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Author(s): Arthur G. Humes and Ju-Shey Ho

Source: *Crustaceana*, Vol. 20, No. 2 (Mar., 1971), pp. 171-191

Published by: BRILL

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# THE GENUS *DIAGENIDIUM* (COPEPODA, CYCLOPOIDA) PARASITIC IN HOLOTHURIANS IN THE WEST INDIES

BY

ARTHUR G. HUMES and JU-SHEY HO

Department of Biology, Boston University, Boston, Massachusetts, U.S.A.

*Diagenidium nasutum* Edwards, 1891, was originally found in *Muelleria* (= *Actinopyga*) *agassizii* Selenka in the Bahamas. Stock (1968) has redescribed this species from specimens found in *Holothuria* (= *Ludwigothuria*) *mexicana* Ludwig in Puerto Rico and Curaçao. Two other species are known, — *D. spinulosum* Stock, 1968 (male only) from *Isostichopus badionotus* (Selenka) in Puerto Rico and *D. deforme* Stock, 1968 from *Holothuria glaberrima* Selenka in Puerto Rico. Collections in the West Indies by the first author and Dr. Richard U. Gooding have made available for study both sexes of all three of these *Diagenidium* and in addition one new species (male only).

The field work was made possible by a grant (G-8628) from the National Science Foundation of the United States. The study of the copepods has been aided by another NSF grant (GB-8381X).

All figures have been drawn with the aid of a camera lucida. The letter after the explanation of each figure refers to the scale at which it was drawn. The abbreviations used are:  $A_1$  = first antenna,  $A_2$  = second antenna, MXPd = maxilliped, and  $P_1$  = leg 1.

The measurements of the length of the body have been made in all cases from specimens in lactic acid and do not include the setae on the caudal rami. The lengths of the segments of the first antenna have been measured along their posterior non-setiferous margins.

We are greatly indebted to Dr. Elisabeth Deichmann of the Museum of Comparative Zoology, Harvard University, for the identifications of the holothurian hosts. We thank Dr. J. H. Stock for generously lending us the type specimens of *Diagenidium deforme*.

This paper comprises the following:

- 1) a redescription of *Diagenidium nasutum* Edwards, 1891, and a new host record for this species from *Ludwigothuria grisea* (Selenka),
- 2) a description of the female of *Diagenidium spinulosum* Stock, 1968, hitherto unknown, and a redescription of the male,
- 3) a redescription of *Diagenidium deforme* Stock, 1968, and two new host records for this species from *Brandtothuria arenicola* (Semper) and *Ludwigothuria mexicana* (Ludwig),

and 4) a description of *Diogenidium tectum* n. sp. from *Actinopyga agassizii* (Selenka), male only.

***Diogenidium nasutum* Edwards, 1891 (figs. 1-24)**

The following redescription, based upon specimens from *Actinopyga agassizii* from Jamaica, supplements the original description by Edwards and the redescription by Stock (1968).

Material examined (collected in 1959). — From *Actinopyga agassizii* (Selenka): 4 ♀♀, 3 ♂♂ from 48 hosts, in 2 m, off the Lerner Marine Laboratory, North Bimini, Bahamas, 3 June; and 1 ♀, 1 ♂ from 21 hosts, in 1 m, northern end of Pigeon Cay, North Bimini, Bahamas, 4 June.

From *Ludwigothuria mexicana* (Ludwig): 3 ♀♀, 3 ♂♂ from 15 hosts, in 0.5 m, small reef south of Magüeyes Island, near La Parguera, Puerto Rico, 31 July; 2 ♀♀ from 6 hosts, in 1 m, Cayo Enrique, south of La Parguera, Puerto Rico, 17 August; and 1 ♀, 1 ♂ from 8 hosts, in 0.5 m, Lime Cay, off Port Royal, Jamaica, 30 August.

From *Ludwigothuria grisea* (Selenka): 2 ♀♀, 4 ♂♂ from 11 hosts, in 2 m, near old quarantine station, western side of entrance to Kingston harbor, Jamaica, 5 September.

Female. — The length of the body (fig. 1) is 1.58 mm (1.55-1.60 mm) and the greatest width 0.53 mm (0.51-0.54 mm), based on 5 specimens. The ratio of the length to the width of the prosome is 1.57 : 1. The ratio of the length of the prosome to that of the urosome is 1.06 : 1.

The segment of leg 5 (fig. 2) is  $165 \times 297 \mu$ . Between this segment and the genital segment there is a weakly developed ventral intersegmental sclerite. The genital segment is elongated,  $220 \times 165 \mu$  in greatest dimensions, broadest anteriorly and tapered posteriorly. The areas of attachment of the egg sacs are located laterally in the anterior part of the segment. Each area (fig. 3) bears a naked seta  $30 \mu$  long, a small spine  $10 \mu$ , and a hyaline area probably indicating the site of a seta now lost. The three postgenital segments are  $120 \times 96 \mu$ ,  $94 \times 83 \mu$ , and  $65 \times 81 \mu$  from anterior to posterior. The posterior margin of the anal segment is unornamented.

The weakly sclerotized caudal ramus (fig. 4) is about  $138 \mu$  long,  $36 \mu$  in greatest width proximal to the lateral seta, and  $24 \mu$  wide distal to this seta, the ratio of length to width being about 4.6 : 1. The six setae are naked except for the innermost terminal seta which has a few proximal inner hairs. (The irregular form and curvature of these setae prevented accurate measurement of their lengths.)

The dorsal surface of the prosome lacks fine ornamentation, but that of the urosome has a few hairs and minute refractile bosses.

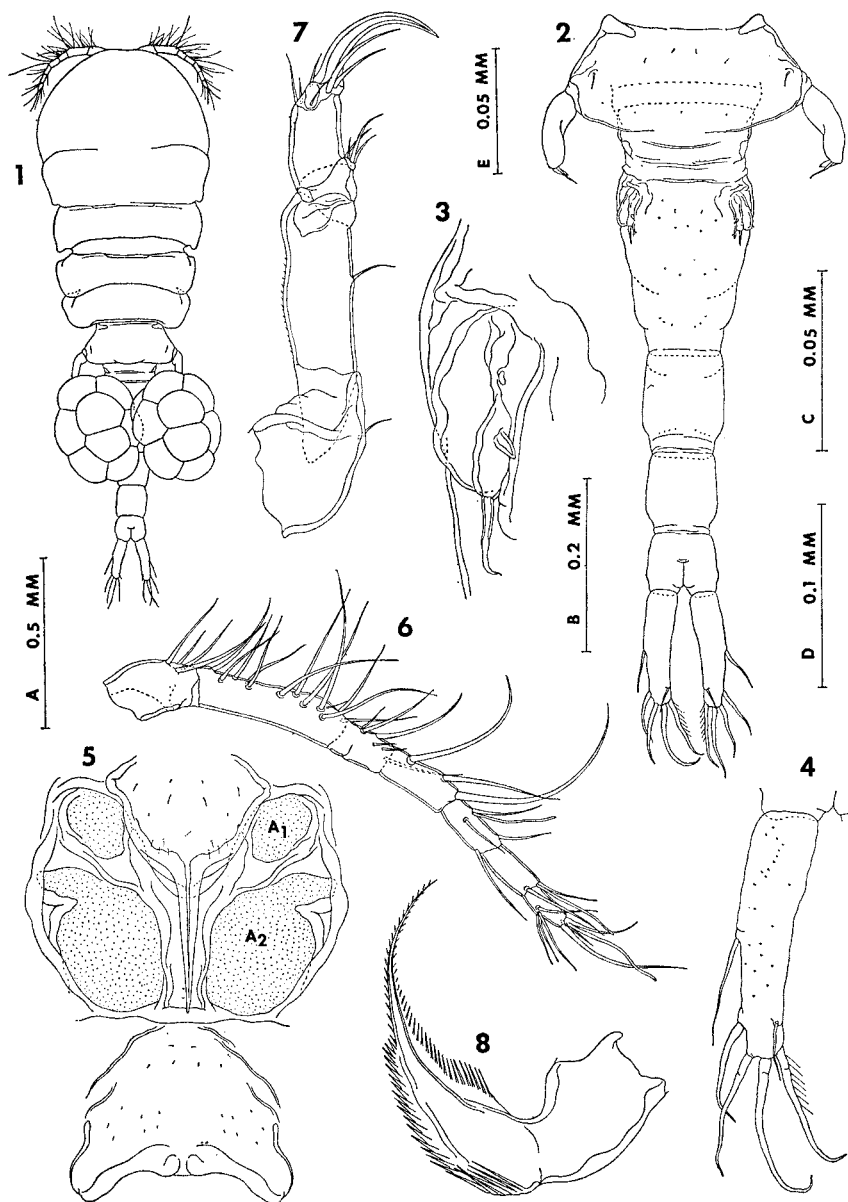
The egg sac (fig. 1) is oval and short,  $330 \times 240 \mu$ , reaching only to the second postgenital segment, and containing 6 to 11 eggs, each about  $105 \mu$  in diameter, but mostly of irregular form.

The rostrum (fig. 5) has a long pointed beak. The first antenna (fig. 6) is  $290 \mu$  long. The lengths of the seven segments are: 24 ( $50 \mu$  along its anterior margin), 77, 34, 41, 34, 31, and  $26 \mu$  respectively. The formula for the armature is 4, 13, 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete. All the setae are naked.

The second antenna (fig. 7) has the formula 1, 1, 4, and I + 6. The fourth

segment is  $46\ \mu$  along its outer edge,  $29\ \mu$  along its inner edge, and  $23\ \mu$  wide. The claw is  $54\ \mu$  along its axis.

The labrum (fig. 5) has two widely separated posteroventral lobes. The mandible is shown in fig. 8. The paragnath is like that of the male (fig. 20). The first



Figs. 1-8. *Diogenidium nasutum* Edwards, 1891, female. 1, dorsal (A); 2, urosome, dorsal (B); 3, area of attachment of egg sac, dorsal (C); 4, caudal ramus, dorsal (D); 5, rostrum and labrum, ventral (D); 6, first antenna, dorsal (D); 7, second antenna, posterior (E); 8, mandible, posterior (C).

maxilla is shown in fig. 9, the second maxilla in fig. 10, and the maxilliped in fig. 11.

The ventral surface between the maxillipeds and the first pair of legs (fig. 12) is not protuberant. A sclerotized line connects the bases of the maxillipeds.

Legs 1 to 4 (figs. 13, 14, 15, and 16) have the armature as already described by Stock (1968), except for the armature on the last exopod segment of leg 2, which is usually II, I, 5, but may be III, I, 5, with an added outer spine (see table I). Although 25 specimens are too few to allow significant correlation of the variation in the number of spines with hosts and localities, the data suggest that the formula III, I, 5 occurs more frequently in females on the left leg rather than the right leg, and that the specimens from Puerto Rico are more variable (5 out of 8 with III, I, 5) than those from the Bahamas (3 out of 9) or from Jamaica (2 out of 8).

TABLE I

The number of outer spines on the last segment of the exopod of leg 2 in  
*Diogenidium nasutum*

host	locality	female		male	
		right leg	left leg	right leg	left leg
<i>Actinopyga agassizii</i>	Bahamas	II	III	II	II
" "	" "	II	II	II	II
" "	" "	II	III	II	II
" "	" "	II	III	II	II
" "	" "	II	II		
<i>Ludwigothuria mexicana</i>	Puerto Rico	II	III	III	III
" "	" "	II	II	III	III
" "	" "	II	III	II	II
" "	" "	II	II		
" "	" "	II	III		
" "	Jamaica	II	II	II	II
<i>Ludwigothuria grisea</i>	Jamaica	II	II	II	II
" "	" "	II	III	II	II
" "	" "			II	III
" "	" "			II	II

The inner margin of the basis of all four legs bears a row of hairs. The anterior surface of the basis of leg 1 bears a group of small spinules (absent in legs 2 to 4). The third segment of the endopod of leg 4 is  $37\ \mu$  long, and its two spines are  $29\ \mu$  (outer) and  $39\ \mu$  (inner). The number of small outer lateral spiniform processes on this segment varies from 0 to 3.

Leg 5 (fig. 17) has an unornamented free segment  $94 \times 32\ \mu$  in greatest dimensions. The two naked terminal elements are  $16\ \mu$  and  $26\ \mu$ . The naked seta near the free segment is  $23\ \mu$ .

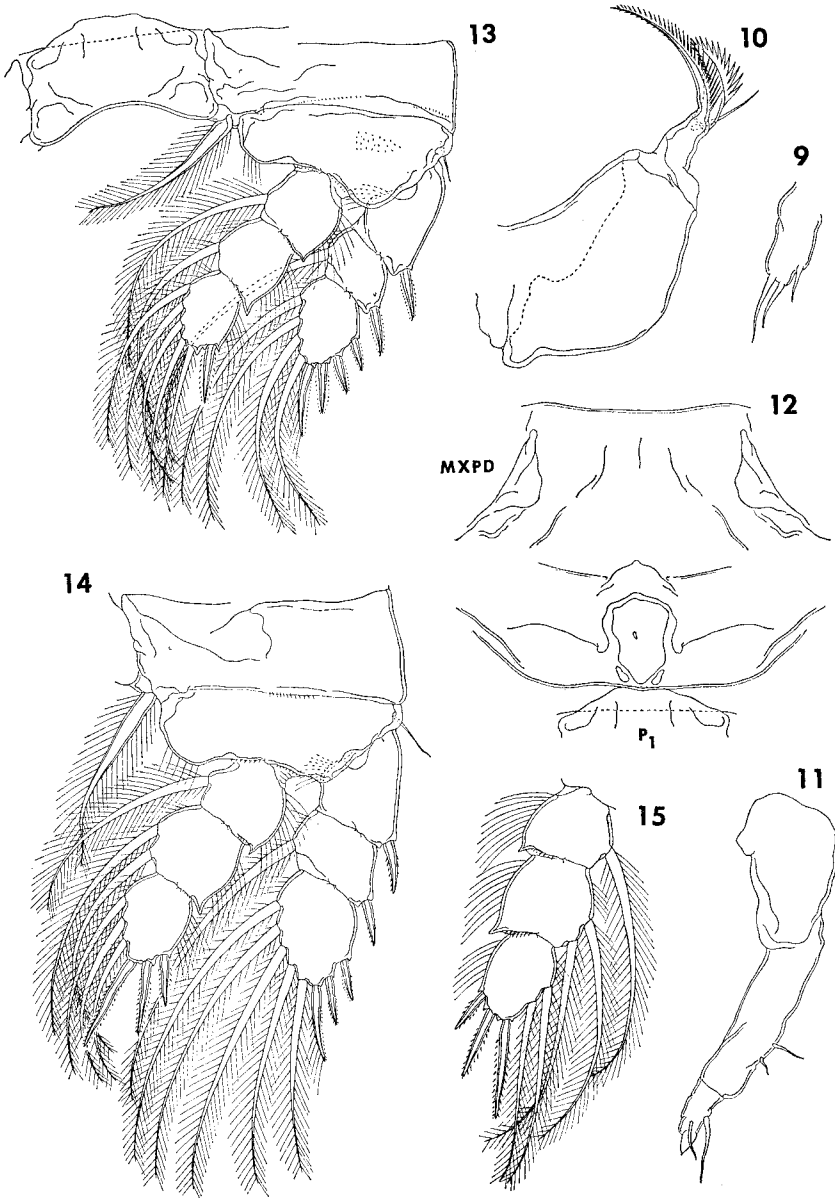
Leg 6 is probably represented by the elements seen near the area of attachment of each egg sac (fig. 3).

The color in life in transmitted light is opaque white, the eye red.

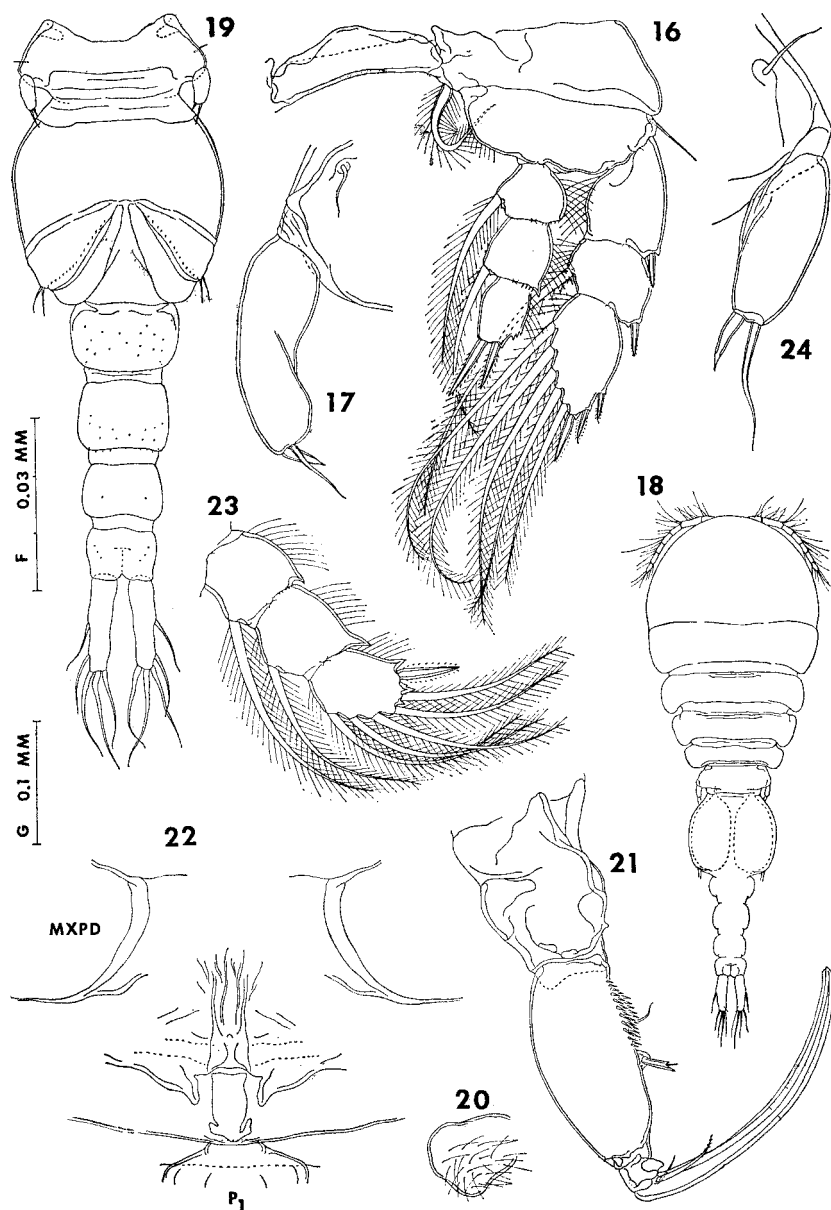
Male. — The length of the body (fig. 18) is 1.49 mm (1.42-1.56 mm) and

the greatest width 0.52 mm (0.50-0.54 mm), based on 4 specimens. The ratio of the length to the width of the prosome is 1.46 : 1. The ratio of the length of the prosome to that of the urosome is 1 : 1.

The segment of leg 5 (fig. 19) is  $107 \times 229 \mu$ . Between this segment and the



Figs. 9-15. *Diogenidium nasutum* Edwards, 1891, female. 9, first maxilla, posterior (C); 10, second maxilla, anterior (E); 11, maxilliped, posterior (E); 12, area between maxillipeds and first pair of legs, ventral (D); 13, leg 1 and intercoxal plate, anterior (D); 14, leg 2, anterior (D); 15, endopod of leg 3, anterior (D).



Figs. 16-17. *Diogenidium nasutum* Edwards, 1891, female. 16, leg 4 and intercoxal plate, anterior (D); 17, leg 5, dorsal (E).

Figs. 18-24. *Diogenidium nasutum* Edwards, 1891, male. 18, dorsal (A); 19, urosome, ventral (B); 20, paragnath, ventral (F); 21, maxilliped, inner (G); 22, area between maxillipeds and first pair of legs, ventral (D); 23, endopod of leg 1, anterior (E); 24, leg 5, dorsal (C).

genital segment there is no ventral intersegmental sclerite. The genital segment is as long as wide,  $252 \times 252 \mu$ . The four postgenital segments, their junctions more clearly defined ventrally than dorsally, are  $86 \times 130 \mu$ ,  $99 \times 109 \mu$ ,  $75 \times 96 \mu$ , and  $65 \times 84 \mu$  from anterior to posterior.

The caudal ramus resembles that of the female, though smaller,  $104 \times 26 \mu$  in greatest dimensions.

The body surface has almost no fine ornamentation except for minute refractile bosses on the dorsal surface of the urosome.

The rostrum, first antenna (with no aesthetes added), second antenna, labrum, mandible, paragnath (fig. 20), first maxilla, and second maxilla are like those of the female. The maxilliped (fig. 21) has a small sclerotized knob on the inner distal surface of the first segment. The claw is  $252 \mu$  along its axis.

The ventral area between the maxillipeds and the first pair of legs (fig. 22) has slightly different sclerotizations than in the female.

Legs 1 to 4 are segmented and armed as in the female. Very slight sexual dimorphism is seen in the endopod of leg 1 (fig. 23), where the terminal spiniform processes on the last segment are slightly longer than in the female.

Leg 5 (fig. 24) has a relatively shorter free segment than in the female. Its dimensions are  $50 \times 22 \mu$ , and the two terminal elements are  $15 \mu$  and  $36 \mu$ .

Leg 6 (fig. 19) consists of a posteroventral flap on the genital segment, bearing two naked setae  $31 \mu$  and  $37 \mu$  and an oblique row of small spinules.

The spermatophore was not observed.

The color in life resembles that of the female.

Remarks. — There seems to be little doubt that both Stock's specimens from *Ludwigothuria* (= *Holothuria*) *mexicana* and our specimens from that holothurian and also from *Actinopyga agassizii* and *Ludwigothuria grisea* represent Edwards' (1891) *Diogenidium nasutum*. It may be noted that two of our collections came from *Actinopyga* (= *Muelleria*) *agassizii* from the Bahamas, as did Edwards' specimens. Stock (1968) has already pointed out the close similarities of his material with Edwards' description. Our specimens agree in all important respects with Stock's redescription.

*Ludwigothuria grisea* is a new host for this species.

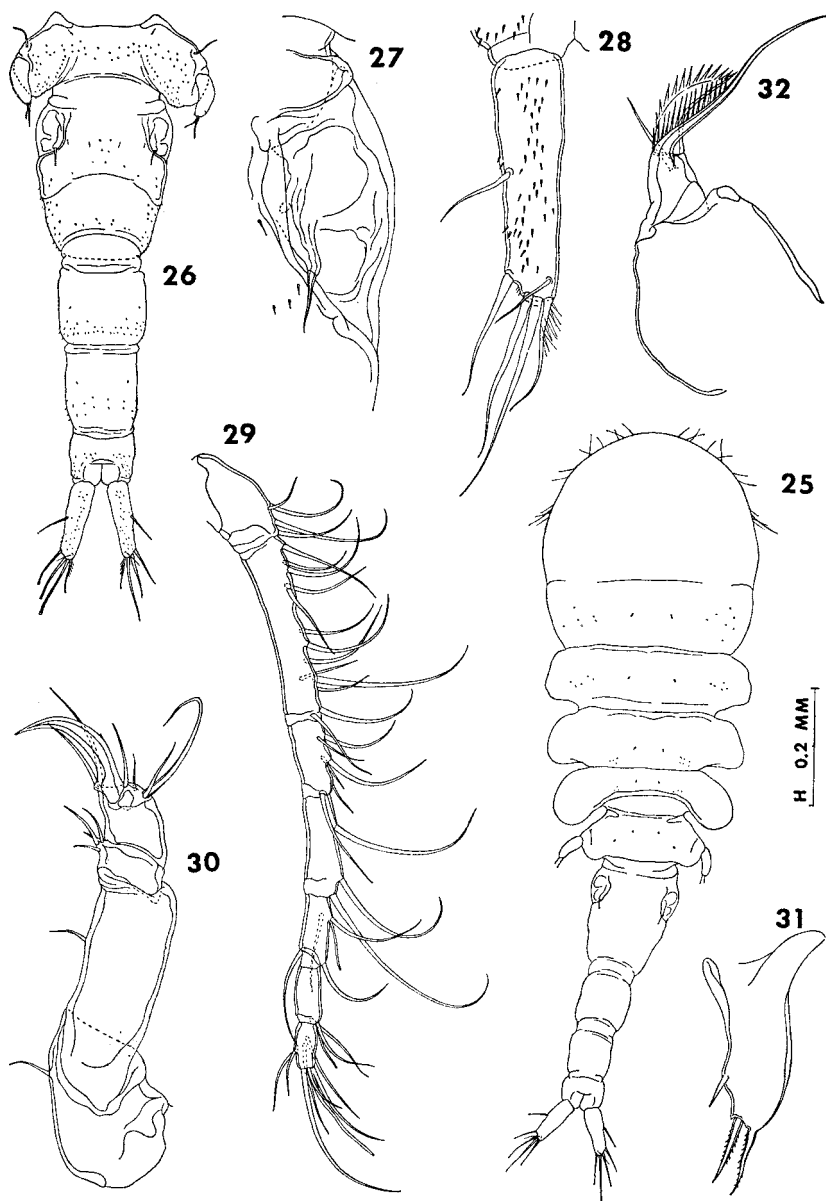
### **Diogenidium spinulosum** Stock, 1968 (figs. 25-47)

This species has been known until now from a single male (the holotype). We take this opportunity to describe the female and to supplement Stock's original description of the male.

Material examined (collected in 1959). — From *Isostichopus badionotus* (Selenka): 1 ♀, 2 ♂♂ from 11 hosts, in 3 m, Drunken Man's Cay, off Port Royal, Jamaica, 29 August; and 1 ♀ from 6 hosts, in 25 cm, eastern end of Magüeyes Island, near La Parguera, Puerto Rico, 29 July.



Female. — The length of the body (fig. 25) is 1.94 mm (1.78-2.10 mm) and the greatest width 0.62 mm (0.61-0.62 mm), based on 2 specimens. The ratio of the length to the width of the prosome is 1.76 : 1. The ratio of the length of the prosome to that of the urosome is 1.11 : 1.



Figs. 25-32. *Diogenidium spinulosum* Stock, 1968, female. 25, dorsal (A); 26, urosome, dorsal (H); 27, area of attachment of egg sac, dorsal (E); 28, caudal ramus, dorsal (D); 29, first antenna, ventral (D); 30, second antenna, anterior (D); 31, first maxilla, posterior (C); 32, second maxilla, anterior (E).

The segment of leg 5 (fig. 26) is  $143 \times 352 \mu$ . Between this segment and the genital segment there is no ventral intersegmental sclerite. The genital segment,  $300 \times 250 \mu$ , is a little longer than wide. The areas of attachment of the egg sacs are situated far anteriorly. Each area (fig. 27) bears a naked seta  $33 \mu$  long and a minute blunt process about  $5 \mu$ . The three postgenital segments are  $156 \times 159 \mu$ ,  $143 \times 135 \mu$ , and  $104 \times 122 \mu$  from anterior to posterior. The posterior margin of the anal segment is unornamented.

The caudal ramus (fig. 28) is  $133 \mu$  long,  $39 \mu$  wide proximally and  $31 \mu$  wide distally, with the ratio of length to width about 3.9 : 1. The six setae are naked except for the innermost terminal one which has inner hairs. The outer lateral seta is  $45 \mu$ , the dorsal seta  $30 \mu$ , the outermost terminal seta  $72 \mu$ , the innermost terminal seta  $68 \mu$ , and the two median terminal setae  $93 \mu$  (outer) and  $120 \mu$  (inner). The dorsal surface of the ramus bears small spinules.

The dorsal surface of the prosome bears a few hairs and minute spinules, and that of the urosome bears hairs and numerous spinules as in fig. 26.

The egg sac is unknown, since neither female was ovigerous.

The rostrum resembles that of the male (fig. 42), with a broadly rounded posteroventral margin. The first antenna (fig. 29) is about  $350 \mu$  long. The lengths of the seven segments are: 20 ( $61 \mu$  along its anterior margin), 99, 43, 54, 40, 33, and  $26 \mu$  respectively. The formula for the armature is like that of *D. nasutum*. All the setae are naked.

The second antenna (fig. 30) is armed as in *D. nasutum*. The fourth segment is  $39 \mu$  along its outer edge,  $26 \mu$  along its inner edge, and  $29 \mu$  wide. The claw is  $68 \mu$  along its axis. The second segment lacks fine ornamentation.

The labrum is similar to that of the male (fig. 42), with two relatively small and widely separated posteroventral lobes. The mandible and paragnath are like those of *D. nasutum*. The first maxilla is shown in fig. 31, the second maxilla in fig. 32, and the maxilliped, stouter than in *D. nasutum*, in fig. 33.

The ventral surface between the maxillipeds and the first pair of legs resembles that of *D. nasutum*.

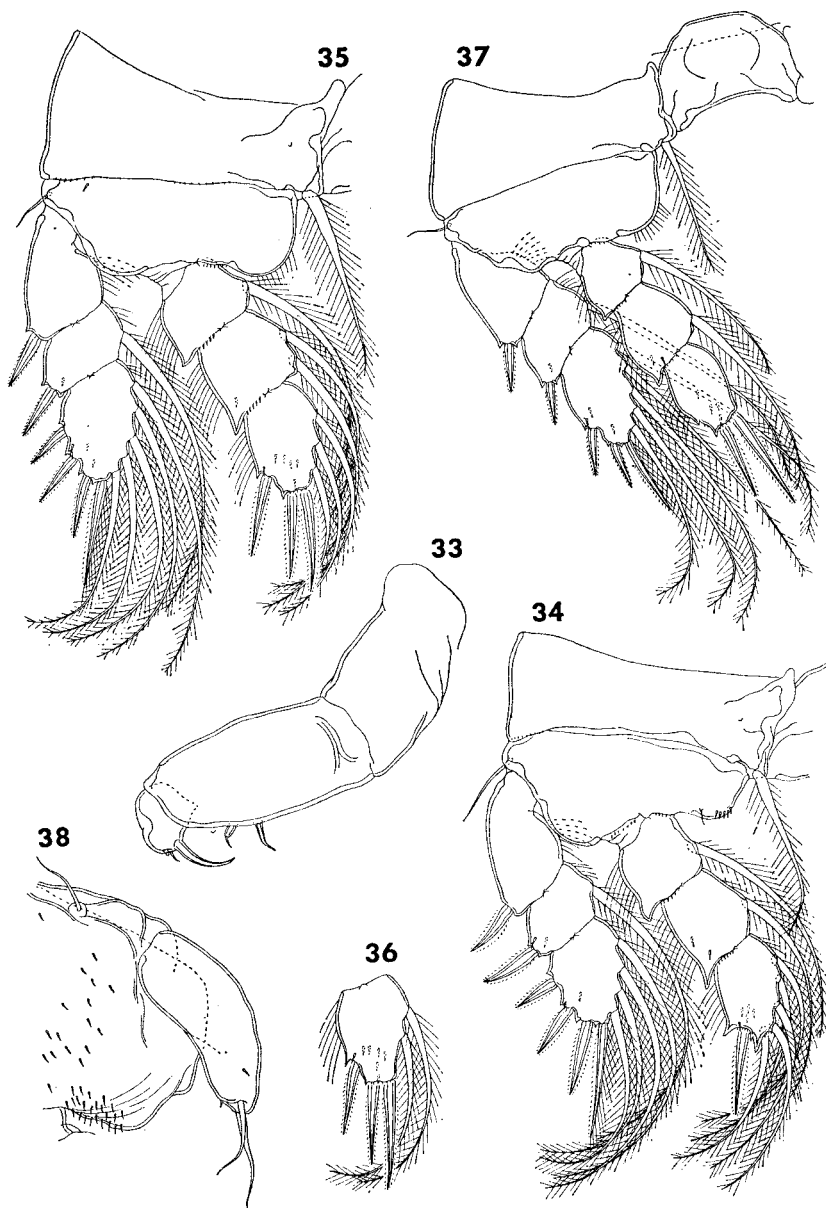
Legs 1 to 4 (figs. 34, 35, 36, and 37) have the same spine and setal formula as in *D. nasutum*, except that all specimens have III, I, 5 on the third segment of the exopod of leg 2. The inner margin of the basis of leg 1 bears short spines, but in legs 2 and 3 has a row of hairs. The second and third segments of both rami in all four legs bear a few small spines on the posterior surface. The third segment of the endopod of leg 4 is  $47 \mu$  long, and its two spines are  $45 \mu$  (outer) and  $62 \mu$  (inner).

Leg 5 (fig. 38) has an elongated slightly arched free segment  $83 \times 31 \mu$ , bearing two terminal naked elements  $34 \mu$  and  $44 \mu$ . The segment is ornamented distally with two small spines. The naked seta near the free segment is  $30 \mu$ .

Leg 6 is probably represented by the seta and process near the area of attachment of each egg sac (fig. 27).

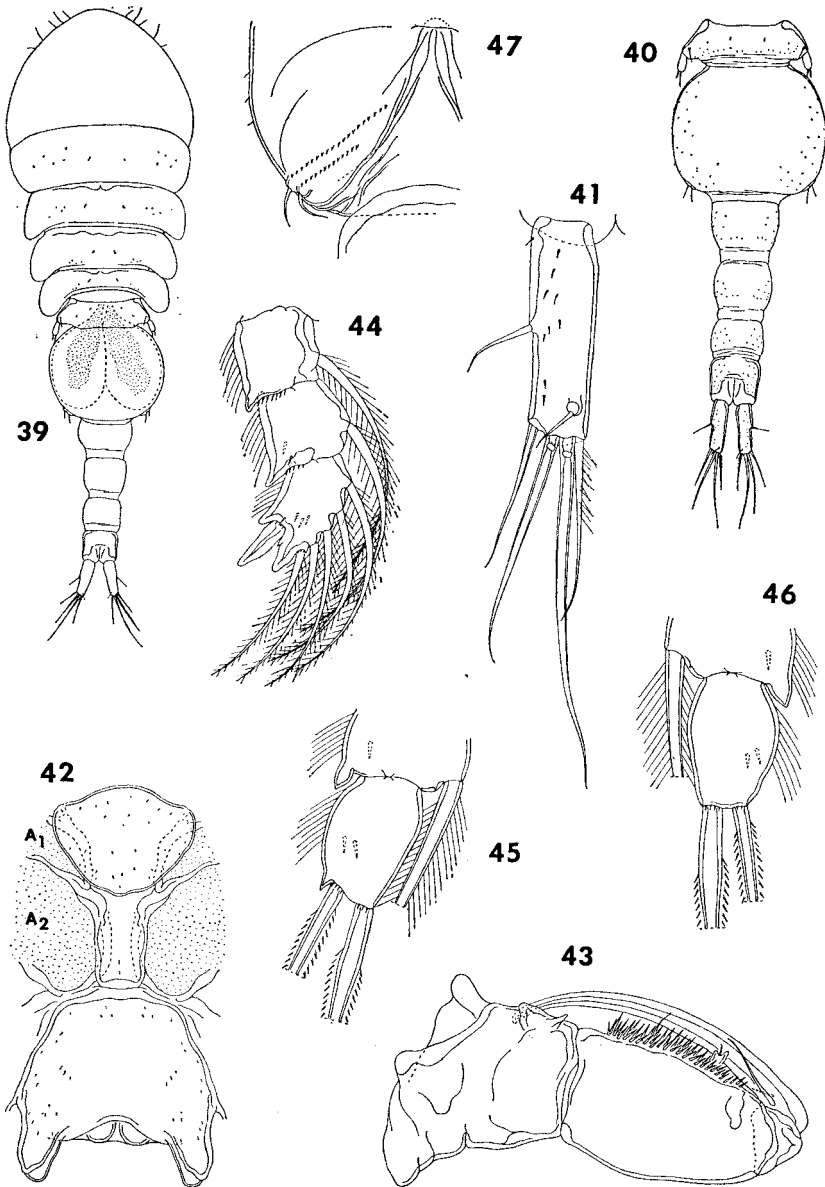
The color in life in transmitted light resembles that of *D. nasutum*.

Male. — The length of the body (fig. 39) is 1.63 mm (1.58-1.67 mm) and the greatest width 0.50 mm (0.45-0.54 mm), based on 2 specimens. The ratio of the length to the width of the prosome is 1.56 : 1. The ratio of the length of the prosome to that of the urosome is 1 : 1.



Figs. 33-38. *Diogenidium spinulosum* Stock, 1968, female. 33, maxilliped, anterior (E); 34, leg 1, anterior (D); 35, leg 2, anterior (D); 36, third segment of endopod of leg 3, anterior (D); 37, leg 4 and intercoxal plate, anterior (D); 38, leg 5, dorsal (E).

The segment of leg 5 (fig. 40) is  $83 \times 224 \mu$ . Between this segment and the genital segment there is no ventral intersegmental sclerite. The genital segment is  $247 \times 281 \mu$ , a little wider than long. The four postgenital segments are  $104 \times 127 \mu$ ,  $104 \times 107 \mu$ ,  $78 \times 100 \mu$ , and  $81 \times 94 \mu$  from anterior to posterior.



Figs. 39-47. *Diogenidium spinulosum* Stock, 1968, male. 39, dorsal (A); 40, urosome, dorsal (H); 41, caudal ramus, dorsal (E); 42, rostrum and labrum, ventral (D); 43, maxilliped, inner (D); 44, endopod of leg 1, anterior (E); 45, third segment of endopod of right leg 4, anterior (D); 46, third segment of endopod of left leg 4, anterior (D); 47, leg 6, ventral (G).

The caudal ramus (fig. 41) is relatively shorter than in the female,  $94\ \mu$  long,  $29\ \mu$  wide proximally and  $24\ \mu$  wide distally, the ratio of length to width being  $3.6 : 1$ .

The body surface has fine ornamentation similar to that of the female.

The rostrum (fig. 42), first antenna (with no aesthetes added), second antenna, labrum (fig. 42), mandible, paragnath, first maxilla, and second maxilla are like those of the female. The maxilliped (fig. 43) has a small sclerotized process on the inner distal surface of the first segment. The claw is  $170\ \mu$  along its axis.

The ventral surface between the maxillipeds and the first pair of legs is like that of the female.

Legs 1 to 4 are segmented and armed as in the female. Slight sexual dimorphism occurs in the endopod of leg 1 (fig. 44), where the terminal spiniform processes on the last segment are larger than in the female. The last segment of the endopod of leg 4 (in the single male dissected) has on the right (fig. 45) one outer spinous process and on the left (fig. 46) no such processes. This segment is a little shorter ( $35\ \mu$ ) in relation to the spines ( $42\ \mu$  and  $62\ \mu$ ) than in the female.

Leg 5 resembles that of the female.

Leg 6 (fig. 47) consists of a posteroventral flap on the genital segment, bearing two naked setae about  $33\ \mu$  long and two oblique rows of small spinules.

The spermatophore was not observed.

The color in life resembles that of the female.

Remarks. — Our two males from Jamaica agree closely with Stock's male holotype from the same host in Puerto Rico. A few minor supplementary points may be observed, such as the small aesthete on the fifth segment of the first antenna, the three setae on the first maxilla, and the inner distal process on the first segment of the maxilliped.

The females of *D. nasutum* and *D. spinulosum* may be easily distinguished by the following features of the latter: the rounded rostrum without a pointed beak, the stouter maxilliped, the spines rather than hairs on the inner margin of the basis of leg 1, the small spines on the posterior surface of the second and third segments of the rami of legs 1 to 4, the nature of the two elements on the free segment of leg 5, and the relatively shorter caudal ramus and its stronger sclerotization.

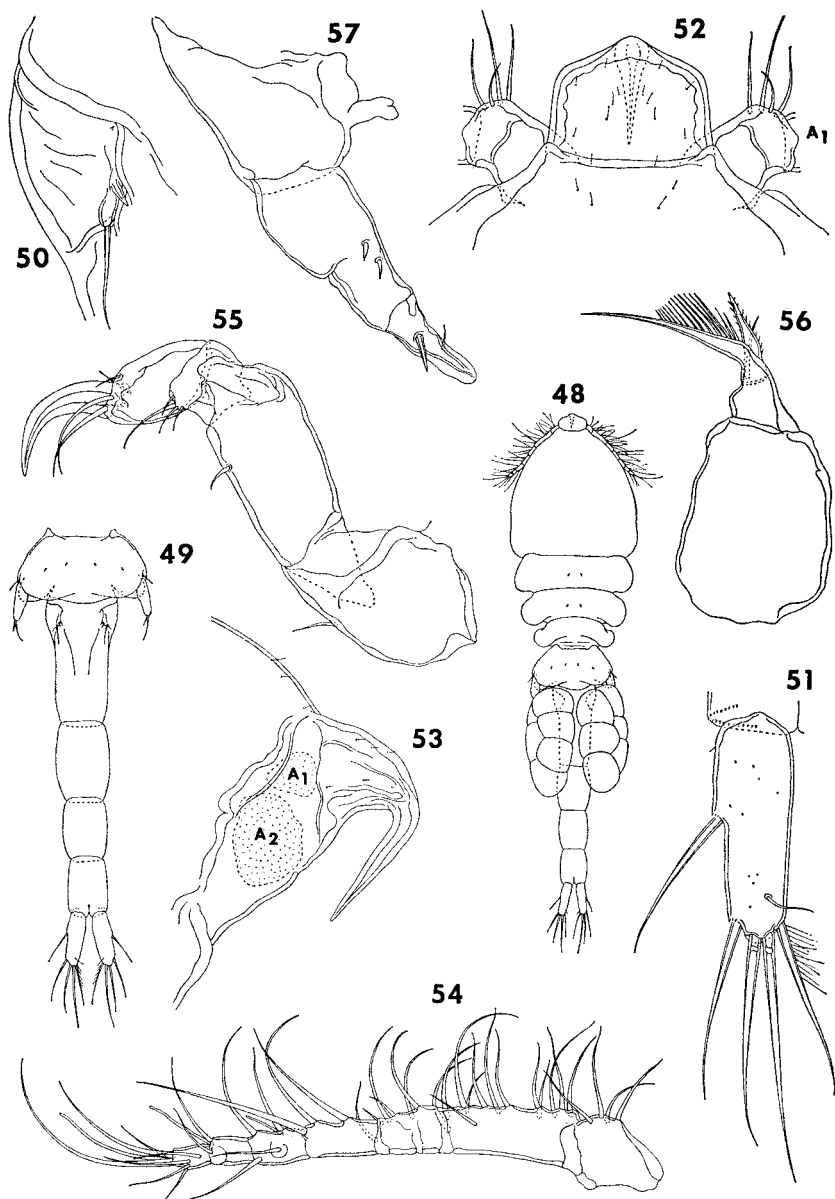
### **Diogenidium deforme** Stock, 1968 (figs. 48-72)

The description below is based upon specimens from *Brandtothuria arenicola* (Semper) unless otherwise stated.

Material examined (collected in 1959). — From *Brandtothuria arenicola* (Semper): 1 ♂ from 16 hosts, buried in intertidal sand, near Holetown, St. James, Barbados, 20 June; and 6 ♀♀ from 71 hosts, in 0.5 m, point north of Colony Club, St. James, Barbados, at about  $13^{\circ}12'15''\text{N}$   $59^{\circ}38'45''\text{W}$ , 22 June.

From *Ludwigothuria mexicana* (Ludwig): 2 ♀♀ from 15 hosts, in 0.5 m, small reef south of Magüeyes Island, near La Parguera, Puerto Rico, 31 July; 2 ♂♂ from 6 hosts, in 1 m, Cayo Enrique, south of La Parguera, Puerto Rico, 17 August; and 1 ♀ from 3 hosts, in 1 m, southern end of Pigeon Cay, North Bimini, Bahamas, 4 June.

Female. — The length of the body (fig. 48) is 1.44 mm (1.22-1.65 mm) and the greatest width 0.32 mm (0.25-0.36 mm), based on 7 specimens. The ratio of the length to the width of the prosome is 1.8 : 1. The ratio of the length of the prosome to that of the urosome is 1 : 1.15.



Figs. 48-57. *Diogenidium deforme* Stock, 1968, female. 48, dorsal (A); 49, urosome, dorsal (H); 50, area of attachment of egg sac, dorsal (C); 51, caudal ramus, dorsal (E); 52, rostrum, dorsal (E); 53, rostrum, lateral (E); 54, first antenna, dorsal (E); 55, second antenna, posterior (C); 56, second maxilla, posterior (C); 57, maxilliped, posterior (E).

The segment of leg 5 (fig. 49) is  $117 \times 221 \mu$ . Between this segment and the genital segment there is a short weakly developed ventral intersegmental sclerite. The genital segment is  $220 \mu$  long,  $130 \mu$  wide anteriorly, and  $101 \mu$  wide posteriorly. The areas of attachment of the egg sacs are located far anteriorly, with each area (fig. 50) bearing a naked seta  $44 \mu$  long, a spiniform process  $10 \mu$ , and a very minute seta (?)  $2 \mu$ . The three postgenital segments are  $138 \times 88 \mu$ ,  $101 \times 82 \mu$ , and  $91 \times 74 \mu$  from anterior to posterior. Near the posterior margin of the anal segment on both sides there is a row of small spines extending dorso-laterally and continuing ventrolaterally.

The caudal ramus (fig. 51) is  $94 \mu$  long,  $34 \mu$  wide proximal to the lateral seta, and  $26 \mu$  wide distal to this seta, the ratio of length to width being 3.1 : 1. (The much larger dimensions given by Stock, 1968, for his holotype appear to be in error, since there is a great discrepancy between them and the length of the caudal ramus in relation to body length as shown in his fig. 16a.) The six setae are naked except for the innermost terminal one which bears inner hairs. The outer lateral seta is  $69 \mu$ , the dorsal seta  $17 \mu$ , the outermost terminal seta  $72 \mu$ , the innermost terminal seta  $72 \mu$ , and the two median terminal setae  $83 \mu$  (outer) and  $105 \mu$  (inner). The dorsal surface of the ramus bears a few minute refractile points.

The body surface is for the most part unornamented, with only a few small hairs as in fig. 48.

The egg sac (fig. 48) is relatively small and oval,  $308 \times 140 \mu$ , contains six irregularly shaped eggs about  $105 \mu$  in diameter, and extends to about the middle of the first postgenital segment.

The rostrum (figs. 52 and 53) has a well-formed pointed beak.

The first antenna (fig. 54) is  $205 \mu$  long. The lengths of the seven segments are: 14 ( $39 \mu$  along its anterior margin), 50, 27, 32, 22, 18.5, and  $16.5 \mu$  respectively. The formula for the armature is the same as in *D. nasutum* and *D. spinulosum*, and all the setae are naked as in those species.

The second antenna (fig. 55) is armed as in the two previous species. The fourth segment is  $29 \mu$  along its outer edge,  $22 \mu$  along its inner edge, and  $18 \mu$  wide. The claw is  $39 \mu$  along its axis. The second segment lacks fine ornamentation.

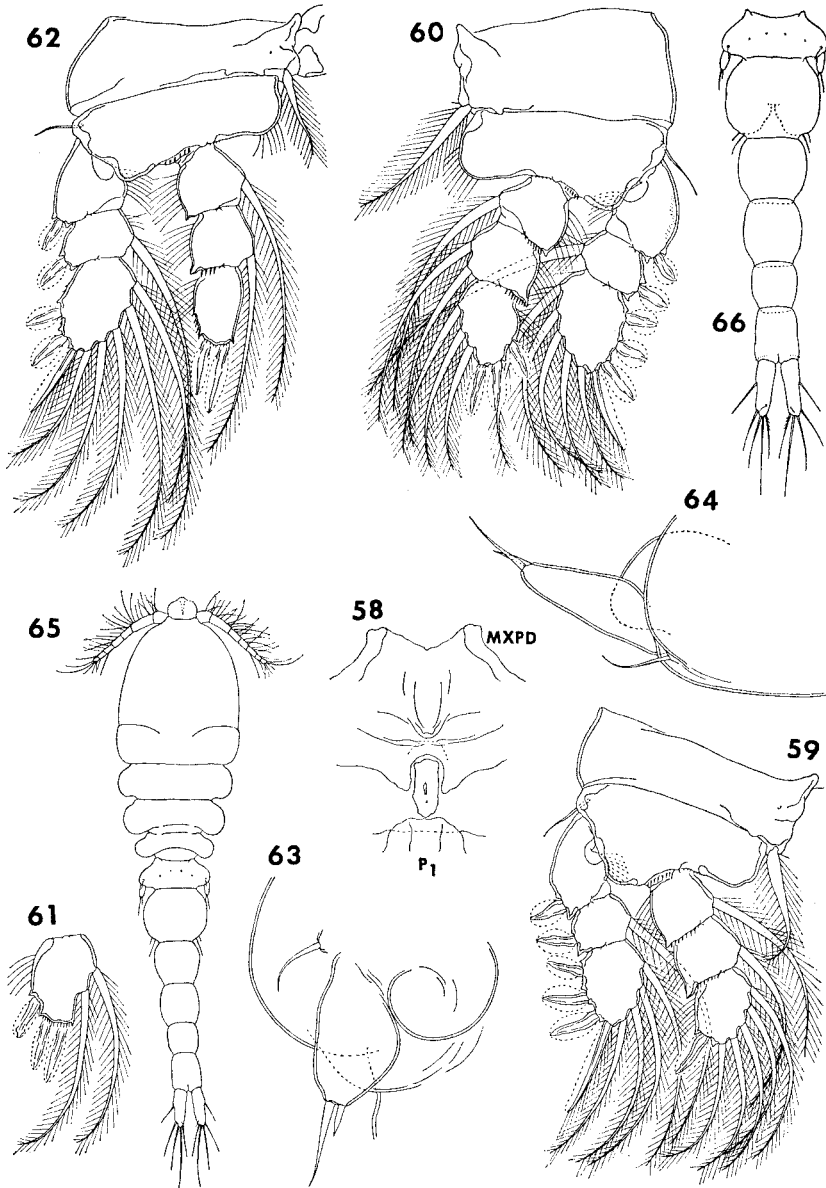
The labrum, mandible, paragnath, and first maxilla resemble those of *D. nasutum*. The second maxilla is shown in fig. 56 and the maxilliped in fig. 57 (the latter drawn from a specimen from *Ludwigothuria*).

The ventral surface between the maxillipeds and the first pair of legs (fig. 58, based on a specimen from *Ludwigothuria*) is not protuberant.

Legs 1 to 4 (figs. 59, 60, 61, and 62) have the same spine and setal formula as in *D. spinulosum*. The inner margin of the basis of leg 1 is naked. The membranous lamellae on the outer spines of the exopod of leg 1 have finely serrated edges, and are broader in specimens from *Brandtothuria* than in those from *Ludwigothuria*. The third segment of the endopod of leg 4 is  $33 \mu$  long, and its two spines are  $25 \mu$  (outer) and  $30 \mu$  (inner).

Leg 5 (figs. 63 and 64) has an unornamented free segment  $41 \times 24 \mu$

(measured in lateral view) bearing two terminal naked elements  $12\ \mu$  and  $32\ \mu$ . Ventral to the insertion of the segment there is a distinct rounded lobe. The naked seta near the segment is  $22\ \mu$ . In dorsal view (fig. 64) the free segment appears to be much more slender.



Figs. 58-64. *Diogenidium deforme* Stock, 1968, female. 58, area between maxillipeds and first pair of legs, ventral (G); 59, leg 1, anterior (E); 60, leg 2, anterior (E); 61, third segment of endopod of leg 3, anterior (E); 62, leg 4, anterior (E); 63, leg 5, lateral (E); 64, leg 5, dorsal (E).

Figs. 65-66. *Diogenidium deforme* Stock, 1968, male. 65, dorsal (H); 66, urosome, dorsal (B).



Leg 6 is probably represented by the long seta, spiniform process, and minute seta (?) near the attachment of each egg sac (fig. 50).

The color in life in transmitted light is similar to that of *D. nasutum*.

**Male.** — The length of the body (fig. 65) is 1.48 mm (0.96-1.79 mm) and the greatest width 0.34 mm (0.22-0.41 mm), based on 4 specimens (2 from *Brandothuria* and 2 from *Ludwigothuria*). The ratio of the length to the width of the prosome is 2.1 : 1. The ratio of the length of the prosome to that of the urosome is 1 : 1.

The segment of leg 5 (fig. 66) is  $57 \times 127 \mu$ . The ventral sclerite between this segment and the next is extremely weak. The genital segment is  $96 \times 112 \mu$ . The four postgenital segments are  $81 \times 82 \mu$ ,  $75 \times 69 \mu$ ,  $52 \times 56 \mu$ , and  $65 \times 54 \mu$  from anterior to posterior.

The caudal ramus is similar to that of the female, but smaller,  $66 \mu$  long,  $22 \mu$  wide proximal to the seta, and  $17 \mu$  wide distally.

The body surface lacks ornamentation almost entirely.

The rostrum, first antenna (without aesthetes added), second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla are like those of the female. The maxilliped (fig. 67) has a relatively short claw  $75 \mu$  along its axis. The second segment bears a seta, a modified trifid element, and numerous small spines (fig. 68, based on a specimen from *Ludwigothuria*).

The ventral surface between the maxillipeds and the first pair of legs is like that of the female.

Legs 1 to 4 are segmented and armed as in the female. The endopod of leg 1 shows slight sexual dimorphism, with the spine on the third segment (fig. 69) much more sclerotized than in the female and lacking membranous lamellae. The last segment of the endopod of leg 4 is  $33 \mu$  long, with the outer spine  $28 \mu$ , the inner  $35 \mu$ .

Leg 5 (fig. 70), as seen in lateral view, shows a less broadened free segment than in the female,  $35 \times 23 \mu$ . Its terminal naked elements are  $21 \mu$  and  $34 \mu$ , and the naked seta near the segment is  $29 \mu$ . There is no lobe near the insertion of the segment, as in the female. In dorsal view (fig. 71) the free segment appears more slender.

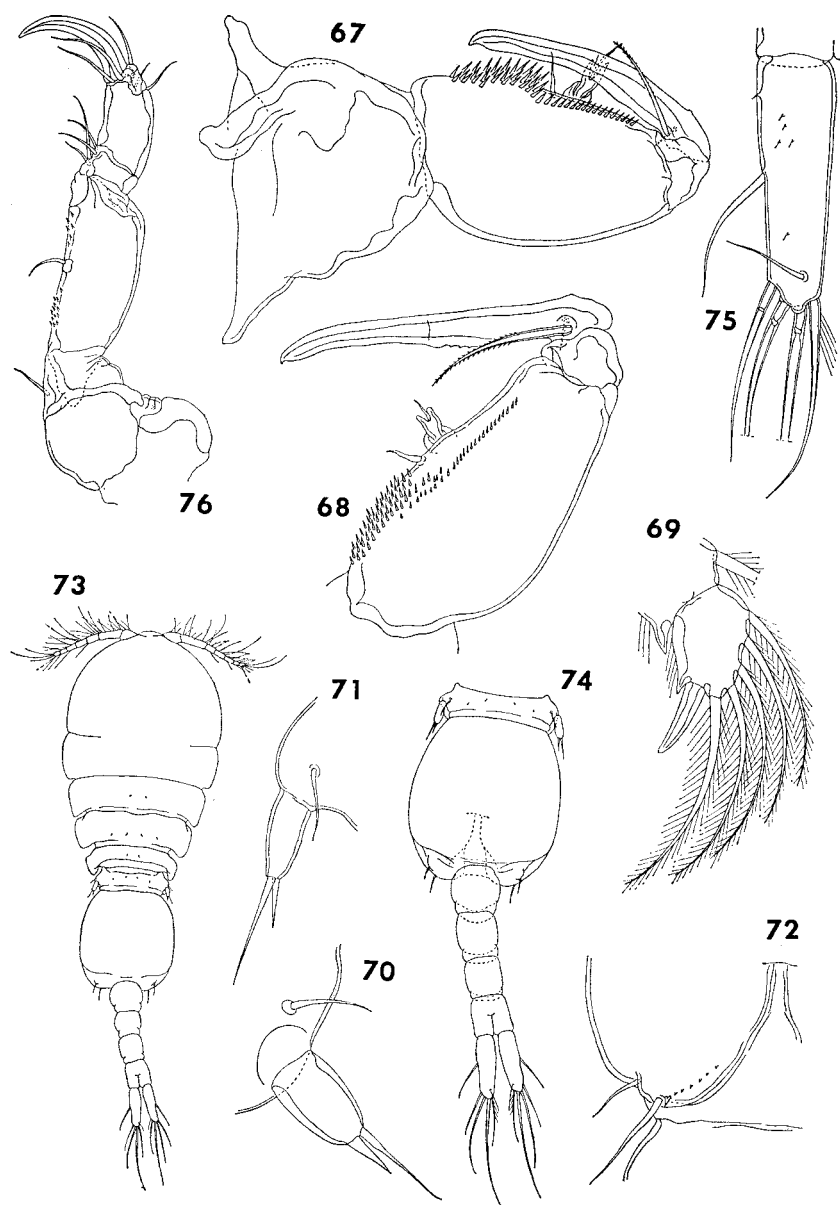
Leg 6 (fig. 72) consists of a posteroventral flap on the genital segment, bearing two naked setae  $17 \mu$  and  $28 \mu$  and a short oblique row of small spinules.

The spermatophore was not observed.

The color in life resembles that of the female.

**Remarks.** — Although our specimens of *D. deforme* conform closely to Stock's original description, there are several minor differences. (In order to verify certain features we have studied the slides of the holotype and allotype from the Zoölogisch Museum in Amsterdam.) The differences may be listed as follows:

1) Both holotype ♀ and allotype are a little larger than our specimens (♀ 2.273 mm, ♂ 1.751 mm in length, according to Stock, 1968).



Figs. 67-72. *Diogenidium deformis* Stock, 1968, male. 67, maxilliped, inner (C); 68, maxilliped, first segment not shown, inner (E); 69, third segment of endopod of leg 1, anterior (C); 70, leg 5, lateral (E); 71, leg 5, dorsal (E); 72, leg 6, ventral (C).

Figs. 73-76. *Diogenidium tectum* n. sp., male. 73, dorsal (A); 74, urosome, dorsal (H); 75, caudal ramus, dorsal (E); 76, second antenna, posterior (E).

2) The ornamentation of the elements on the second segment of the second maxilla is slightly different (compare our fig. 56 with Stock's 16a).

3) The tip of the maxilliped of the female is less drawn out in Stock's specimen (compare our fig. 57 with his 15j).

4) The small lobe near the insertion of the free segment of leg 5 of the female is not visible in the holotype.

5) The spines on the second segment of the maxilliped of the male do not extend distal to the two elements in the allotype (compare our fig. 68 with Stock's 16b).

The first antenna of the holotype has 4 setae and 1 aesthete on segment 5, and 2 setae and 1 aesthete on segment 6, as in other species of the genus.

The differences just enumerated are not in our opinion of specific value, but rather are the expression of intraspecific variability. They may be related to the host species, since Stock's types came from *Holothuria glaberrima*, but our material was recovered from two other species of holothurians, *Brandtothuria arenicola* and *Ludwigothuria mexicana*.

### ***Diogenidium tectum* n. sp. (figs. 73-86)**

Type material. — 2 ♂♂ from 19 *Actinopyga agassizii* (Selenka), in 2 m, Drunken Man's Cay, off Port Royal, Jamaica, 3 September 1959. Holotype deposited in the United States National Museum, Washington. Paratype (dissected) in the collection of A. G. Humes.

Other specimen. — 1 ♂ from 45 *Actinopyga agassizii*, in 2 m, off the Lerner Marine Laboratory, North Bimini, Bahamas, 3 June 1959.

Female. — Unknown.

Male. — The length of the body (fig. 73) is 1.41 mm (1.38-1.45 mm) and the greatest width 0.43 mm (0.42-0.45 mm), based on 3 specimens. The ratio of the length to the width of the prosome is 1.54 : 1. The ratio of the length of the prosome to that of the urosome is about 1 : 1.

The segment of leg 5 (fig. 74) is  $60 \times 222 \mu$ . Between this segment and the genital segment there is no ventral intersegmental sclerite. The genital segment is about as long as wide,  $286 \times 275 \mu$ . The four postgenital segments are  $81 \times 96 \mu$ ,  $78 \times 78 \mu$ ,  $68 \times 68 \mu$ , and  $70 \times 70 \mu$  from anterior to posterior. The posterior margin of the anal segment is unornamented.

The caudal ramus (fig. 75) is  $106 \mu$  long,  $33 \mu$  wide proximal to the lateral seta, and  $25 \mu$  wide distal to this seta, the ratio of length to width being 3.66 : 1. The six setae are relatively longer than in other species and all naked except the innermost terminal one which has inner hairs. The outer lateral seta is  $60 \mu$ , the dorsal seta  $34 \mu$ , the outermost terminal seta  $82 \mu$ , the innermost terminal seta  $94 \mu$ , and the two median terminal setae  $143 \mu$  (outer) and  $208 \mu$  (inner). A minute spinule  $3 \mu$  occurs on the proximal outer margin of the ramus.

The surface of the body is unornamented except for a few small hairs as in fig. 73.

The rostrum is similar to that of *D. nasutum*, with a pointed beak. The first antenna resembles that of *D. deforme*. The length is  $252 \mu$ , with the segments

17 ( $42\ \mu$  along its anterior edge), 65, 22, 39, 32, 26, and  $26\ \mu$  respectively. All the setae are naked.

The second antenna (fig. 76) has the formula 1, 1, 4, and I + 6. The fourth segment is  $45\ \mu$  along its outer edge,  $26\ \mu$  along its inner edge, and  $21\ \mu$  wide. The inner surface of the second segment bears small spines.

The labrum, mandible, paragnath, first maxilla, and second maxilla resemble those of *D. nasutum*. The maxilliped (fig. 77) is slender. The claw is  $192\ \mu$  along its axis. In one male there is a small membranous projection on the concave edge of the claw; in another male this edge of the claw is smooth.

The ventral surface between the maxillipeds and the first pair of legs (fig. 78) is not protuberant.

Legs 1 to 4 (figs. 79, 80, 81, and 82) have the same spine and setal formula as in *D. spinulosum* and *D. deforme*. The inner margin of the basis of leg 1 bears a few hairs. The third segment of the endopod of leg 4 is  $39\ \mu$  long, and its two spines are  $23\ \mu$  (outer) and  $29\ \mu$  (inner). The outer margin of this segment may vary in outline in the same individual, either smooth (fig. 82, right leg) or with two spiniform processes (fig. 83, left leg), or with one such process (fig. 84, right leg) or three processes (fig. 85, left leg).

Leg 5 (fig. 86) has an unornamented free segment  $37 \times 15\ \mu$ .

Leg 6 consists of an unornamented posteroventral flap on the genital segment, bearing two naked setae  $20\ \mu$  and  $30\ \mu$ .

The spermatophore was not observed.

The color in life in transmitted light is opaque white, the eye red.

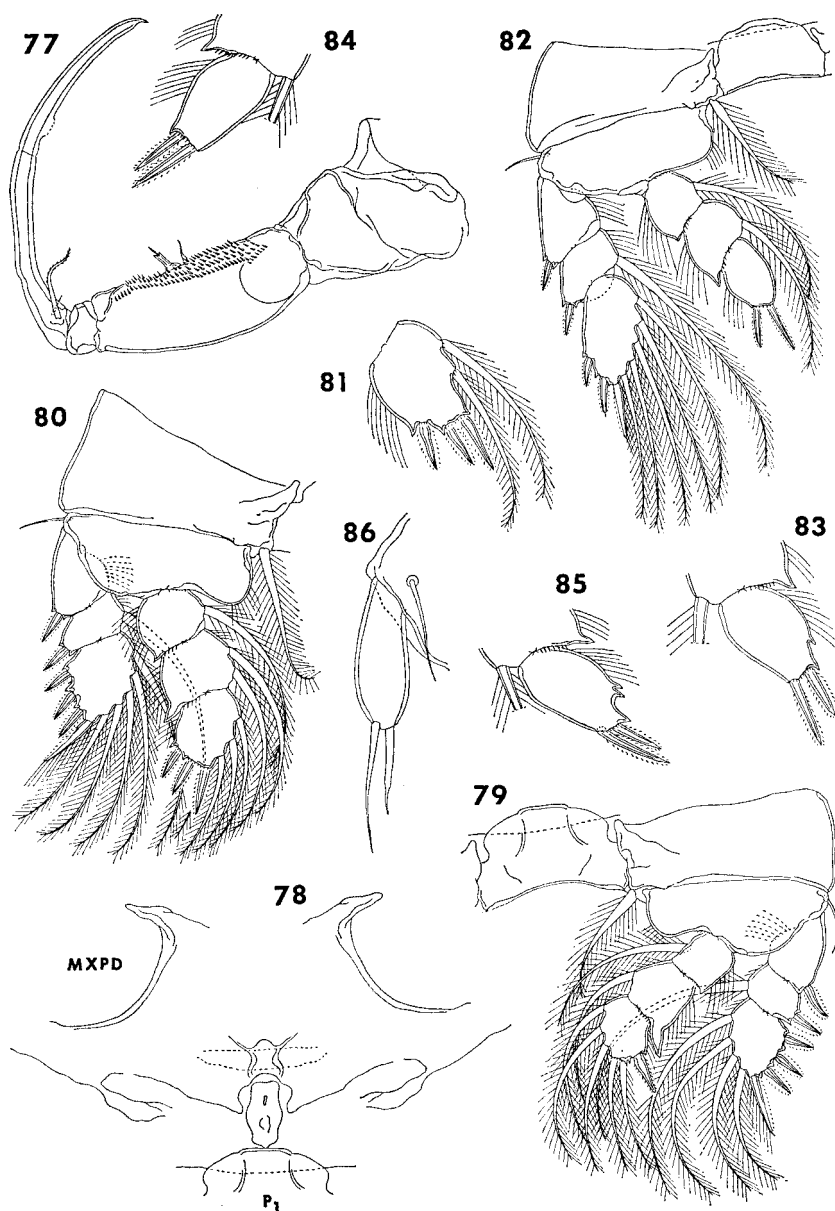
**Etymology.** — The specific name *tectum*, from Latin = concealed or protected, alludes to the sheltered habitat within the host.

**Remarks.** — The new species may be distinguished from the three other species in the genus by the longer terminal setae on the caudal ramus, the small spines on the second segment of the second antenna, the slender second segment of the maxilliped with the spines extending distal to the modified trifold seta, and the absence of small spinules on leg 6.

On the basis of identical host species one might be tempted to regard our specimens from *Actinopyga agassizii* as Edwards' *D. nasutum*. However, in spite of the imperfect nature of Edwards' figures, a close comparison will show that our copepods from *A. agassizii* do not represent *D. nasutum*. Two features of *D. nasutum* by which it differs from *D. tectum* are: the relatively short setae on the caudal rami (Edwards' pl. 4 fig. 12), and the spinose area on the second segment of the male maxilliped not extending beyond the two elements (Edwards' pl. 4 fig. 14).

#### KEY TO THE SPECIES OF DIOGENIDIUM (FEMALE OF *D. TECTUM* N. SP. UNKNOWN)

1. Rostrum without a pointed beak; segments 2 and 3 of rami of legs 1 to 4 with small spines on posterior surface . . . . . *D. spinulosum*
- Rostrum with a pointed beak; without such spines on the rami of legs 1 to 4 . . . . . 2



Figs. 77-86. *Diogenidium tectum* n. sp., male. 77, maxilliped, inner (D); 78, area between maxillipeds and first pair of legs, ventral (D); 79, leg 1 and intercoxal plate, anterior (D); 80, leg 2, anterior (D); 81, third segment of endopod of leg 3, anterior (E); 82, leg 4 and intercoxal plate, anterior (D); 83, third segment of endopod of left leg 4, anterior (E); 84, third segment of endopod of right leg 4, anterior (E); 85, third segment of endopod of left leg 4, anterior (E); 86, leg 5, dorsal (C).

2. Second segment of second antenna unornamented . . . . . *D. deforme*  
 — Second segment of second antenna with outer spinules . . . . . 3
3. Longest terminal seta on caudal ramus shorter than ramus; armature of last segment of exopod of leg 2 usually II, I, 5, but sometimes III, I, 5 . . . . . *D. nasutum*  
 — Longest terminal seta on caudal ramus about twice the length of ramus; armature of last segment of exopod of leg 2 always III, I, 5 . . . . . *D. tectum*

## RÉSUMÉ

Quatre espèces de copépodes cyclopoïdes du genre *Diogenidium* vivent comme endoparasites dans les holothuries des Indes Occidentales. Trois de ces espèces, *D. nasutum* Edwards, 1891, *D. deforme* Stock, 1968, et *D. spinulosum* Stock, 1968, sont redécrites; la femelle de *D. spinulosum* est décrite pour la première fois. Une quatrième espèce, *D. tectum* n. sp., est décrite d'*Actinopyga agassizii*.

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