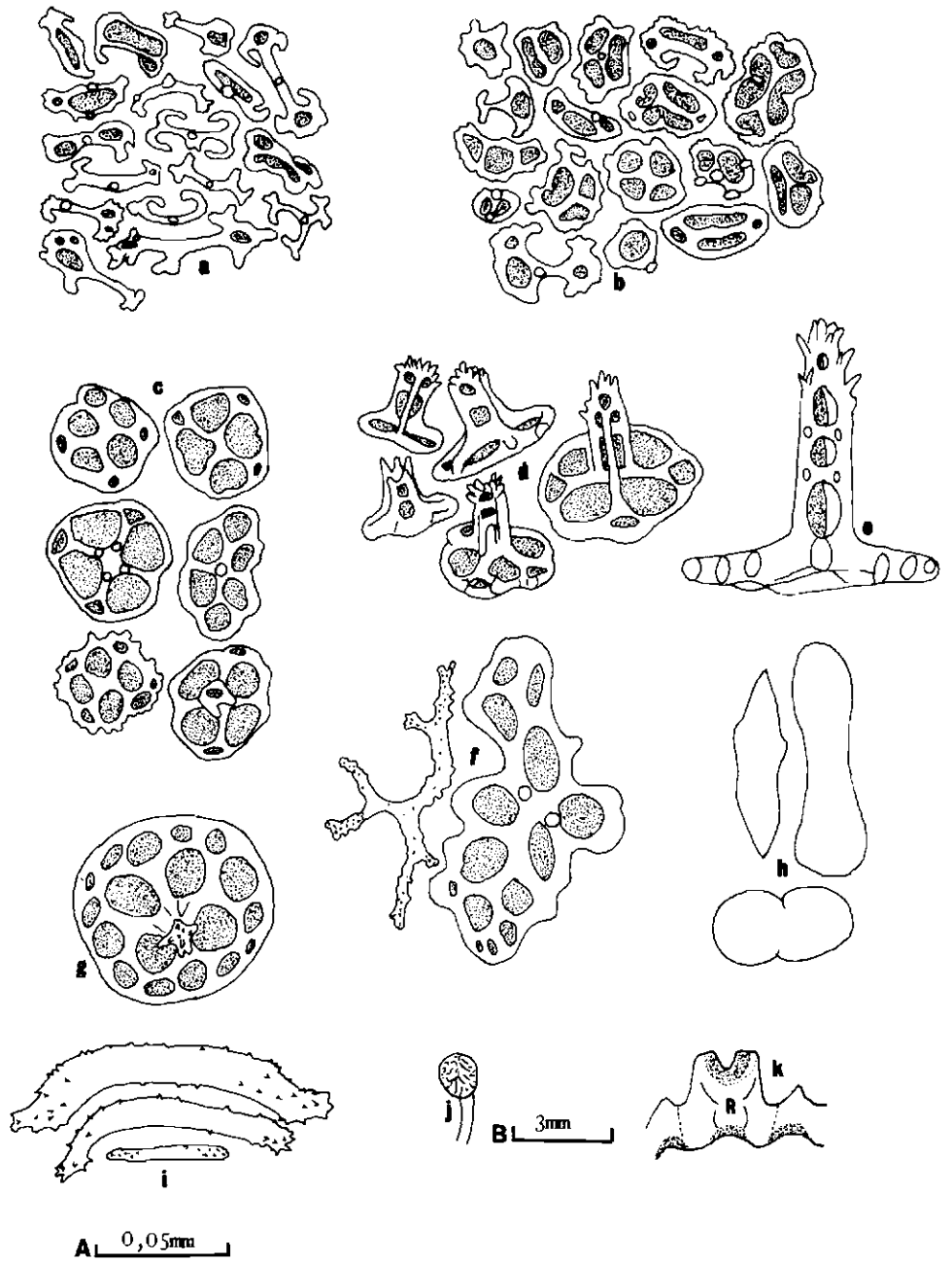

Figure 4 Spicules and other internal structures of *Neostichopus grammatus* (H.L. Clark). (a) Asymmetrical deposits from body wall; (b) minute plates ('pseudobuttons') from body wall; (c) degenerating tables; (d) tables with low spires from juvenile (side view); (e) table with high spire from juvenile (side view); (f) branched rod and abnormal table disc from anal region; (g) large table of juvenile (from above); (h) papillae rods; (i) tentacular rods; (j) madreporite; (k) part of calcareous ring. R = radial plate. (a–i Scale A; j & k scale B).

Thus, quite unlike most aspidochirote holothurians, the composition of the spicules of *N. grammatus* changes drastically with growth, so much so that if one is not careful or working with preserved material, juveniles and adults may be referred to different species. Since tables are the first spicules to appear in many aspidochirote holothurians, the identification of preserved juveniles is an additional difficulty. However, the spicules of the dorsal papillae of *N. grammatus* are quite consistent in both juveniles and adults including, besides perforated plates, peculiar large dumb-bell or skittle-shaped bodies, which, as far as could be ascertained, have not been reported for any other holothurian species. These deposits were overlooked by both H.L. Clark (1923) and Deichmann (1948) although they are definitely present in some of Deichmann's specimens that were here re-examined. These deposits provide a reliable and easily accessible morphological character in living and preserved specimens of both juveniles and adults of *N. grammatus*.

The minute perforated plates develop from simple rods which are dichotomously branched at one or both ends. Clark (1923) thought that the extraordinary diversity in form of the spicules results from the more or

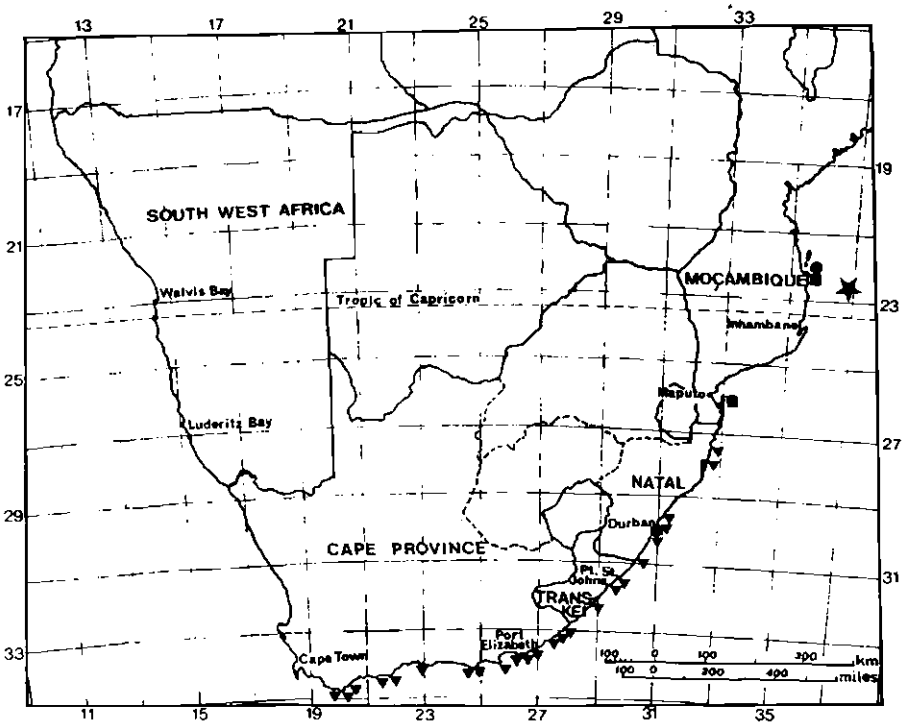

Figure 5 Distribution of southern African stichopodid holothurians. ▼ *Neostichopus grammatus* (H.L. Clark). ● *Stichopus variegatus* Semper. ■ *S. chloronotus* Brandt. ★ *Thelenota anax* H.L. Clark.

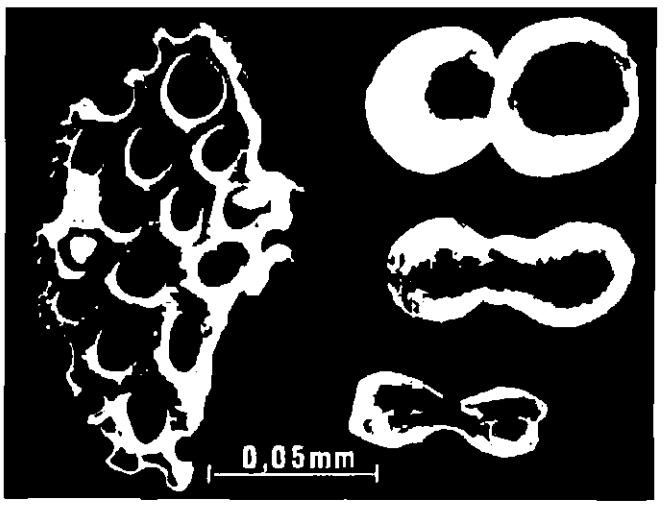

Figure 6 Scanning electron micrograph of papillae deposits of *Neostichopus grammatus* (H.L. Clark).

less extensive development with growth of the forks of the rods. While such development does result in the formation of the minute perforated plates with 2–8 holes, the asymmetrical deposits which appear in older individuals are a result of later modifications of these plates, as Deichmann concluded. Nevertheless, since transitory stages in the formation of the minute plates do resemble asymmetrical deposits, it is difficult or well nigh impossible to state emphatically whether each asymmetrical deposit observed is a transitory stage in the formation of the minute plates as Clark suspected or their modifications as Deichmann concluded. In any case such a question is purely academic and not pertinent to the correct identification of a species.

Distribution: From Cape Agulhas to Cape Vidal in N. Natal. Figure 5.

Habitat: Fairly common under rock at low spring tide; in Durban found from low tide mark down to about 3 m.

Remarks: H.L. Clark's (1923) material was in a poor state of preservation while the description of the species by Deichmann (1948) is very brief. Thandar (1971: unpublished M.Sc. thesis) re-described the species on the basis of a few specimens from Natal. With ample material of both juvenile and adult in hand, the diagnosis of the species is here amended. Although Deichmann recorded a maximum length of the species as 150 mm, none of the numerous living animals brought into the laboratory exceeded 120 mm in length.

This species was described as *Holothuria grammata* by H.L. Clark (1923) who suspected that it belonged in *Stichopus* but, because of the poor quality of his material, did not assign it to this genus. However, Stephenson, Stephenson & du Toit (1937) listed the species as *Stichopus grammatus,* which is clearly a synonym of *Neostichopus grammatus.*

The binomen *Neostichopus grammata* was first published in 1944 by Stephenson, based upon identification of some UCT material by Deichmann. However, it was only in 1948 that Deichmann diagnosed the genus and fixed the type species. Since the nomen *Neostichopus* was first published without indication and without satisfying the provisions of Article 13 of the International Code of Zoological Nomenclature, it is a

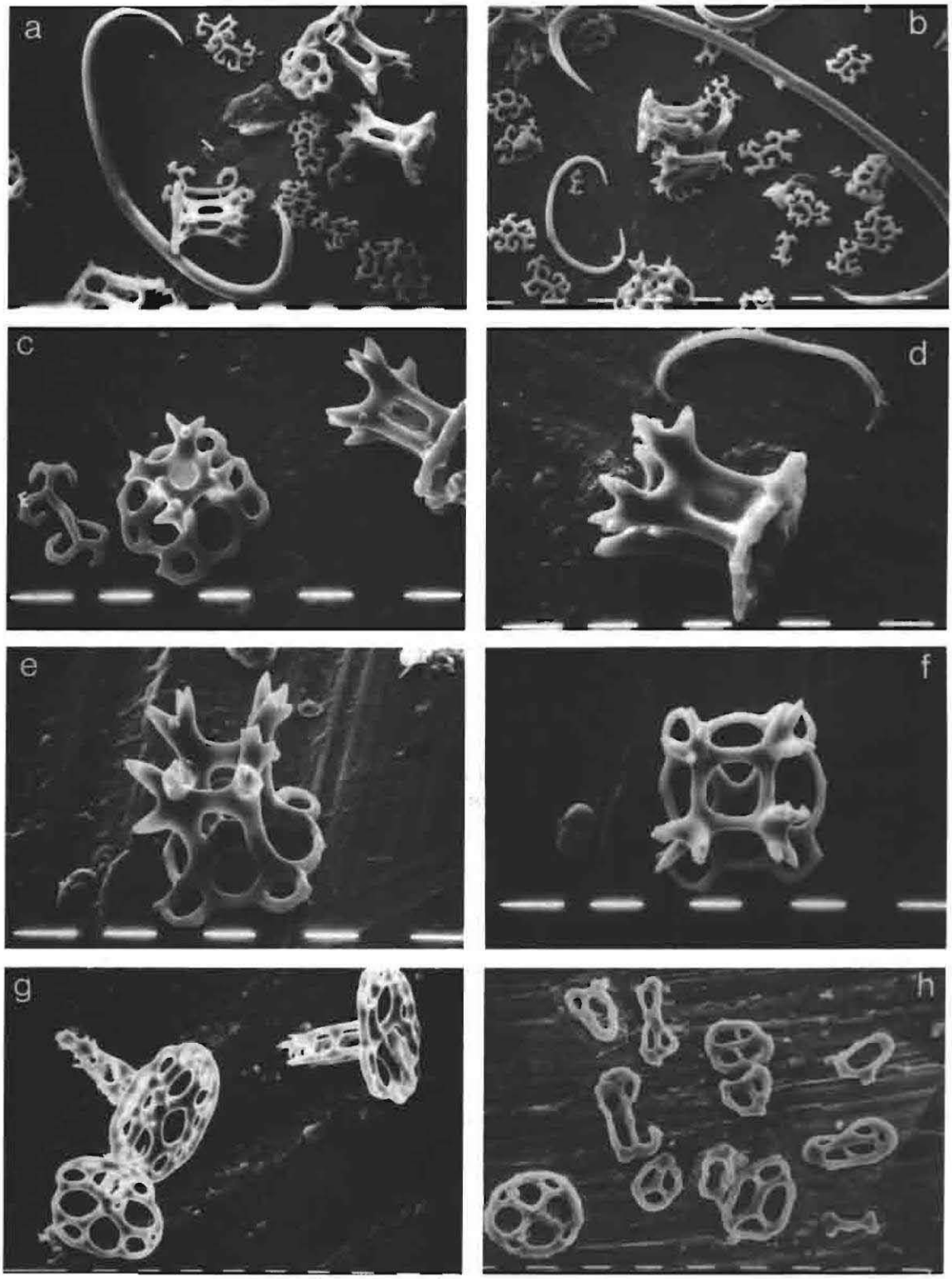

Figure 7 Scanning electron micrographs of body wall spicules of southern African stichopodid holothurians. (a)–(c) *Stichopus variegatus* Semper; (d)–(f) *S. chloronotus* Brandt; (g) tables from juvenile of *Neostichopus grammatus* (H.L. Clark); (h) reduced table (bottom left) and minute plates and rods of adult of *N. grammatus*. Scale bars = 10 μm.

nomen nudum. Hence it is an unavailable name and should not have been used subsequently by Deichmann. However, since *Neostichopus* was both proposed and diagnosed by Deichmann and is in common usage locally, it should be retained for the sake of stability of nomenclature. A petition is presently being drafted to the International Commission on Zoological Nomenclature to use its plenary powers to exempt this particular case from the application of the Code and validate *Neostichopus* Deichmann, 1948 with *Holothuria grammata* H.L. Clark, 1923 as type species.

Deichmann (1948: 375), further listed some material

(E24) from Port Elizabeth, identified by either Heding or John, as *Holothuria curiosa* (?) Ludwig. Six specimens from the UCT collection, bearing this number, proved to be referable without doubt to *N. grammatus*. Although it could not be established whether the same or some other material bearing the same label was examined by Heding or John, *H. curiosa* (?) Deichmann (non Ludwig) is here also relegated, with some doubt, to the synonymy of *N. grammatus*.

Acknowledgements

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References

BRANCH, G. & BRANCH, MARGO. 1981. The living shores of southern Africa. Struik Publishers, Cape Town. 272 pp, 388 figs., 177 pls.

CHERBONNIER, G. 1979. Description d'*Actinopyga flammea* nov. sp., et données nouvelles sur deux espéces connues d'Holothuries Aspidochirotes (Échinodermes). *Bull. Mus. natn. Hist. nat., Paris* (4)1: 3–12, 5 text-figs.

CLARK, AILSA M. & ROWE, F.W.E. 1971. Monograph of the shallow-water Indo-West Pacific echinoderms. *Brit. Mus. (Nat. Hist.), Lond.* 238 pp, 100 text-figs., 31 pls.

CLARK, H.L. 1921. The echinoderm fauna of Torres Strait. *Pap. Dep. mar. biol. Carnegie Instn Wash.* 10: vi + 223, 38 pls.

CLARK, H.L. 1922. Holothurians of the genus *Stichopus*. *Bull. Mus. comp. Zool. Harv.* 65: 39–74, 2pls.

CLARK, H.L. 1923. The echinoderm fauna of South Africa. *Ann. S. Afr. Mus.* 13(7): 221–435, 4 figs., pls. 8–23.

DEICHMANN, ELIZABETH. 1948. The holothurian fauna of South Africa. *Ann. Natal Mus.* 11: 325–376, 9 text-figs., 5 pls.

FISHER, W.K. 1907. The holothurians of the Hawaiian Islands. *Proc. U.S. natn. Mus.* 32: 637–744, pls. 66–82.

JAMES, D.B. & PEARSE, J.S. 1969. Echinoderms from the Gulf of Suez and the northern Red Sea. *J. Mar. Biol. Ass. India.* 11(1&2): 78–125.

KALK, MARGARET. 1958. Ecological studies on the shores of Mocambique. 1. The fauna of intertidal rocks at Inhaca Island, Delagoa Bay. *Ann. Natal Mus.* 14: 189–242, 8 text-figs., 2 pls.

KALK, MARGARET. 1959. A general ecological survey of some shores in northern Mocambique. *Revta Biol., Lisb.* 2: 1–24, pls. 1–4.

LUDWIG, H. 1887. Drei mitteilungen über alte und neue Holothurienarten. *Abh. preuss. Akad. Wiss.* 54: 1217–1244, pl. 15.

MACNAE, W. & KALK, MARGARET (eds.) 1958. A natural history of Inhaca Island, Mocambique. Witwatersrand Univ. Press. Johannesburg: i–iv, 163 pp, 30 text-figs., 11 pls.

MAHONEY, R. 1966. Laboratory techniques in Zoology. Butterworths, London. 404 pp.

PAWSON, D.L. 1982. Holothuroidea. In: Synopsis and classification of living organisms. (Ed.) Sybil P. Parker. McGraw-Hill, New York. pp. 791–818, 5 text-figs., pls. 136 and 137.

PEARSON, J. 1910. Littoral marine fauna of Kerimba Archipelago, Portuguese East Africa. Holothuroidea. *Proc. zool. Soc. Lond.* 1910: 167–182, 5 text-figs.

ROWE, F.W.E. 1969. A review of the family Holothuriidae (Holothurioidea: Aspidochirotida). *Bull. Br. Mus. nat. Hist. (Zool.)* 18(4): 119–170, 21 text-figs.

ROWE, F.W.E. & DOTY, J.E. 1977. The shallow-water holothurians of Guam. *Micronesica.* 13(2): 217–250, 9 text-figs.

STEPHENSON, T.A., STEPHENSON, ANNE & DU TOIT, C.A. 1937. The South African intertidal zone and its relation to ocean currents. 1. A temperate Indian Ocean shore. *Trans. R. Soc. S. Afr.* 24: 341–382, 8 text-figs. 4 pls.