

Solenogaster Mollusks from Southern California

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THE SOLENOGASTER MOLLUSKS named below were collected off southern California by the research vessel "Velero IV" of the University of Southern California, Los Angeles, California, during the course of quantitative surveys made along the shelf and slope marine bottoms from Santa Barbara, California, to south of the Mexican border. Depths of bottoms ranged from shallow shelf (about 20 m) to deep offshore basins (about 1800 m). Most station numbers referred to in the text have been published in the Pacific Expedition series of the Hancock Foundation; they can be consulted in volumes 19 and 22. Data for additional station numbers are given in the Appendix to this report. The types of all new species and duplicates after the first are deposited in the collections of the Allan Hancock Foundation at the University of Southern California; a first set of duplicates is retained by the author.

Solenogasters have been previously recorded from California, based on collections of the USS "Albatross," and described by Heath (1911 and 1918). They were taken during dredging operations and the specimens can be only approximately located with respect to precise place, depth, and kinds of sediments.

Figures 1 and 2 plot the distributions of solenogasters taken from sea bottoms between the mainland of California and Santa Catalina Island. The dots locate the positions of intersections; they mark the even-numbered minutes of latitude and longitude, and are about 2 nautical miles apart. This area is more completely detailed in Hartman (1955). A large impoverished subsill area in the deepest part of the Channel sustains almost no life. The surrounding fringe and shelf in shallower bottoms supports characteristic kinds of solenogasters, as indicated by the symbols used in the two charts.

The diagnoses of the species require a few comments. The illustrations of the spines show only typical kinds, as these structures show strong individual variations. Nevertheless certain features, such as comparative size, being strongly keeled or not, and others, remain constant throughout the species. The small letters, *a, b, c, d*, used in the figures, refer to the body regions from which the spicules were taken and can be ascertained by reference to the entire figure of *Crystallophrisson recisum* n. sp.

I have come to the conviction that the so-called subradular organ of the *Crystallophrissonidae* is primarily the papilla bearing the outlets of a third group of salivary glands, which up to now has escaped the attention of other authors. It is not a sensory organ. A small number of gland follicles is situated ventrally of the fore-gut and just in front of the radula. The cells of these follicles resemble those of the lateral salivary glands, which empty their secretion through more or less well-defined ducts. An unpaired, subradular ganglion is situated among these gland follicles and was found present in each species examined; therefore, it has not been specially mentioned.

Limifossor fratula, *Crystallophrisson nanulum*, and *C. scabrum* have been described by Heath (1911, 1918); for these, abbreviated diagnoses are given.

GENUS *Limifossor* Heath, 1904

Type *L. talpoides* Heath, 1904

Limifossor fratula Heath, 1911

Heath, 1911, pp. 44, 72.

COLLECTIONS:

2189 (9) in 228 fm, with *Crystallophrisson hartmani* and *C. scabrum*.

2190 (1) in 186 fm.

2218 (1) in 249 fm, with *C. hartmani*.

2220 (3) in 180 fm, with *C. hartmani* and *C. nanulum*.

¹ Berlin Lichterfelde Kommandantenstrasse 18, Germany. Manuscript received November 22, 1961.

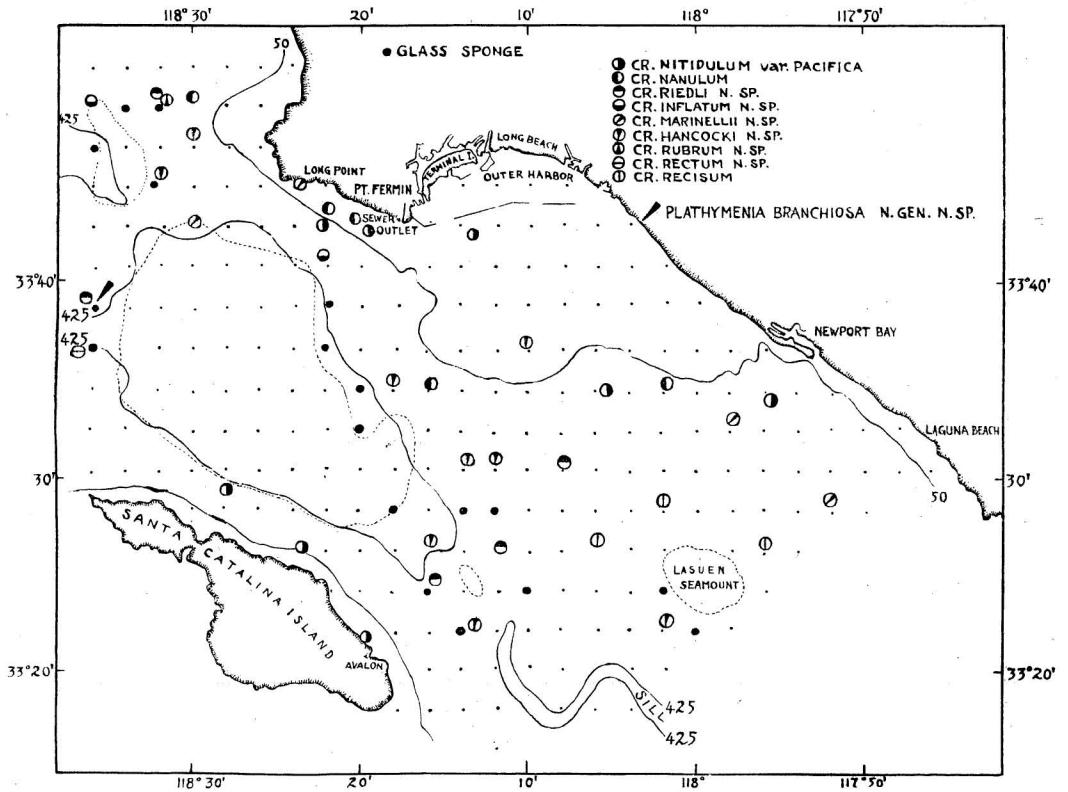


FIG. 1. The San Pedro area between the mainland of southern California and Santa Catalina Island, showing the distribution of species of solenogasters in different locations. Other data are from Hartman, 1955.

- | | |
|--|--|
| 2221 (2) in 147 fm, with <i>C. nanulum</i> . | 2500 (1) in 450 fm. |
| 2230 (1) in 300 fm, with <i>Prochaetoderma californicum</i> and <i>C. bartmani</i> . | 2612 (1) in 100 fm, with <i>C. nanulum</i> . |
| 2231 (3) in 115 fm, with <i>Crystallophrisson</i> sp. | 2625 (6) in 230 fm, with <i>C. bartmani</i> and <i>C. nanulum</i> . |
| 2293 (1) in 252 fm, with <i>C. sp.</i> | 2644 (4) in 310 fm, with <i>C. bartmani</i> and <i>C. rectum</i> . |
| 2297 (1) in 181 fm. | 2723 (2) in 325 fm, with <i>C. bartmani</i> and <i>C. hancocki</i> . |
| 2306 (3) in 215 fm, with <i>C. scabrum</i> . | 2738 (1) in 342 fm, with <i>C. bartmani</i> and <i>C. sp.</i> |
| 2329 (1) in 260 fm. | 2749 (1) in 277 fm, with <i>C. scabrum</i> . |
| 2337 (1) in 170 fm, with <i>C. sp.</i> | 2792 (1) in 300 fm, with <i>Crystallophrisson</i> sp. |
| 2361 (4) in 167 fm, with <i>C. nanulum</i> , <i>C. bartmani</i> and <i>C. sp.</i> | 2851 (1) in 230 fm, with <i>C. sp.</i> |
| 2362 (2) in 352 fm, with <i>C. bartmani</i> . | 3704 (1) in 115 fm, with <i>C. nitidulum pacifica</i> . |
| 2404 (1) in 438 fm. | 3731 (2) in 275 fm, with <i>C. incrassatum</i> . |
| 2412 (1) in 324 fm, with <i>C. bartmani</i> and <i>C. hancocki</i> . | 4756 (2) in 202.2 m. |
| 2418 (2) in 185 fm, with <i>C. scabrum</i> and <i>C. nitidulum pacifica</i> . | |
| 2430 (2) in 80 fm, with <i>C. sp.</i> | |

- 4776 (1) in 167.1 m, with *Crystallophrisson* sp.
- 4778 (1) in 215.8 m, with *C.* sp.
- 4835 (1) in 140 m.

DIAGNOSIS: The body is short, about 10 mm long; the radula is very large, distichous, and has 28 transverse rows. This organ with its muscles is heavier than that in *L. talpoides*. Dorsal salivary glands are present. The stomach and digestive glands are well developed and distinct from the intestine. Color is slate gray with a yellowish cast. Spicules from the middle of the body measure 0.5 mm long. The length index is 1.3–4.7.

DISTRIBUTION: Two individuals were reported by Heath (1911) from southern California in 260–284 fm. The present collection contains 64 specimens; 14, or 21.9%, come from depths of 77 and 150 fm; 31, or 48.8%,

are in 150 to 245 fm; 19, or 29.7%, in depths greater than 245 and 450 fm. The habitats are on various substrata, but certain kinds were selected: 52 individuals, or 81.2%, on clay, 1 on silt, 1 on rocks and mud, and 3 on clayey mud.

The station numbers refer to localities that are either in the San Pedro channel area (Fig. 2), in Santa Monica Bay to the north, or in Redondo canyon or the San Pedro Sea valley.

GENUS *Plathymenia* Schwabl, 1961

Type *P. branchiosa* Schwabl, 1961

Schwabl, 1961*b*, p. 100, figs. 1–5.

Neomeniid with short and plump body; the spicules are hollow needles. The body has a subterminal atrial opening and a terminal slit-like dorsoventral cloacal opening. Cirri in the atrial chamber are reduced; the fore-gut is

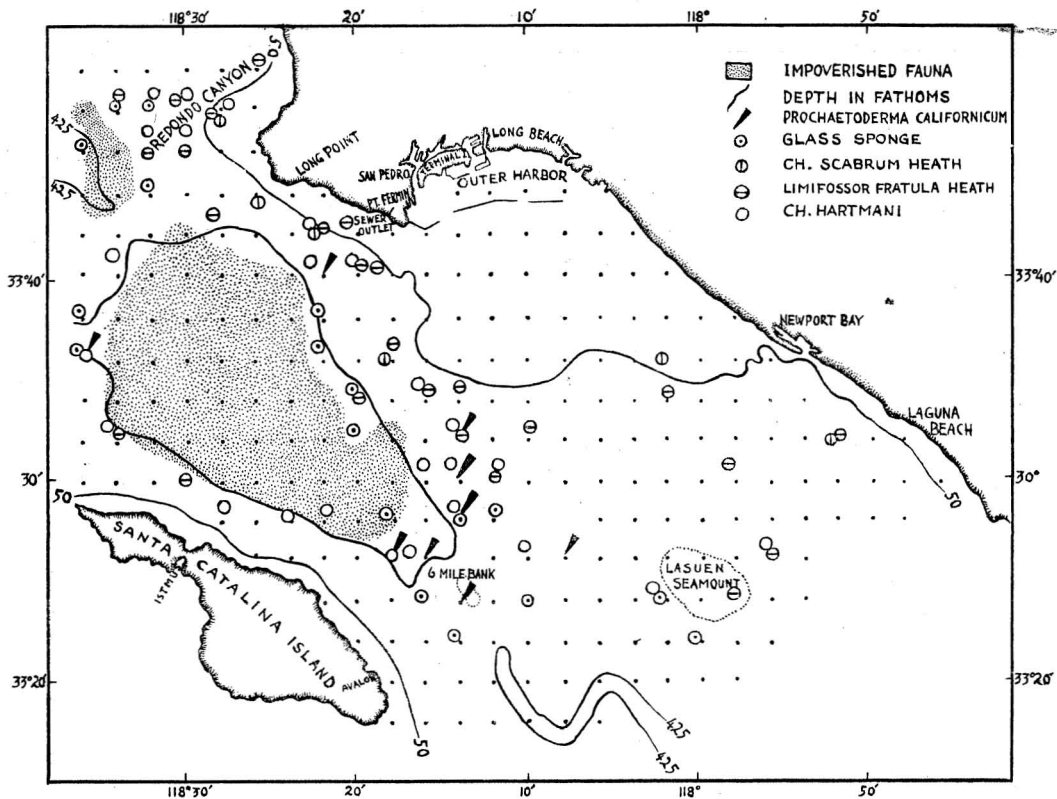


FIG. 2. The San Pedro area between the mainland of southern California and Santa Catalina Island, showing the distribution of species of solenogasters in different locations. Other data are from Hartman, 1955.

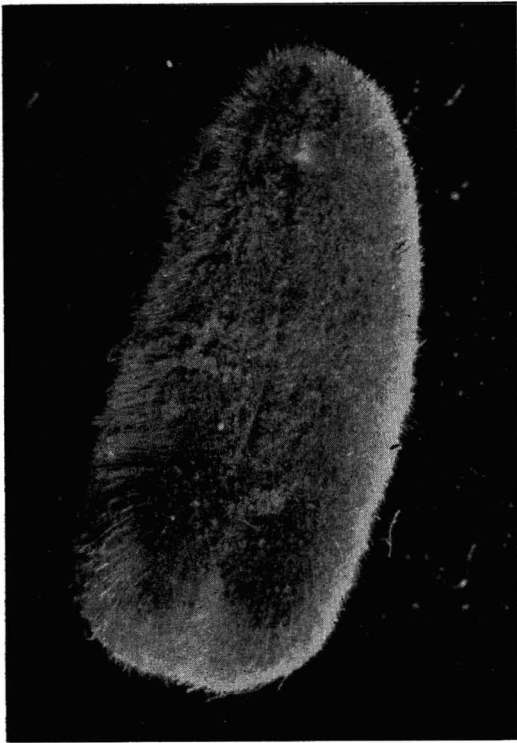


FIG. 3. *Plathymenia branchiosa*. Sta. 2324.

without a radula but has unicellular subepithelial (=dorsal diffuse) and very small ventral salivary glands; a well-developed oesophagus with villi is surrounded by numerous gland-follicles. The mid-gut is largely divided into diverticles, and the gonads also have large lateral diverticles. The brain is bilobed, has a dorsoterminal organ of the *Entonomenia* type. The shell-gland has subepithelial glands; there are no copulatory organs.

The genus is known for a single species, *P. branchiosa* Schwabl.

Plathymenia branchiosa Schwabl, 1961

Fig. 3

Schwabl, 1961*b*, p. 100, figs. 1-5.

COLLECTION: 2324 (1) in 400 fm, with *Crystallophrisson riedli* n. sp.

DIAGNOSIS (translated from the German): The species has the characteristics of the genus. The body is flattened ventrally; length of the body is 10 mm, width 2.5 mm. There is no

dorsal keel but a tapering front end and a broadened or rounded hind end. Color in alcohol is muddy gray. The cuticle is heavy and there are no epidermal papillae. The spicules are hollow, straight or slightly curved needles, the radial ones up to 700 μ long, the tangential ones up to 100 μ . The ventral furrow is distinctly separated from the cloacal opening, one single ventral fold. About 30 sensory setae in epidermal pockets surround the atrial opening. The muscles are very weak. The parenchyma of the hind end has a gelatinous basic substance. The pericardium is very large and has short distal appendages. The ventricle for half its length is dorsally connected with the pericardium, the auricle is free, and has two atrio-ventricular openings. A large cloacal chamber has about 110 simple radial gill-folds. There are no abdominal spicules.

DISTRIBUTION: This species is known through a single specimen from the San Pedro area, in 400 fm, in mud with glass sponge.

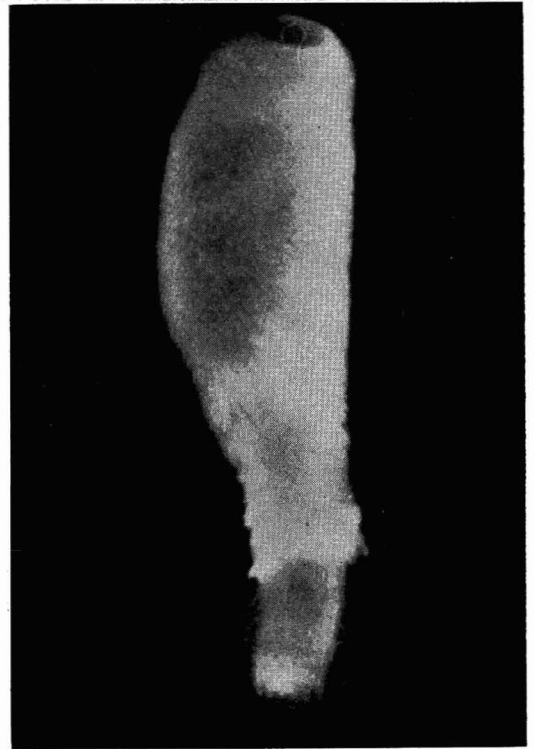


FIG. 4. *Prochaetoderma californicum* n. sp. Sta. 2802-54.

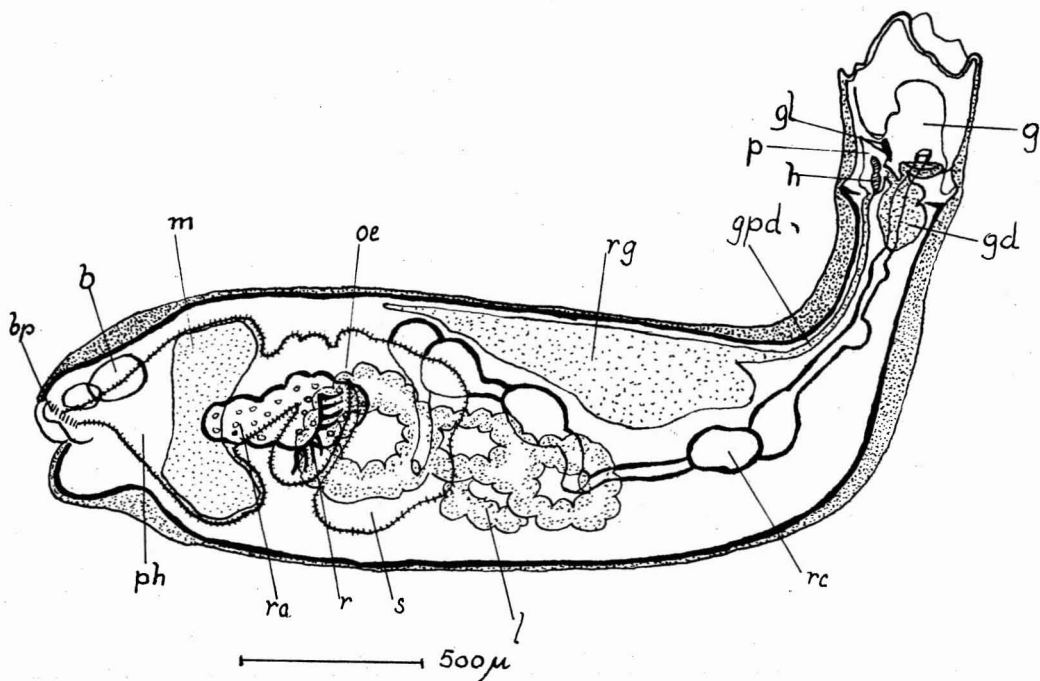


FIG. 5. *Prochaetoderma californicum*. Diagram of entire animal, showing arrangement of internal organs. *b*, Brain; *bp*, buccal plate; *g*, gill; *gd*, gonoduct; *gpd*, gonopericardial duct; *gl*, ganglion; *h*, heart; *l*, liver; *m*, mandible; *oe*, oesophagus; *p*, pericardium; *ph*, pharynx; *r*, radula; *ra*, radula cartilage; *rc*, rectum; *rg*, reproductive gland; *s*, stomach.

GENUS *Prochaetoderma* Thiele, 1902

Type *P. raduliferum* (Kowalevsky) 1901

2899 (3) in 335 fm.

3037 (1) in 360 fm.

Prochaetoderma californicum n. sp.

Figs. 4-7

COLLECTIONS:

2228 (1) in 293 fm.

2230 (3) in 300 fm, with *Limifossor fratula* and *Crystallophrisson bartmani*.

2321 (34) in 385 fm, with *C. bartmani* and *C. sp.*

2363 (2) in 429 fm, with *C. marinellii* and *C. sp., juv.*

2411 (4) in 400 fm, with *C. bartmani*, *C. hancocki*, and fragments.

2798 (5) in 386 fm, with *C. bartmani* and *C. recisum*.

2802 (1) in 420 fm, with *C. bartmani*.

2837 (2) in 454 fm, with *C. bartmani*.

2839 (6) in 446 fm, with *C. bartmani* and *C. hancocki*.

DIAGNOSIS: These very small animals measure 2.25 to 3.05 mm in length; greatest diameter is 0.42-0.85 mm; they show a very characteristic habitus (Fig. 4); a short head region is not separated from the following trunk region (Fig. 5) but is distinguished from it by the spines, which are small leaflike structures (Fig. 7), densely arranged and mostly standing upright on the body wall. The following region, occupying the greater part of the body and containing such main organs as stomach or mid-gut, liver, and gonads, is covered by flat imbricating spines arranged obliquely towards the dorsal midline of the body. The tail-like hind part of the body is provided with spicules resembling those of the head region but of larger size. The terminal end, containing part of the gonoducts, pericardium, and cloacal chamber with its organs, is protected by a

brushlike wreath of long and pointed thorn-like spicules.

The mouth opening is flanked by the paired triangular buccal plate, and the entire front end can be withdrawn into the semicircular groove. The subepidermal muscle layers, with the exception of those in the tail region, are very weak, and the diagonal one is almost totally lacking. Three pairs of distinct retractors in the front end, and six pairs of gill retractors, pass laterally from the pericardium and are present with the thick radula muscles.

The nervous system consists of paired brain lobes, the two halves connected by a strong commissure and of three pairs of precerebral ganglia. The buccal connective leaves the brain separately, whereas the lateral and ventral ones have a common root. The buccal system consists of three ventral commissures and a single dorsal one; an unpaired subradular ganglion is present.

The digestive tract begins with a wide phar-

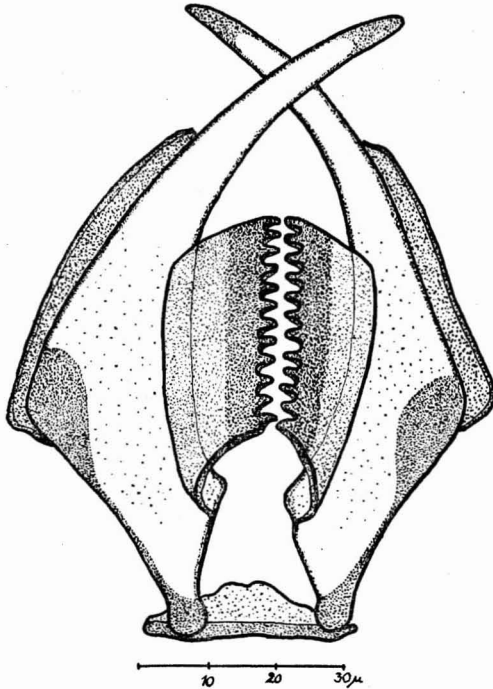


FIG. 6. *Prochaetoderma californicum*. A transverse row of the distichous radula, showing basal plate, tooth, and lateral plate.

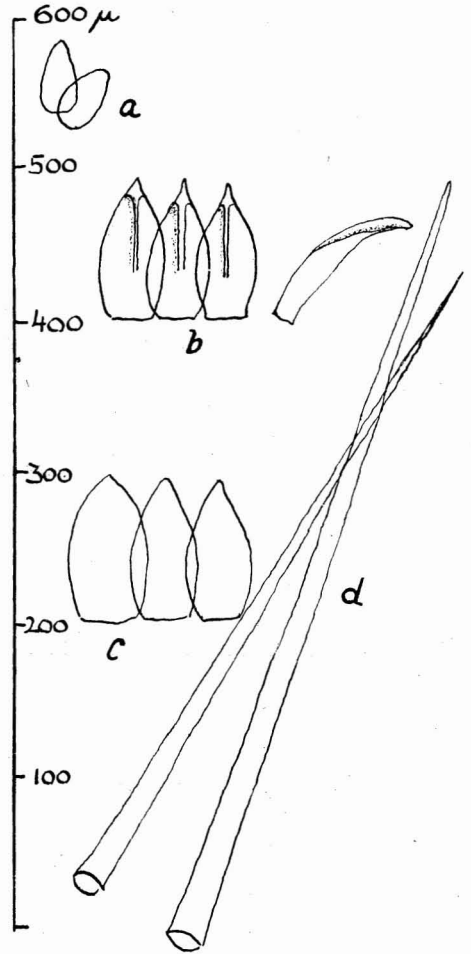


FIG. 7. *Prochaetoderma californicum*. Different kinds of spines from body regions a, b, c, d, illustrated in Fig. 9.

ynx, its epithelium bearing a distinct cuticle which, in two large lateral pockets, is differentiated into a pair of mandibles. Small salivary glands are developed at the junction of the pharynx and the short ciliated oesophagus. A glandular subradular organ lies in front of the large distichous radula; it consists of 9-12 transverse rows of teeth (Fig. 6) and is situated in a distinct radular sack. The oesophagus connects with a short wide stomach from which the long rectum and the short sacculate liver originate.

The reproductive organs consist of a short reproductive gland, a long unpaired (!) gonopericardial duct, and the typical gonoducts with their ciliated glandular parts. The pericardium is wide and short, its appendages unite ventrally and surround the supra-rectal ganglion as well as the distinct gill-sinus, but do not extend backwards along the cloacal chamber. Blood cells are present. The animal possesses two pairs of gills of a rather primitive structure.

DISTRIBUTION: Southern California, chiefly in the San Pedro area; 62 specimens all from considerable depth, between 293 and 454 fm. Eleven samples were taken, 9 from mud (5 in the glass sponge area), and only 2 samples (with 4 specimens) came from other than mud (gravel or sandy mud). Figure 4 shows one from station 2802.

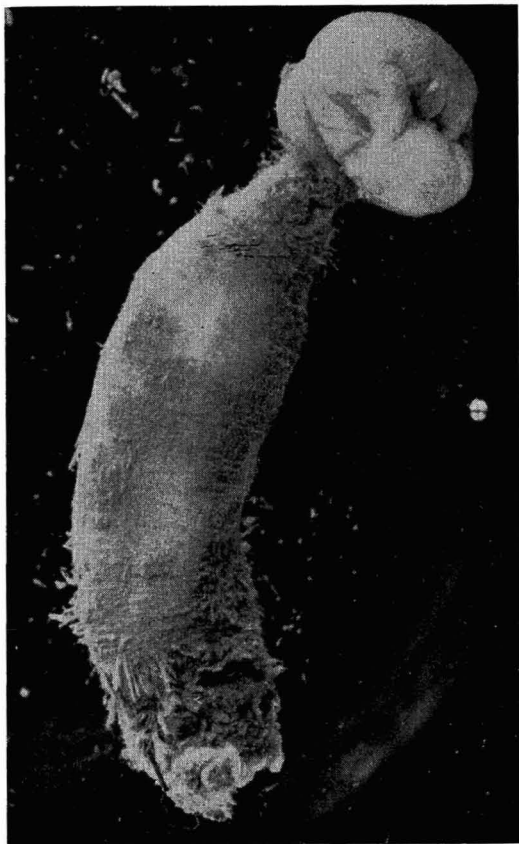


FIG. 8. *Crystallophrisson incrassatum*. Sta. 3831-55.

GENUS *Crystallophrisson* Möbius, 1875

Type *C. nitidulum* (Lovén) 1844

Includes *Chaetoderma* Lovén, 1845, preoccupied in Pisces by Swainson, 1839 (see Thiele, 1932).

Crystallophrisson incrassatum n. sp.

Fig. 8

COLLECTIONS:

3731 (2) in 275 fm, with *Limifossor fratula*.
3733 (2) in 305 fm.

DIAGNOSIS: The animals were very poorly preserved; the diagnosis therefore is largely based on external appearances.

Spicules were totally lacking but the species obviously possessed these structures originally. The habitus is very characteristic (Fig. 8). The body is very stout; the length ranges from 12-17 mm, the greatest diameter between 3 and 4.5 mm, and the length index is 4-5. The prothorax is white, highly swollen, and may attain a third of the total length of the animal. Color of the body is gray, covered with mud. The metathorax is slender and short; the pre-abdomen is swollen and contains the particularly large liver. The postabdomen forms a characteristic conical ring around the cloacal opening; the gills are mostly protruding from the cloacal chamber. Buccal, dorsal, and lateral salivary glands are present. A "tongue" is provided with a sharp chitinous edge on both sides behind the main tooth, but real teeth are lacking. There are four pairs of precerebral ganglia. The muscles consist of one pair of dorsal and some pairs of lateral retractors at the front end. Granular cells are also situated on the numerous septa dividing the liver into countless lobules.

DISTRIBUTION: This is known only from the Santa Barbara basin, southern California, in about 300 fm, in mud. Fig. 8 an individual in station 3731.

Crystallophrisson recisum n. sp.

Figs. 9, 10

COLLECTION: 2895 (1) in 265 fm.

DIAGNOSIS: This is a small species, measuring 11 mm long, with an average diameter of

2 mm. Color of the body is light brown. The rather swollen prothorax (Fig. 9) measures about a third of the entire length. The rounded buccal plate is pierced by the mouth opening. The spicules (Fig. 10), including the small ones, are distinguished by a distinct keel; the pointed thornlike spicules of the hind end bear conspicuous brown incrustations. With the exception of the gill retractors, the muscles are fairly weak; the longitudinal ones split up into five or six bundles on each side before giving origin to two pairs of dorsal and three pairs of lateral retractors of the front end. Among the usual six pairs of gill retractors, the dorsal posterior ones are markedly thick and partly attached to the wall of the cloacal chamber between the two gills. The posterior vertical

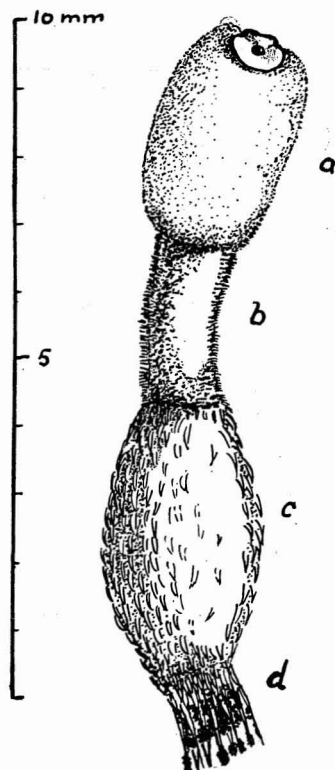


FIG. 9. *Crystallophrisson recisum*. Entire animal in side view, showing the body regions, *a*, *b*, *c*, *d*, from which are taken the spines named in the text.

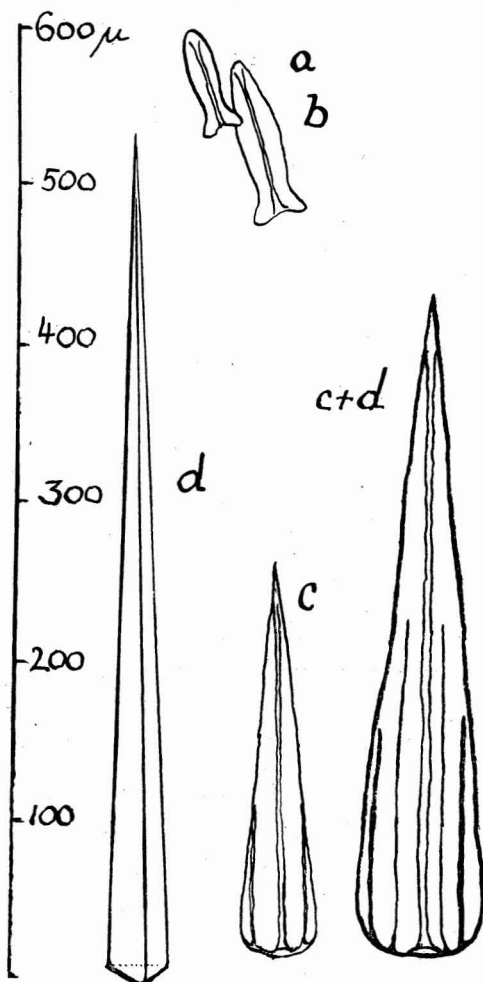


FIG. 10. *Crystallophrisson recisum*. Spines from body regions, showing characteristic ones from regions *a*, *b*, *c*, and *d*. (Compare with Fig. 9.)

diaphragm is very strong. Three free gill-lamellae on each side arise from the cloacal wall. The nervous system is typical; the location of the brain is rather far back above the radula. The cerebro-buccal connective is split off the common trunk shortly behind its origin. The narrow fore-gut possesses a very strong sphincter some distance from the mouth opening; buccal glands are to be found only in front of it. The three kinds of salivary glands are present but are unusually small; the radula is

provided with two small denticles; the cuticle of the tongue is thin but highly chitinous. The cuticular ridge on the dorsal wall of the mid-gut is near the opening of the liver, and a rectum is present. Granular cells occur on the dorsal wall of the liver and on the edges of the septa which divide the liver into numerous lobules. The pericardium is spacious; the heart is typical and has two atrioventricular openings. The gonoducts open on papillae; their epithelium is not continued on the wall of the cloacal chamber.

DISTRIBUTION: This has been found only once, in the San Pedro area of southern California, in 265 fm, on gray green mud.

Crystallophrisson scabrum Heath, 1911

Heath, 1911, pp. 44, 63, pl. 4, figs. 2, 16, pl. 29, figs. 6, 7, 9-11, pl. 30, figs. 1, 3, pl. 37, fig. 19.

COLLECTIONS:

- 2189 (12) in 228 fm, with *Limifossor fratula* and *C. bartmani*.
 2306 (1) in 215 fm, with *Limifossor fratula*.
 2357 (1) in 100 fm.
 2418 (13) in 185 fm, with *Limifossor fratula* and *C. nitidulum pacifica*.
 2749 (1) in 277 fm, with *Limifossor fratula*.
 2793 (2) in 251 fm, with *C. sp.*

DIAGNOSIS: This is a rather small species, 10-12 mm in length, and 2 mm in greatest diameter. The region of the liver is greenish, and the hind end has brown incrustations. The prothorax is short and swollen, and the second half of the body is considerably thickened. The mouth opening is rather large and surrounded by the round buccal plate. Compact groups of gland cells occur mainly on the dorsal side of the fore-gut. The pericardium is large and the heart highly muscular. The cloacal chamber is small.

DISTRIBUTION: This species was originally described from Monterey Bay in 715 fm (Heath, 1911); the present records are from the San Pedro area, including Redondo canyon, in depths of 100-277 fm, in mud.

Crystallophrisson bartmani Schwabl, 1961
 Figs. 11, 12

Schwabl, 1961a, pp. 258-277, figs. 1-10.

COLLECTIONS:

- 2150 (3) in 310 fm, with *C. rubrum* and *C. riedli*.
 2189 (1) in 228 fm, with *C. scabrum* and *Limifossor fratula*.
 2218 (1) in 249 fm, with *Limifossor fratula*.
 2220 (1) in 180 fm, with *Limifossor fratula* and *C. nanulum*.
 2223 (1) in 480 fm, with *C. sp.*
 2230 (2) in 300 fm, with *Limifossor fratula* and *Prochaetoderma californicum*.
 2299 (1) in 360 fm.
 2301 (1) in 335 fm.
 2302 (1) in 185 fm, with *C. sp.* (used for Fig. 12, left).
 2321 (1) in 385 fm, with *Prochaetoderma californicum* and *C. sp.*
 2361 (1) in 167 fm, with *Limifossor fratula*, *C. nanulum* and *C. sp.*

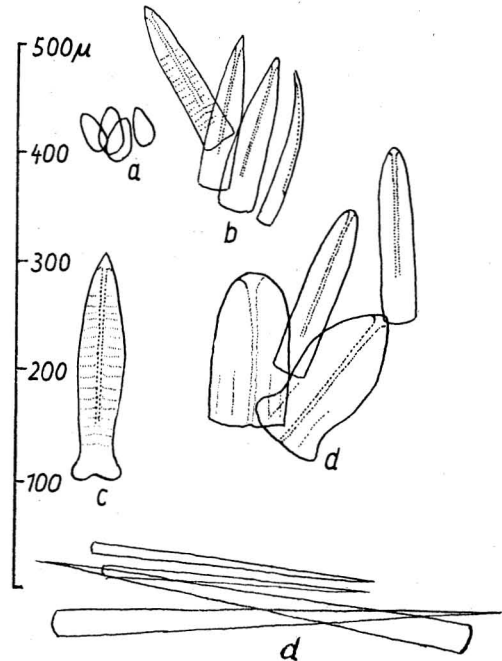


FIG. 11. *Crystallophrisson bartmani*. Characteristic spicules from body regions a, b, c, d.

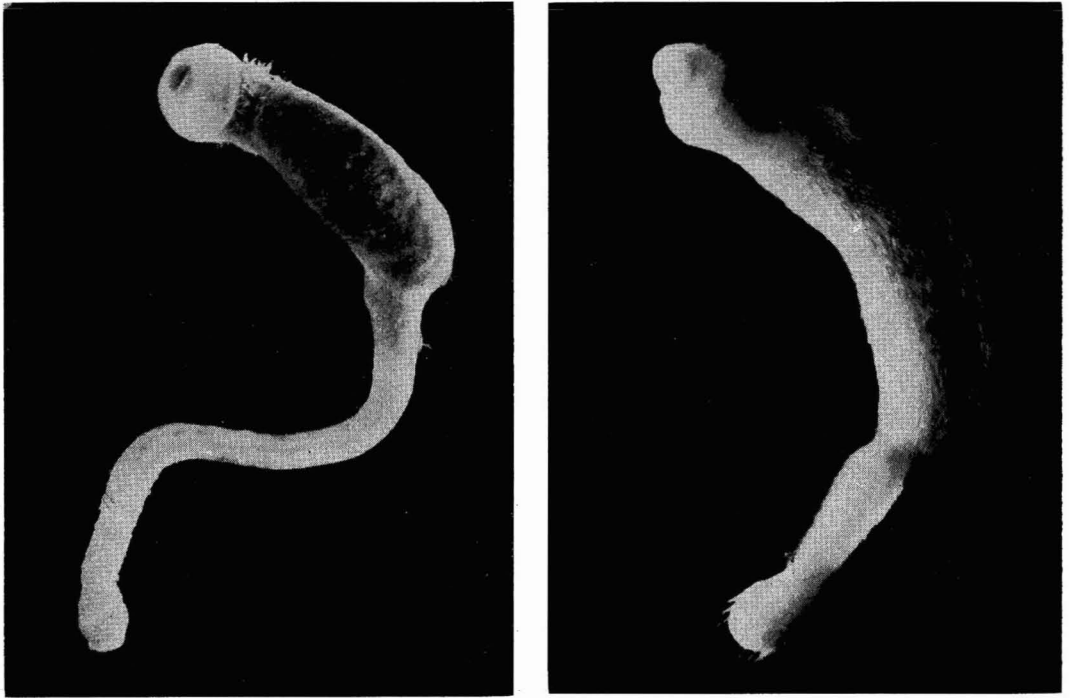


FIG. 12. *Crystallophrisson bartmani*. Left, Sta. 2302-53. Right, Sta. 2644-54.

- 2362 (1) in 352 fm, with *Limifossor fratula*.
 2410 (1) in 410 fm, with *C. hancocki*.
 2411 (2) in 400 fm, with *Prochaetoderma californicum* and *C. hancocki*.
 2412 (1) in 324 fm, with *Limifossor fratula* and *C. hancocki*.
 2441 (3) in 340 fm.
 2625 (2) in 230 fm, with *Limifossor fratula* and *C. nanulum*.
 2642 (4), in 422 fm.
 2644 (2) in 310 fm, with *Limifossor fratula* and *C. rectum* (see Fig. 12, right).
 2723 (1) in 325 fm, with *Limifossor fratula* and *C. hancocki*.
 2738 (2) in 342 fm, with *Limifossor fratula* and *C. sp.*
 2795 (1) in 290 fm, with *C. sp.*
 2798 (3) in 386 fm, with *Prochaetoderma californicum* and *C. rectum*.
 2802 (2) in 420 fm.
 2837 (2) in 454 fm, with *Prochaetoderma californicum* and *C. sp.*
 2839 (4) in 446 fm, with *Prochaetoderma californicum* and *C. hancocki*.

- 2846 (2) in 612 fm.
 3019 (4) in 425 fm, with *C. sp.*

DIAGNOSIS: Length of body 5-18 mm, width of body in front 0.8-2 mm, posteriorly 0.4-0.6 mm. The anterior half of the body, containing the short liver, is swollen; the posterior half is slender and tail-like, terminating in a button-like posterior end (Fig. 12). The head region is whitish and the rest of the body is yellowish-brown with dark incrustations on the hind end. The buccal plate is round, and the terminal opening of the cloacal chamber is surrounded by longer and shorter thorns. The spicules (Fig. 11) of the anterior end are small and squamiform; those of the rest of the body are lancet-like or leaflike and have a keel. The four groups of longitudinal muscles are limited to the posterior half of the body; one pair of dorsal and one of lateral retractors occur anteriorly. There are five pairs of gill retractors. The nervous system consists of four pairs of precerebral ganglia. One pair of small ganglia connects with the buccal ganglia near the junc-

tion of fore- and mid-gut. Buccal glands and lateral and dorsal salivary glands are present. The radula has one pair of sickle-like teeth, one pair of small lateral teeth, and an unpaired piece. The mid-gut bears a cuticular stripe dorsally. The liver has granular cells which are present also at the end of the irregular septa. Gill lamellae number 15–20. The heart is muscular and has two atrioventricular openings.

DISTRIBUTION: This species occurs commonly in the San Pedro area of southern California, in depths of 330–1100 m, in sediments of mud or clay. It is frequently found in glass sponge associations.

Crystallophrisson nanulum (Heath) 1911

Fig. 13

Chaetoderma nanula Heath, 1911, pp. 66–67, pl. 4, figs. 1, 12, pl. 27, fig. 3, pl. 28, figs. 7, 10, 11, 12, pl. 37, fig. 18.

COLLECTIONS:

2220 (7) in 180 fm, with *C. hartmani* and *Limifossor fratula*.

2221 (2) in 147 fm, with *Limifossor fratula*.

2361 (2) in 167 fm, with *Limifossor fratula*, *C. hartmani* and *C. sp.*



FIG. 13. *Crystallophrisson nanulum*. Sta. 2220.

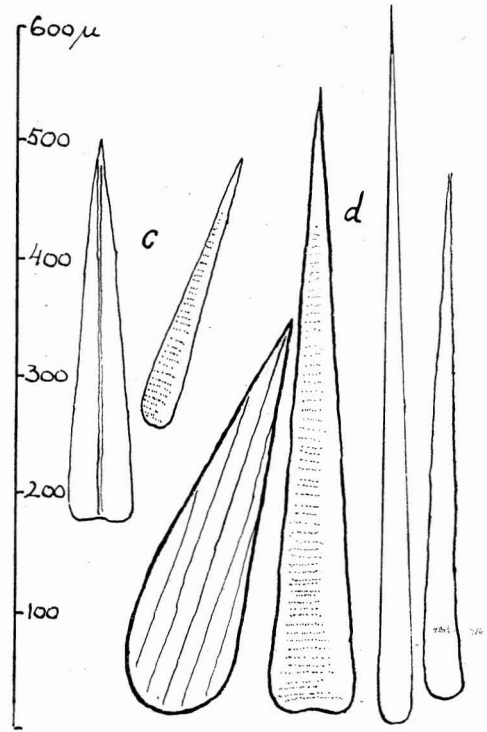


FIG. 14. *Crystallophrisson hancocki*. Characteristic spicules from body regions *c* and *d*.

2612 (1) in 100 fm, with *Limifossor fratula* and *C. sp.*

2625 (1) in 230 fm, with *Limifossor fratula* and *C. hartmani*.

DIAGNOSIS: The body is small, comparatively stout (Fig. 13), and measures 7–9 mm long and up to 1.2 mm at its greatest width. The spines are keeled and appear heavy. The color of the body is yellowish-brown. The radula is small and has two small denticles. Salivary glands are reduced to a small group of cells near the radula.

DISTRIBUTION: This was originally described based on a single specimen from southern California, in 260–284 fm. The present collections include 13 specimens, all from the San Pedro area, in depths of 100–230 fm, and always associated with *Limifossor fratula* in sediments of green or sandy mud.

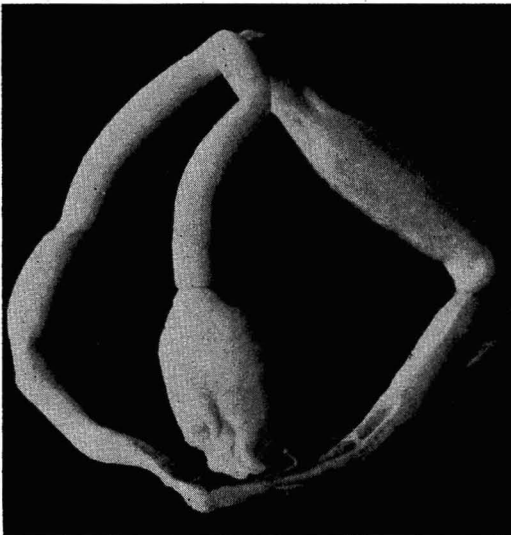
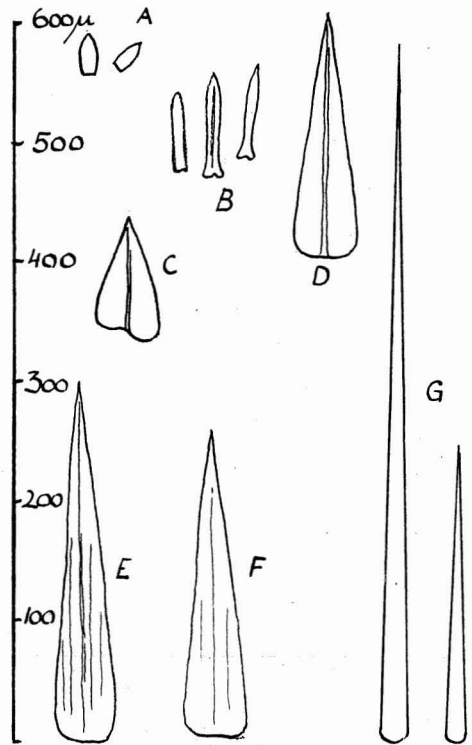
Crystallophrisson hancocki n. sp.

Figs. 14, 15

COLLECTIONS:

- 2411 (2) in 400 fm, with *Prochaetoderma californicum* and *C. bartmani*.
 2412 (1) in 324 fm, with *Limifossor fratula* and *C. bartmani*.
 2475 (1) in 405 fm.
 2497 (1) in 24 fm.
 2628 (1) in 350 fm.
 2641 (1) in 373 fm.
 2723 (2) in 325 fm, with *Limifossor fratula* and *C. bartmani*.
 2839 (2) in 446 fm, with *C. bartmani* and *Prochaetoderma californicum*.
 2888 (1) in 390 fm.
 2901 (2) in 310 fm.

DIAGNOSIS: This species is of moderate size and measures between 19 and 25 mm long, with a fairly large prothorax (Fig. 15). The color in alcohol is brownish-gray. The spines are large but weak, and most of them lack a marked keel (Fig. 14). The body is distinctly narrowed between the preabdomen and the slender and somewhat elongated postabdomen; on the latter the slitlike dorsoterminal sense organ is clearly visible. The buccal plate is rounded and pierced by the mouth opening

FIG. 15. *Crystallophrisson hancocki*. Sta. 2839.FIG. 16. *Crystallophrisson nitidulum* var. *pacifica*. Characteristic spicules from body regions a, b, c, d, and other spines, labeled E, F, G, discussed in the text.

near its dorsal edge. A glandular zone on the postabdomen and moderate incrustations of the latter are present. The subepidermal muscle layers are fairly strong, even in the region of the liver; in the prothorax the longitudinal layer splits up at once into numerous bundles. One finds several pairs of ventral, dorsal, and lateral retractors; the gill-retractor muscles are typical. The nervous system is characterized by a brain more clearly bilobed than usual, by a cerebrobuccal nerve split off the one common trunk shortly behind its origin, and by a supra-rectal ganglion surrounded by the pericardium.

The digestive tract begins with a narrow fore-gut; its sphincter muscle is very strong. Buccal glands are observed only in front of it. Small ventral salivary glands with outlets on a very marked papilla; small dorsal ones behind

the radula and particularly large lateral ones extend from the radula to the junction of the fore-gut with the mid-gut. The radula is large and highly chitinous but without denticles. It extends far into the lumen of the fore-gut and has unusually large supports. The mid-gut and rectum are spacious. The pericardium is not very wide but extends far proximally. The ventricle is muscular and has two atrioventricular openings. The dorsal vessel begins with a bulb. The epithelium of the gonoducts continues for some distance on the wall of the cloacal chamber.

DISTRIBUTION: All specimens come from the San Pedro area, southern California, and all but one from depths between 310 and 446 fm. Eleven, or 78.5%, are from mud, and 5, or 35.7%, from glass sponge areas.



FIG. 17. *Crystallophrisson nitidulum* var. *pacifica*. Sta. 2176.



FIG. 18. *Crystallophrisson nitidulum* var. *pacifica*. Sta. 2418.

Crystallophrisson nitidulum (Lovén) 1844,
stem species

Crystallophrisson nitidulum var. *pacifica* n.
var.

Figs. 16–18

COLLECTIONS:

- 2121 (1) in 32 fm, with *C. sp.*
- 2168 (1) in 12 fm.
- 2176 (3) in 28 fm.
- 2417 (1) in 34 fm, with *C. sp.*
- 2418 (2) in 185 fm, with *Limifossor fratula*
and *C. scabrum*.
- 2614 (2) in 155 fm.
- 2457 (1) in 111 fm.
- 2743 (1) in 150 fm.
- 3204 (1) in 115 fm, with *Limifossor fratula*.
- 3205 (1) in 88 fm, with *C. sp.*

DIAGNOSIS: Overall length is 20–40 mm; greatest width 1.0–2.5 mm, the largest specimens coming from greater depths. This variety of the well-known *C. nitidulum* Lovén agrees with the stem species in its outer appearance. Characteristic are the not very swollen prothorax, the outline of the buccal plate, the short but clearly visible dorsoterminal sense organ, and its inner organization showing the development and number of muscles of the stem. The nervous system is like that of its stem species, and the radula similarly has two denticles. Other similarities include the structure of the liver, the epithelium of the gonoducts

and anus which continues for a great distance on the cloacal wall, and above all by the presence of only one atrioventricular opening.

The variety differs from the stem species by its greyish color and by the short but widely expanded postabdomen (Figs. 17, 18), which contains a large blood sinus surrounding the cloacal chamber, reducing the latter to an unusually small cavity. The spines (Fig. 16) corresponding to those of type C (see Fig. 9), which are characteristic of the stem form, occur only sparsely, whereas spines of types B, E, and G (the last only on the postabdomen) are abundant. On smaller specimens the spicula of type F could be found in great numbers on the metathorax, pre- and postabdomen; on larger specimens they were replaced by spines of type D, showing a distinct keel. Characteristic of the variety is the large, clearly outlined atrium of the heart which surrounds the supra-rectal ganglion.

DISTRIBUTION: The stem species has been widely recorded from both sides of the north Atlantic Ocean, the west coast of Sweden, Norway, Iceland, the North Sea, the eastern coast of North America from New Foundland to Virginia, and the West Indies; depths have ranged from 20–2250 m. The new variety is known through 14 specimens coming from the San Pedro area of southern California, in depths of 12–185 fm, in sediments of mud, sandy mud (2 specimens), and sandy clay (1 specimen).

Crystalloporisson riedli n. sp.

Figs. 19, 20

COLLECTIONS:

- 2150 (2) in 310 fm, with *C. hartmani* and *C. rubrum*.
 2324 (1) in 400 fm, with *Platbymenia branchiosa*.
 2352 (1) in 420 fm.
 2414 (1) in 177 fm.
 2838 (1) in 394 fm.

DIAGNOSIS: Individuals range in length from 15–22 mm and have an average diameter in the prothorax of 2 mm. Alcohol preserved specimens are gray with a whitish prothorax. In fixed state the posterior half of the prothorax

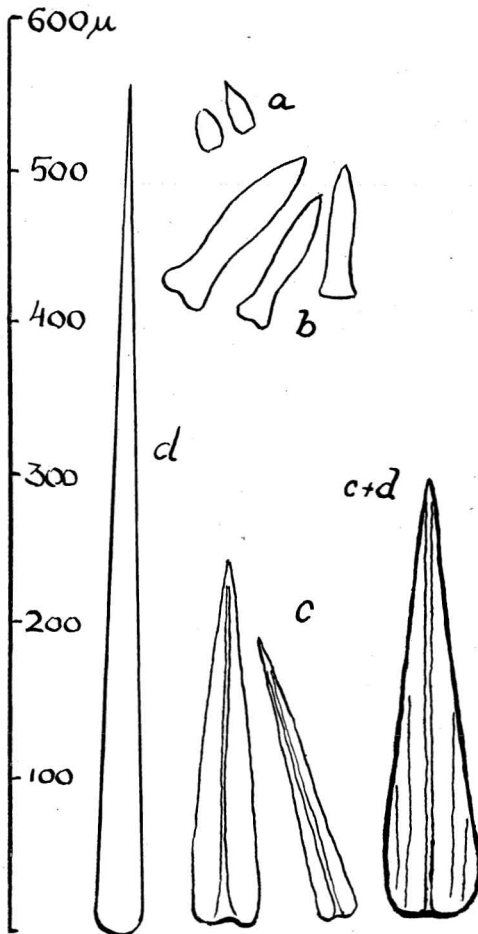


FIG. 19. *Crystalloporisson riedli*. Characteristic spines from body regions a, b, c, and d.



FIG. 20. *Crystallophrisson riedli*. Sta. 2838.

is frequently more contracted than the anterior half (Fig. 20). The dorsoterminal organ is very short but continuous with the opening of the cloacal chamber. The buccal plate is rounded and has a dorsal cleft containing the mouth opening. The abdominal gland zone is present. Spines (Fig. 19) are of medium size and have a marked keel.

Dorsal, lateral, and ventral retractor muscles are present at the front end; the longitudinal muscle layer in the prothorax is gradually split up into numerous bundles. The gill retractors are short; the ventral anterior ones are very heavy; the second pair of dorsal posterior ones are lacking or, if present, attach to the cloacal wall between the gills. Lateral, ventral, and part of the dorsal anterior gill retractor unite before entering the gill, which gives the transverse section of the gill a very characteristic appearance. The gill axis consists of a bulbous

ventral half, and a very slender dorsal half. The posterior vertical diaphragm is unusually strong.

The nervous system is typical; the buccal nerve leaves the common root very soon. The fore-gut has a strong circular and longitudinal muscle layer, circular in outline. Numerous buccal glands occur behind the sphincter muscle. All three kinds of salivary glands are present but the ventral ones are very small. The radula is typical. Granular cells in the liver are not only concentrated on the dorsal wall but irregularly distributed. The circulatory organs are typical, with two atrioventricular openings. The gonopericardial duct is fairly long and curved; the ciliated part of the gonoducts is comparatively long. The openings of the gonoducts are mostly on flat papillae, and their epithelium is not continued on the wall of the cloacal chamber.

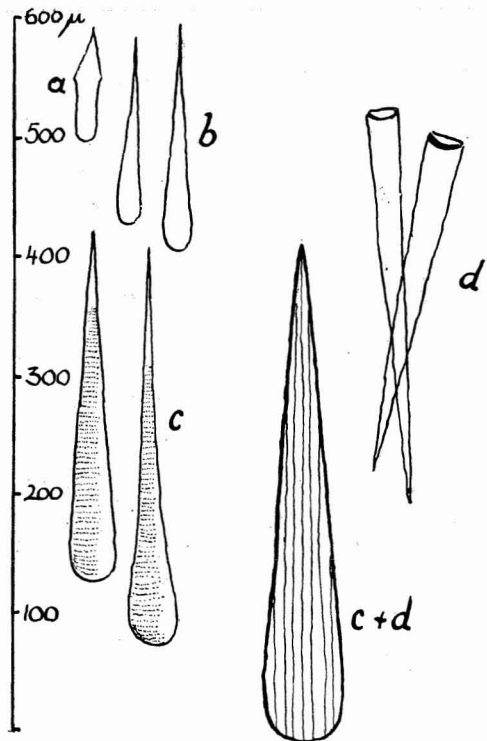


FIG. 21. *Crystallophrisson inflatum*. Characteristic spicules from body regions *a*, *b*, *c*, and *d*.



FIG. 22. *Crystallophrisson inflatum*. Sta. 2791.

DISTRIBUTION: This species is known through six specimens, all from the San Pedro area including Redondo canyon, southern California, in depths of 177–420 fm. Three were found in mud, one in mud and gravel, and one in coarse sand.

Crystallophrisson inflatum n. sp.

Figs. 21, 22

COLLECTIONS:

2110 (3) in 427 fm.

2791 (2) in 415 fm.

DIAGNOSIS: This is a large species, with total length ranging between 25 and 35 mm, and greatest width 4 mm; the prothorax region is greatly inflated (Fig. 22). The hind end is provided with two lateral prolongations of the body wall which can be withdrawn into the circler of thorns protecting the opening of the cloacal chamber and the adjacent glandular

zone. Spines (Fig. 21) are only very slightly or not at all keeled. The color in alcohol is dark gray with a brown tinge. The prothorax is whitish-brown, and the buccal plate is darker and shows three incisions on its dorsal edge of which the median one contains the mouth opening. The muscles are fairly thick, consisting of two pairs each of dorsal and lateral retractors at the front end. In the anterior half of the prothorax there is a characteristic isolated small bundle of longitudinal muscles on both sides of the mid-dorsal line. Gill-retractor muscles are typical. The nervous system is also typical, with a brain situated very near the

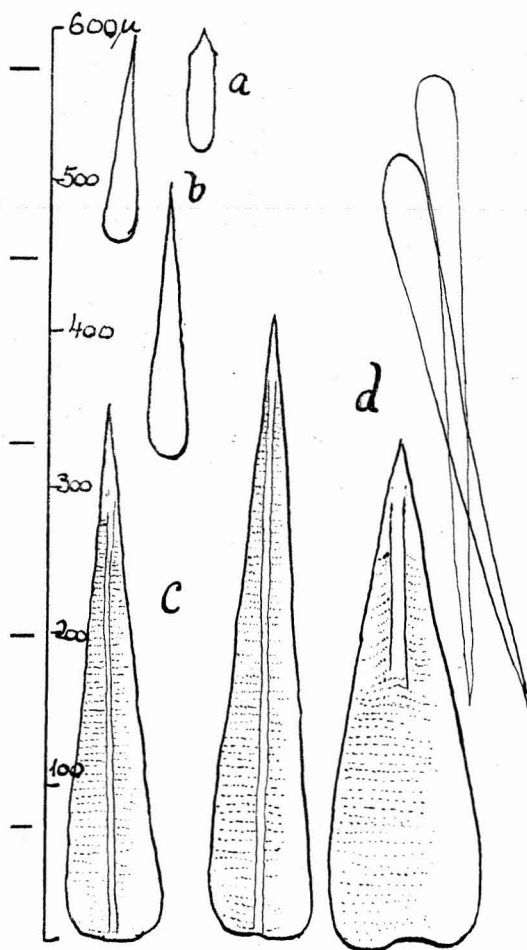


FIG. 23. *Crystallophrisson marinellii*. Characteristic spicules from body regions a, b, c, and d.

anterior end of the body, with three pairs of precerebral ganglia, and the cerebrobuccal connective split off the common trunk immediately after leaving the brain. The fore-gut is short and unusually wide, with small lateral folds occurring only in the radular region. The buccal glands are in front of the sphincter muscle, and all three kinds of salivary glands are present, the lateral ones being notably large and surrounding also the junction of mid- and fore-gut. The radula is characteristic, large, and lacking real teeth; the tongue has a very stout, highly chitinous cuticle which on either side of the median toothlike structure may attain a thickness of 25 μ . The mid-gut is narrow. The liver has granular cells on the dorsal wall and on the edge of the numerous septa.

Reproductive organs are typical; the openings of the gonoducts are on papillae, their epithelium not continued on the wall of the cloacal chamber. The pericardium is very spacious and extends far backward; the ventricle is highly muscular, and there are two atrio-ventricular openings.

DISTRIBUTION: Five specimens, all from the San Pedro area of southern California, come from depths of 415–430 fm, in mud.

Crystallophrisson marinellii n. sp.

Figs. 23, 24

COLLECTIONS:

- 2363 (1) in 429 fm, with *Prochaetoderma californicum* and *C. sp.*
 2473 (1) in 16 fm.
 2753 (1) in 322 fm.
 2884 (1) in 190 fm.

DIAGNOSIS: This is a comparatively large specimen (Fig. 24), measuring from 20–40 mm long in a state of contraction; the greatest width is 3 mm in the region of the pinkish-white prothorax which may attain a length of 5–7 mm. The terminal buccal plate is brown and rounded in shape. It has a single deep cleft on its dorsal side which contains the wide mouth opening. In alcohol the body is gray with a distinct pink shade. The spines (Fig. 23) are large but weak, and have a slight keel; abdominal spines are very short. The dorso-terminal sense organ is covered with small



FIG. 24. *Crystallophrisson marinellii*. Sta. 2884.

spines. It is continuous with the opening of the cloacal chamber in front of which is found a glandular region. Except for the six pairs of very strong gill retractors, the muscles are weak. The longitudinal ones in the prothorax region are split up gradually into numerous bundles. Two pairs of dorsal and several pairs of lateral and ventral retractor muscles are present.

The brain is located near the radular region and is not attached to the dorsal wall of the fore-gut but is surrounded by numerous groups of piriform gland cells belonging to the glands of the buccal plate. The common trunk of the three large connectives follows its course for some distance before the buccal connective is free. Four pairs of precerebral ganglia are present. The suprarectal ganglion may be surrounded by the pericardium and even by the atrium. Behind the mouth opening the fore-gut narrows conspicuously and does not widen

much along its course. The radula is powerful but without real teeth or denticles. All three kinds of salivary glands are present. Buccal glands occur only in front of the sphincter muscle. The mid-gut is very wide. The pericardium is notably large, the ventricle highly muscular and there are two atrioventricular openings. The dorsal vessel originates as a conspicuous ampulla situated in the pericardium.

Reproductive organs are without peculiarity. The ciliated portion of the gonoduct is rather long; the gonoduct openings are on papillae, their epithelium not continued on the wall of the cloacal chamber.

DISTRIBUTION: Four specimens, all from the San Pedro area of southern California, were taken in depths of 16–429 fm, in mud or sandy mud.

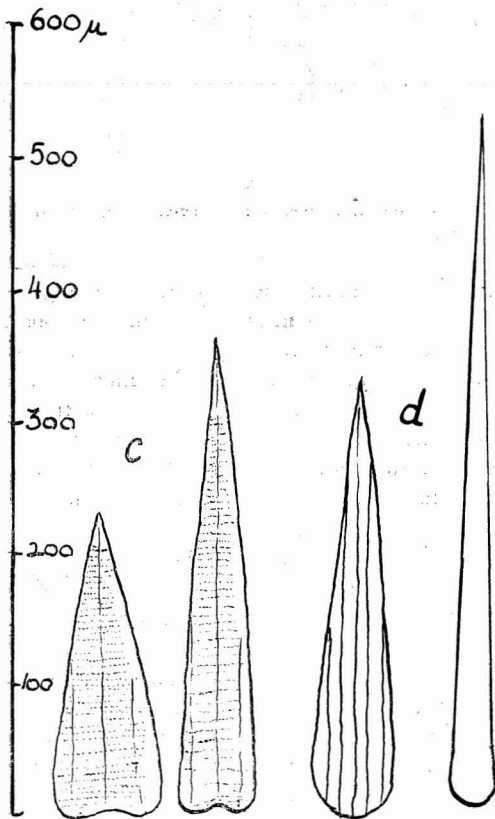


FIG. 25. *Crystallophrisson rectum*. Characteristic spicules from body regions *c* and *d*.



FIG. 26. *Crystallophrisson rectum*. Sta. 2798.

Crystallophrisson rectum n. sp.
Figs. 25, 26

COLLECTIONS:

2644 (1) in 310 fm, with *Limifossor fratula* and *C. hartmani*.

2798 (1) in 386 fm, with *Prochaetoderma californicum* and *C. hartmani*.

DIAGNOSIS: These animals are moderately large (Fig. 26) being 10–18 mm long, and having an average diameter of 1–1.5 mm. The prothorax may reach 2.5 mm in diameter. The color is yellowish-brown. The spines (Fig. 25) are weak and have little structure. The buccal plate is semicircular and has a deep and wide dorsal cleft which contains the mouth opening. The cuticle is very thin, the abdominal gland zone present. The subepidermal muscle layers are weak; there are three pairs of dorsal, three pairs of lateral, and several pairs of ventral

retractor muscles. Only five pairs of gill retractors are present; the ventral posterior ones are lacking.

The nervous system shows a very compact mass of three pairs of precerebral ganglia and a markedly bilobed brain, both attached to the dorsal wall of the fore-gut; the buccal nerve is shortly freed. The supraectal ganglion is surrounded by the pericardium. The fore-gut is narrow, triangular in outline where located

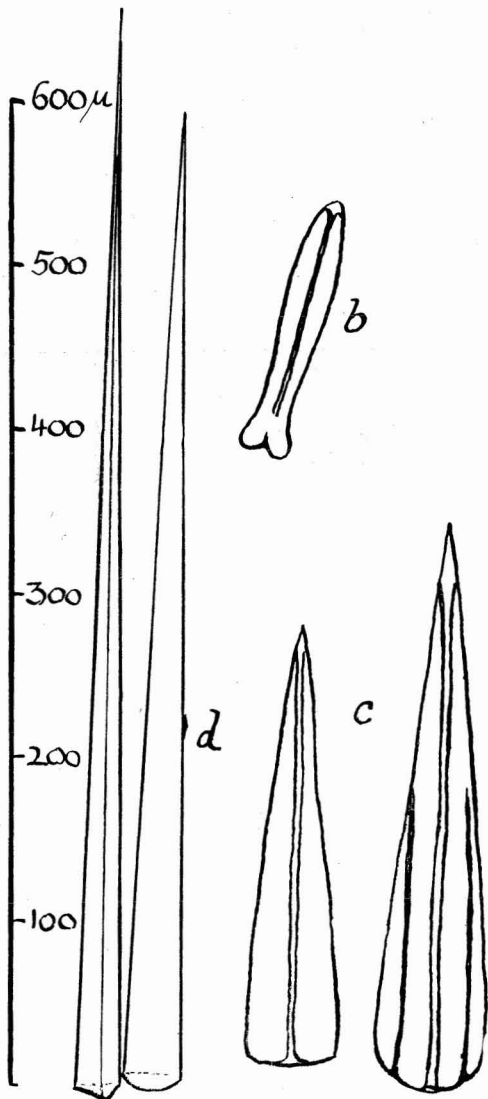


FIG. 27. *Crystallophrisson rubrum*. Characteristic spicules from body regions *b*, *c*, and *d*.



FIG. 28. *Crystallophrisson rubrum*. Sta. 2150.

between the mouth opening and the brain, then semicircular in the brain region, and somewhat widened and quadrangular in the region of the radula. Numerous buccal glands are visible behind the sphincter and all three kinds of salivary glands are present. The radula is typical and lacks denticles. The mid-gut is wide and has a cuticular region near its opening to the liver. The rectum is slightly winding.

The pericardium is spacious, the ventricle slender and not very muscular, with two atrio-ventricular openings. The dorsal vessel begins with a bulb. Gills are conspicuously small and have only a few gill lamellae. The epithelium of the gonoducts is not continued on the wall of the cloacal chamber.

DISTRIBUTION: Two specimens come from the San Pedro area, southern California, in 310–386 fm, one from clay sediments, the other from mud with glass sponge.

Crystallophrisson rubrum n. sp.

Figs. 27, 28

COLLECTION:

2150 (1) in 310 fm, with *C. bartmani* and *C. riedli*.

DIAGNOSIS: This species is readily distinguished from others by its outer purple color and its plump body (Fig. 28). The single specimen measured 17 mm long and 2.5 mm at its greatest width. The front end was withdrawn and the exact outline of the buccal plate is thus not known, but it is certainly pierced by the mouth opening. The spines (Fig. 27) are large and stout and have a distinct keel; the abdominal needle-like spines attain a length of 800 μ . A glandular zone in front of the opening of the cloacal chamber is present and "giant cells" are frequently encountered in the epidermis of the entire body. The animal is highly muscular; there are two pairs of dorsal, one pair of lateral, and one pair of ventral retractors of the front region, all of them very strong. These retractors split off from the longitudinal muscle layer which is located dorsally in the prothorax, dividing only into a few rather large bundles. The six pairs of gill-retractor muscles are typical; the anterior dorsal one has a double origin. The diaphragms are very strong, and an anterior vertical one can be distinguished.

The nervous system shows three pairs of small compact precerebral ganglia, a small brain, separated from the dorsal wall of the fore-gut by a large sinus, and a cerebrobuccal connective split off the common trunk at some distance from the latter's origin. The fore-gut is provided with strong longitudinal muscle fibres and with a stout sphincter, with buccal glands anterior to the last and with all three kinds of salivary glands, of which the dorsal ones open into an unusually large pouch of the fore-gut. The strong radula consists of the typical parts in addition to a pair of small pointed, curved denticles.

The reproductive organs are typical; the gonoducts are simple without sacculations; their dorsal ciliated parts are long and slender tubes. The epithelium of their outlets continues on the wall of the cloacal chamber. The

pericardium is very large and together with the posterior part of the atrium surrounds the suprarectal ganglion. The muscular ventricle, connected with the atrium by two atrioventricular openings, is attached at its front end to the dorsal and ventral pericardial wall. The dorsal vessel begins as a large bulb.

DISTRIBUTION: This species is known through a single specimen from Redondo canyon, in the San Pedro area, southern California, in 310 fm, in mud.

ACKNOWLEDGMENTS

The author is indebted to all those who made these collections possible. The operations of the "Velero IV" were supported by funds provided partly by the Allan Hancock Foundation, the California State Water Pollution Control Board, and the National Science Foundation. The sorting of solenogasters was done by staff members of the Hancock Foundation; the anatomical preparations were prepared in the laboratory of the Department of Zoology, University of Vienna. The author is also indebted to the Austrian Department of Education and the Department of Zoology of the Free University of West Berlin.

APPENDIX

ADDITIONAL STATION DATA

Physical data are published for most of the station numbers listed above. Those not separately listed below are to be found in Hartman (1955) and Hartman and Barnard (1958, 1960). The following are newly listed; all localities are in southern California.

2457-53. Oct. 17, 1953. 4.0 miles SE of Point Fermin lighthouse, 33° 39' 19" N. lat., 118° 14' 20" W. long. In 21.5 fm. A snapper sampler took a very small sample of sand.

2884-54. July 27, 1954. 5.6 miles SW of end of Newport pier. 33° 31' 58" N., 118° 00' 00" W. In 190 fm. The orange-peel-grab took 1.93 cu ft of gray green mud.

- 2888-54. July 27, 1954. 14.7 miles EWE of East end, Santa Catalina Island. $33^{\circ} 21' 58''$ N., $118^{\circ} 02' 00''$ W. In 390 fm. OPG took 2.67 cu ft of gray green mud.
- 2895-54. July 28, 1954. 9.9 miles SSW of end of Newport pier. $33^{\circ} 27' 57''$ N., $118^{\circ} 01' 58''$ W. In 265 fm. OPG took 2.58 cu ft of gray green mud.
- 2899-54. July 28, 1954. 8.25 miles SW of end of Newport pier. $33^{\circ} 30' 00''$ N., $118^{\circ} 02' 02''$ W. In 266 fm. OPG took 2.64 cu ft of gray green mud.
- 2901-54. Aug. 11, 1954. 12.8 miles SW of East end, Santa Catalina Island. $33^{\circ} 26' 00''$ N., $118^{\circ} 06' 06''$ W. In 312 fm. OPG took 3.02 cu ft gray green mud.
- 3037-55. May 8, 1955. 3.75 miles from North light, Santa Barbara Island. $33^{\circ} 31' 17''$ N., $118^{\circ} 58' 00''$ W. In 360 fm. OPG took 2.58 cu ft of gray green sandy mud.
- 3204-55. July 7, 1955. Santa Monica Bay. $33^{\circ} 58' 10''$ N., $118^{\circ} 39' 10''$ W. In 115 fm. OPG took 2.08 cu ft of green silty mud.
- 3205-55. July 7, 1955. Santa Monica Bay. $33^{\circ} 58' 00''$ N., $118^{\circ} 37' 00''$ W. In 88 fm. OPG took 2.08 cu ft of green silty mud.
- 4756-56. Dec. 8, 1956. 4.1 miles from Scripps pier, La Jolla. $32^{\circ} 51' 55''$ N., $117^{\circ} 20' 30''$ W. In 102 fm. OPG took 2.39 cu ft of green mud and some broken shells; temperature of sediment 9.8 C.
- 4776-56. Dec. 10, 1956. 2.2 miles from Dana Point. $33^{\circ} 26' 00''$ N., $117^{\circ} 43' 30''$ W. In 87 fm. OPG took 3.46 cu ft of green mud; temperature of sediment 10.2 C.
- 4778-56. Dec. 10, 1956. 5.2 miles from Dana Point. $33^{\circ} 30' 20''$ N., $117^{\circ} 47' 45''$ W. In 100 fm. OPG took 2.96 cu ft of green mud. Temperature of sediment 9.7 C.

- 4835-57. Feb. 6, 1957. 11 miles from Port Hueneme Light. $34^{\circ} 02' 15''$ N., $119^{\circ} 01' 45''$ W. In 77 fm. OPG took 1.38 cu ft of olive green sandy silt.

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