

MALACOLOGY.—*Mollusca dredged by the Orca off the Santa Barbara Islands, California, in 1951.* S. STILLMAN BERRY, Redlands, Calif. (Communicated by Harald A. Rehder.)

Through the kindness of Dr. Carl L. Hubbs, of the Scripps Institution of Oceanography, there was recently placed in my hands a collection of mollusks taken by himself, J. W. Sefton, and others, working from Mr. Sefton's research vessel, the *Orca*, off the Santa Barbara Islands, Calif., in the summer of 1951. Mollusca were not the items principally sought by this expedition, and since the collections were obtained in one of the more important areas in the Californian province where few precise studies in this field have been made it is most fortunate that in the press of the other important pursuits so many of them were eventually salvaged. By reason of our inadequate knowledge of the area the resulting list gains a significance quite out of proportion to the size of the collection. It is of further interest in that it includes a number of infrequently reported or little-known species, several of which constitute

important extensions of range. In the first part of the paper each station from which mollusks have been submitted is cited in turn, and an annotated list of the species obtained is appended. These include dredge hauls from seven stations having recorded depths from 11 to 58 fathoms. The richest of these was H51-254, in 46 to 58 fathoms, north of Anacapa Island, whence no less than 59 species are here recorded. The second part of the report covers the formal descriptions of the three species obtained which are recognized as new.

The author is happy to express his appreciation of the kindness of both Mr. Sefton and Dr. Hubbs in supplying the material studied. The assistance of Ellis Rich, of the College of Medical Evangelists, Loma Linda, Calif., who made the photographs used in the accompanying illustrations, is likewise gratefully acknowledged.

ANNOTATED LIST

Stations H51 240 and 241 (pipe-dredge), 11 to 20 fathoms, lat. 34°01'45" to 34°02'20-35" N., long. 119°41'40" to 119°42'07-22" W., off Pelican Bay, Santa Cruz Island, June 29, 1951.

Lima hemphilli Hertlein and Strong: 3 adolescents.

Cardium (*Trachycardium*) *quadrigenarium* Conrad: 1 juvenile.

Calliostoma gloriosum Dall: 4 adolescents.

Callicstoma supragranosum Carpenter: 1.

Pteropurpura carpenteri (Dall): 1 adult, 2 juveniles. It appears not impossible that the oldest name for this species is *Murex macropteron* Deshayes (1839:360; 1841:pl. 38; 1843:606). This was originally described without citation of locality. Its subsequent history has been a checkered one. Poirier (1883:93) attributed it to Japan, but I have found no confirmation of an Oriental habitat in the writings of any recent worker in that field. Dall (1889:201) thus identified two specimens dredged off Cape Hatteras, N. C. This western Atlantic species has since

been separately recognized as *M. (P.) bequaerti* Clench and Farfante (1945:40). Unhappily I have only once seen the original figure of *M. macropteron*, and the holotype has never been refigured unless, perchance, it be the shell figured under this name by Reeve (1845: *Murex* pl. 27, sp. 123) and Sowerby (1880: *Murex* pl. 11, fig. 111). These figures, both drawn by Sowerby, are so nearly alike as almost certainly to have been made from the same shell, that in Reeve being by all odds the better executed and more detailed. That these are excellent representations of the Californian shell subsequently named *carpenteri* by Dall is at once apparent when shell and drawing are placed side by side. Should they then have been correctly affiliated by the iconographers with Deshayes' species, there would seem little doubt where that century-old enigma will finally come to rest. As I intend dealing with this situation much more fully in a forthcoming contribution, no further elaboration of the case history seems necessary here.

Station H51-243 (pipe dredge), 43 to 45 fathoms, lat. $34^{\circ}02'37''$ N., long. $119^{\circ}41'$, 35 to 05" W., northeast of Pelican Bay, Santa Cruz Island; mud bottom; June 29, 1951.

Nucula (*Nucula*) *tenuis* (Montagu): 23, nearly all mature.

Nucula (*Acila*) *castrensis* Hinds: 114 of various ages, and 2 valves.

Nuculana taphria (Dall): 1 valve.

Nemocardium centifilosum (Carpenter): 5 immature.

Compsomyx subdiaphana (Carpenter): $3\frac{1}{2}$.

Tellina (*Merella*) *carpenteri* Dall: 1.

Dentalium neohexagonum Pilsbry and Sharp: 2.

Turritella orthosymmetra Berry: 1 (plus a fragment).

Bittium sp. (nov.?): 1. This can be referred to no described species known to me, but in so difficult a genus as *Bittium* a new species should be distinct indeed to justify its foundation upon a single specimen.

Crepidula adunca (Sowerby): 1 bleached shell.

Megasurcula carpenteriana (Gabb): 1 juvenile. Probably referable to the form *tryoniana* (Gabb).

Turbonilla (*Mormula*) *regina* Dall and Bartsch: 2. These can presently be identified in no other way, although the larger has three brown bands on the body whorl not specified in the original description or in Bartsch's key.

Acteocina intermedia Willett: 2. This and *eximia* (Baird) seem not too happy in *Acteocina*. I fail to see why either of them ever need be confused in any way with *A. culcitella* (Gould).

Station H51-251 (pipe dredge), 162-150 feet (26-27 fathoms), lat. $34^{\circ}00'38''$ to $20''$ N., long. $119^{\circ}30'35''$ to $13''$ W., Anacapa Passage; gravel bottom, with some stones; July 2, 1951. Vegetation: *Callophyllis*, *Drouetia*, *Reticulobotrys*, *Lithothamnium*, predominant.

Pecten (*Pecten*) *diegensis* Dall: 2 not quite mature. Both carried *Capulus*, q.v. infra.

Oldroydia percrassa (Dall): 1 juvenile.

Dendrochiton (?) sp.: 1 juvenile.

Capulus californicus Dall: 3 immature. Two of these *in situ* on *Pecten diegensis*, the third loose in jar.

Trivia (*Pusula*) *ritteri* Raymond: 1. Surface of shell somewhat altered by preservative used.

Bursa californica (Hinds): 3. Very small for the species, but of mature aspect.

Odostomia (*Evalea*) *santarosana* Dall and Bartsch: 1. The specimen seems best referable to this little-known species. The color, however, is

much paler than would be inferred from its original description as "light olive."

Station H51-252 (pipe dredge), 174-190 feet (29-31.5 fathoms), lat. $34^{\circ}00'10''$ N., long. $119^{\circ}27'35''$ to $05''$ W., Anacapa Passage; gravel bottom, with stones; July 2, 1951. Vegetation: *Drouetia*, *Reticulobotrys*, *Lithothamnium*, etc.

Terebratulina unguicula (Carpenter): 11. The specimens were taken adhering to a small piece of coral. Not a mollusk, but included for the sake of the record.

Chlamys hastatus (Sowerby): 1.

Diplodonta cf. *subquadrata* Carpenter: 2 adolescents. Californian shells are more acutely beaked and possess a much more strongly developed dentition than any of the west Mexican mainland specimens examined by me. The question of their identity might well be reinvestigated by someone having access to more complete series than I have seen.

Semele aff. *incongrua* Sowerby: 1, probably immature.

Acmaea funiculata Carpenter: 1 juvenile shell, remarkable in that a sharply ribbed initial stage is abruptly succeeded by a stage in which the ribs become in large degree obsolescent. For a finely detailed discussion of this still somewhat enigmatic species see Hanna and Smith, 1931:21.

Astraea (*Pachypoma*) *inaequalis rutila* (C. B. Adams): 2. The specimens are small for the species. I am unable to detect any material difference between this form and *A. i. montereyensis* Oldroyd. Carpenter's suggestion that *rutila* belongs under *A. undosa* (Wood) I believe to be erroneous.

Calliostoma annulatum (Martyn): 2 juveniles. Those who reject Martyn's names can save this one by quoting it as of Humphrey (1786:101).

Vermicularia fewkesii (Yates): 1.

Trivia (*Pusula*) *ritteri* Raymond: 1. A perfect example of this lovely chaste species.

Nassarius insculptus (Carpenter): 1.

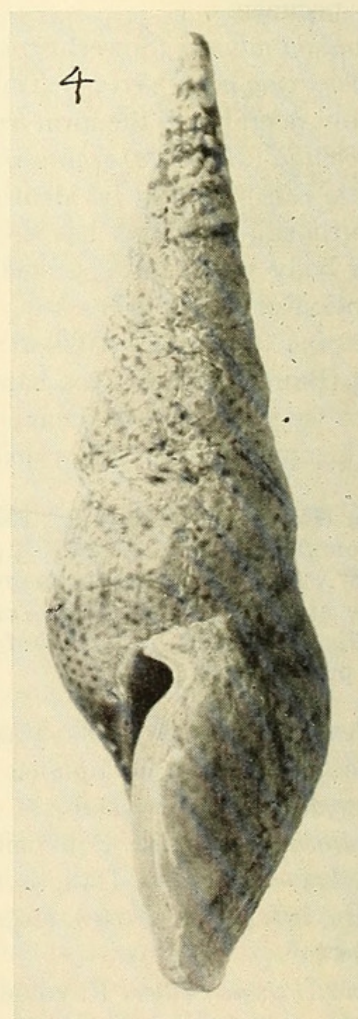
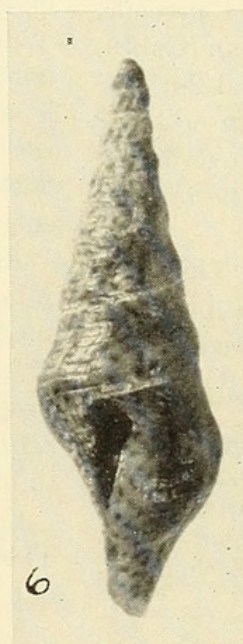
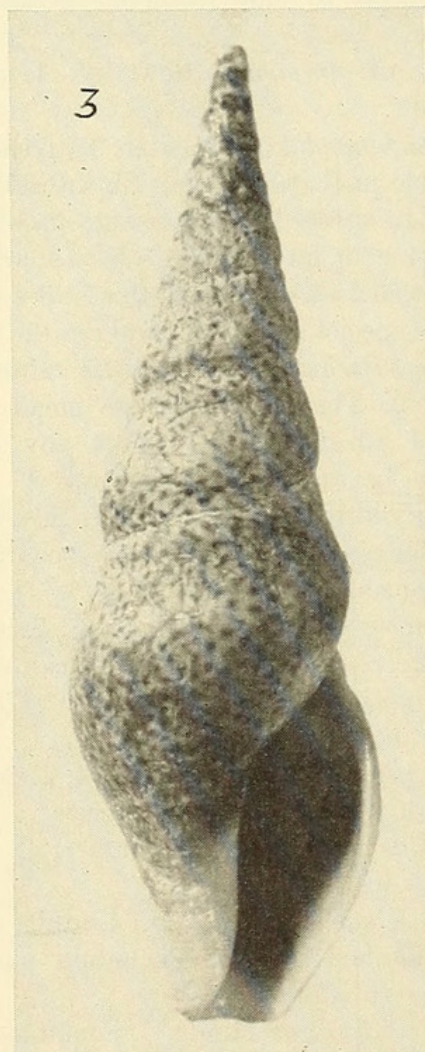
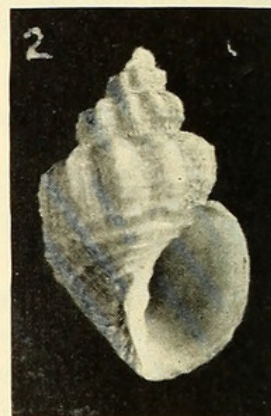
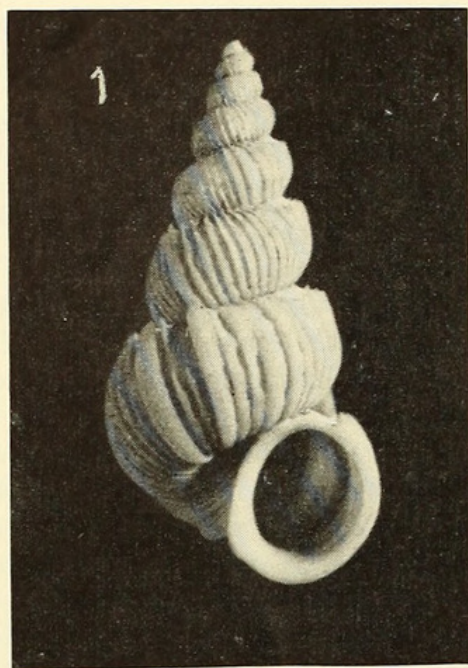
Fusinus sp.: 1 adolescent.

Pseudomelatomia sticta, n.sp.: 1 adult; 1 immature. Described in the concluding portion of this paper (p. 156).

Conus californicus Hinds: 7 immature.

Station H51-254, 46-58 fathoms, lat. $34^{\circ}03'05''$ to $45''$ N., long. $119^{\circ}26'02''$ to $25'28''$ W., ca. $2\frac{1}{2}$ miles N. of W. end of Anacapa Island; July 2, 1951.

This was the richest in Mollusca of any haul



FIGS. 1-6.—1, *Epitonium* cf. *lowei* (Dall), mature shell taken in 46-58 fathoms, north of west end of Anacapa Island, Calif., $\times 2.6$; 2, *Admete seftoni*, n.sp., holotype, taken in 46-58 fathoms, north of west end of Anacapa Island, Calif., $\times 4.25$; 3, *Pseudomelatomia sticta*, n.sp., ventral aspect of holotype, taken in 26-27 fathoms, Anacapa Passage, Calif., $\times 3.5$; 4, *P. sticta*, n.sp., lateral aspect of holotype, same scale; 5, *P. sticta*, n.sp., ventral aspect of the immature paratype, $\times 3.5$; 6, *P. sticta*, n.sp., lateral aspect of same specimen; same scale.

made, both as to species and as to number of individuals.

Nucula (Acila) castrensis Hinds: 105½.

Nuculana hamata (Carpenter): 1½.

Modiolus pallidulus (Dall): 1.

Cardita (Cyclocardia) longini Baily: 13½. For this name and the reasons impelling rejection of two prior names for the species see Baily, 1945.

Pseudochama granti Strong: 1 juvenile valve. The specimen shows the larval shell with exceptional distinctness.

Nemocardium centiflosum (Carpenter): 14 juveniles and adolescents.

Tellina (Moerella) carpenteri Dall: 6.

Spisula cf. *planulata* (Conrad): 1 right valve.

Hiatella arctica (Linné): 2 juveniles.

Cuspidaria (Cardiomya) californica Dall: 1.

Leptochiton oldroydi (Dall): 1. A distinctive species, although one of the smallest of west American chitons.

Puncturella cooperi Carpenter: 1. This example clearly displays the curious punctations which characterize the shells of a number of species in this genus.

Margarites (Lirularia) acuticostatus (Carpenter): 2 shells.

Margarites (Lirularia) pedroanus (Arnold): 3. The Californian species of *Lirularia* are exceedingly difficult of satisfactory disposition. The determinations here suggested are believed to be about as close as is possible in the absence of a thoroughgoing revision.

Solariella peramabilis (Carpenter): 4, plus 3 empty shells.

Cidarina cidaris (Carpenter): 1 half-grown shell.

Calliostoma annulatum (Martyn): 1 juvenile bleached shell.

Calliostoma turbinum Dall: 1.

Lictia farallonensis A. G. Smith: 1. This rare species has hitherto been known only from the vicinity of the Farallon Islands (see Smith, 1952:385). A fine mature example now provides an important extension of range.

Homalopoma sp.: 1. A thoroughly puzzling specimen, the closer determination of which is postponed pending the acquisition of additional material.

Turritella cooperi Carpenter: 10 shells, representing a form in which the spiral keels are quite strongly developed.

Turritella orthosymmetra Berry: 6 shells. These

are badly bleached but are apparently referable here.

Bittium sp. indet.: 7 (plus 15 shells). This is a form rather close to *B. subplanatum* but with flatter whorls and more regular tuberculation. It is possibly undescribed, but for the time being I refrain from adding another name to this genus of many and difficult species.

Bittium sp. indet.: 1 bleached shell. Similar to the preceding but much more sparsely and coarsely tuberculate.

Bittium cf. *rugatum* Carpenter: 5 bleached shells.

Seila montereyensis Bartsch: 1. Altitude of shell exclusive of missing apex, 14.2 mm.

Epitonium (Nitidiscala) indianum (Carpenter): 1.

Epitonium (Asperiscala) cf. *lowei* Dall (Fig. 1): 1. This superb example is remarkable for its very numerous and crowded, strongly reflexed, coronate costae, a few of which become much thickened and with their exaggerated reflexed portions also much wider than the ordinary costae, thus taking on the character of true varices and to this extent casting doubt on current interpretations of simple repetitive costae as varices. The costae number 30–31 on each of the last two whorls and 28–29 on whorls higher up the spire. The inadequately known *E. lowei* is stated to have 26–27 costae, none of which is described as varically thickened, but the recorded specimens are much smaller with an altitude of only 7 mm. (see Dall, 1906:44; 1921:214, pl. 6, fig. 11), and I am unable to find any really trenchant characters whereby they might be distinguished from the apical whorls of this shell. The *Orca* specimen measures: altitude 21.6; maximum diameter 10.6; altitude of aperture 6.4 mm.; extreme apex decollated.

Balcis (Balcis) micans (Carpenter): 1.

Balcis (Vitreolina) titubans, n.sp.: 1. Described in the concluding section of this paper (p. 154).

Calyptrea contorta (Carpenter): 1 juvenile shell.

Crepidula cf. *onyx* Sowerby: 1 bleached shell. An example of a small narrow form such as one sometimes seen on a *Turritella* or *Olivella* shell.

Natica (?) sp. indet.: 3 small shells. These have much the aspect of *Cryptonatica*, but as there is at least one species in the area with a tight umbilical callus of this type, yet having a horny operculum, they must for the time being be left unplaced.

Polinices (Euspira) draconis Dall: 1.

Trivia (Pusula) ritteri Raymond: 1 immature.

Neosimnia catalinensis (Berry): 1. A perfect although not quite typical adult example of this rarely taken species.

Ocenebra clathrata (Dall): 5 shells.

Ocenebra (?) sp.: 1 shell.

Boreotrophon triangulatus (Carpenter): 1 shell.

Boreotrophon aff. *bentleyi* Dall: 2 (plus 1 shell).

These seem quite similar to *B. bentleyi* and may represent a form of it, but the shell is smaller, more compact, and obscurely spirally striate.

Mitrella tuberosa (Carpenter): 5 shells.

Amphissa reticulata Dall: 2 shells.

Amphissa undata Carpenter: 198 (plus 70 shells). By far the most abundant species in the haul.

Nassarius aff. *perpinguis* (Hinds): 1 shell. A puzzling shell, similar in general aspect to *N. perpinguis*, but much higher and with a different and peculiar sculpture, especially on the spire. More material will be needed for its satisfactory disposition.

Nassarius insculptus (Carpenter): 2 (plus 6 shells).

Olivella baetica Carpenter: 1 bleached shell.

Mitra (Atrimitra) idae Melville: 1 shell. A hermit-crab shell of fair size.

Admete cf. *gracilior* Carpenter: 2. These represent a form close to typical *gracilior*, differing chiefly in the more acute shoulder tuberculation and in the possession of but 8 axial ribs on the body whorl. It may eventually prove nameable as a further-evolved living race of the earlier species.

Admete, n.sp.?: 2. These appear quite close to a fossil form which the author has in MS.

Admete seftoni, n.sp.: 2. Described in the concluding section of this report (p. 155).

Elaeocyma empyrosia (Dall): 4 (plus 1 doubtful bleached shell).

Antiplanes perversus (Gabb): 5. These are of medium size only.

Antiplanes (Rectiplanes) sp.: 2. Surface corrosion is here too great to permit certain determination without additional material.

Lioglyphostoma crystallina (Gabb): 1 (plus 3 shells): Although there are obvious discrepancies with Dall's figure (1921:214, pl. 6, fig. 4), there is reasonable agreement with the original description of Gabb. Relative age may conceivably explain the differences.

Mangelia (Kurtzia) roperi Dall: 1 shell.

Turbonilla (Pyrgolamprocs) sp. indet.: 1. A

long slender species which can not at present be affiliated with any of the described forms.

Turbonilla (Mormula) regina Dall and Bartsch: 5. Of various ages and sizes, several showing spiral bands on the body whorl. Altitude of largest shell, 21.0 mm.

Acteocina intermedia Willett: 1 (plus 7 shells).

"*Retusa*" *harpa* (Dall): 1.

Cylichna diegensis Dall: 2.

Station H51-260 (pipe dredge), 86-94 feet (ca. 14-16 fathoms), west of Ford Point, Santa Rosa Island. Vegetation: abundant red and brown algae; July, 4, 1951.

Glycimeris corteziana Dall: 1.

Cardita (Cyclocardia) longini Bailey: 13½.

Chama pellucida Conrad: 1 damaged immature.

Dentalium sp.: 1.

Callicstoma splendens Carpenter: 3.

Bittium attenuatum Carpenter: 1.

Balcis (Vitreolina) thersites (Carpenter): 1 immature.

Ocenebra clathrata (Dall): 1.

Ocenebra (?) cf. *munda* Carpenter: 1 imperfect shell.

Mitrella carinata (Hinds): 98. Small for the species, but nearly all mature.

Nassarius cocperi (Forbes): 4 shells.

Conus californicus Hinds: 7, mostly immature.

DESCRIPTIONS OF NEW SPECIES

***Balcis (Vitreolina) titubans*, n. sp.**

Figs. 7, 8

Shell of fair size for a Californian member of the genus, solid, smooth, polished, basally robust, with an acute, rapidly tapering, doubly flexed spire; apex moderately tipped dorsad, with the body of the shell strongly diverted to the right. Whorls 10 to 11, the first translucent, the second less so, and those succeeding opaque milky white, very slightly swollen above the tightly appressed and barely indented suture; last whorl rounding smoothly into the full and moderately produced base. Sculpture wanting except for the distinct varical grooves, which, beginning dorsally on the sixth whorl, descend the shell in narrowly stepped obliquely protractive alignment, each groove producing an angular downward dip in the suture as it leaves it, the series terminating just back of the lip; final whorl without a varix and without a sutural indentation. Aperture a trifle over one-quarter the altitude of the shell, narrowly pyriform, its posterior angle acute, rounded and slightly pro-

duced in front; parietal wall barely convex, forming a widely obtuse angle where it adjoins the nearly straight, narrow, and somewhat oblique columella, the whole covered by a moderately thick, sharply bounded callus which is slightly expanded in front and appressed against the base of the shell; output lip entire, gently sinuate below the suture, thence rather weakly produced peripherally; from the periphery the lip rounds smoothly back and inward to its narrow expansion into the columellar thickening.

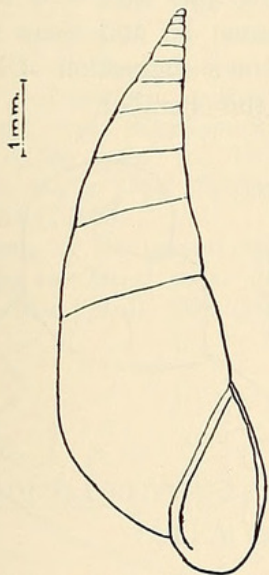


FIG. 7.—*Balcis (Vitreolina) titubans*, n. sp., camera-lucida outline of holotype; much enlarged.

Measurements (of holotype): Altitude 7.4; maximum diameter (est.) 2.7; altitude of aperture (to suture) 1.87; diameter of aperture (edge of columellar lip to outer lip) 0.9 mm.

Holotype: Berry Collection no. 23624.

Type locality: 46–58 fathoms, ca. $2\frac{1}{2}$ miles north of Anacapa Island, Calif.; one example, *Orca*, July 2, 1951.

Commentary: The distortion of symmetry in *B. titubans* is one of the most extreme seen in any of our species. It is much larger than the more or less similar *B. grippi* (Bartsch) of the same region, and it is both more robust and more eccentric in form than either that species or the more northern and likewise similar *B. columbiana* (Bartsch).

The specific name is the present participle of the Latin *titubo*, I stagger.

Admete seftoni, n. sp.

Figs. 2, 9

Shell small, robust, with 5 to $5\frac{1}{4}$ whorls; spire short, acutely conic, with sunken channeled sutures; nuclear whorls rounded, more or less

corroded in examples studied, but apparently smooth, subcarinate above, and at the beginning partially immersed; subsequent whorls strongly convex, slopingly subtabulate above, with 8 to 9 strong, moderately retractive, axial ribs, and with a strong spiral cord on the angle as well as another below it a little more than halfway to the suture; between these two primary spirals a third cord shortly arises, followed sometimes on the penultimate whorl by a fourth more slender cord below these and a fifth above the shoulder cord; body whorl more narrowly and less distinctly tabulate than the preceding whorls, bearing about 9 axial ribs, the last of which back of the aperture is somewhat obsolescent, and the above-mentioned 4 or 5 spiral cords, the most emphatic of these being the strong cord on the periphery separated by quite a wide space from a similar cord farther down the whorl, while below on the base are 4 lesser spirals of diminishing strength, the subperipheral and two posterior basal threads penetrating the aperture parietally; entire surface including the cords delicately spirally striate and more crudely axially threaded; axial ribs subtuberculate where crossed by the spiral cords, the nodules being best developed on the earlier whorls. Aperture ovate, rounded posteriorly, more pointed, though very obtusely so, in front; outer lip thin, smooth within, although the external cords shine through to give somewhat the effect of a liriation; lip margin ascending a little from the suture, then roundly descending into the very short, widely open canal; inner lip covered by a wash of callus which is thin, well expanded, and closely applied parie-

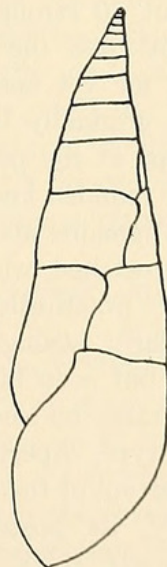


FIG. 8.—*Balcis (Vitreolina) titubans*, n. sp., camera-lucida outline of holotype as seen from right side; same scale as Fig. 7.

tally, but heavier and lip-like at the columella where it becomes appressed over the very narrow and impermeable umbilical chink; columella sloping very slightly inward and furnished with two fairly strong oblique plications.

Measurements (of holotype): Altitude 9.4; maximum diameter 5.8; altitude of aperture 5.4; maximum diameter of aperture (edge of columellar flare to margin of outer lip) 3.5 mm.

Holotype: Berry Collection no. 23679. *Paratype*: Berry Collection no. 23629.

Type locality: 46–58 fathoms, ca. 2½ miles North of Anacapa Island, Calif.; 2 examples, Orca, July 2, 1951.

Commentary: This very attractive little species is closely similar to no described form known to me. Its large body whorl, low-conic spire, deep suture, and strong axial plication afford a combination of characters which sets it well apart. In general form it somewhat resembles the considerably larger Alaskan species which currently passes for *A. couthouyi* (Jay), but it differs sharply in nearly every detail.

The species is dedicated to Joseph W. Sefton, of San Diego, master of the *Orca*.

***Pseudomelatoma sticta*, n. sp.**

Figs. 3–6

Shell of moderate size, elongate-fusiform, with tall, sharply conic spire; whorls 9+, slightly constricted in front of the suture, the anteriorly thrust periphery smoothly convex; suture sharply defined; first nepionic whorl and a quarter smooth, mammillate; succeeding whorl rather abruptly showing about 6 fairly sharp spiral grooves and about 10 strong protractive axial ribs which do not cross the fasciole; although remaining strong for yet another whorl or so, all this sculpture gradually tends thereafter to obsolescence except at the periphery where the ribs persist as low rounded knobs, the number of which to a whorl remains about the same until the body whorl is reached, when the entire later portion becomes practically smooth; spiral grooving particularly strong on the base of adolescent shells, but even in this region represented only by traces on such a fully mature shell as the holotype. Aperture elongate-pyriiform, about 38 percent of the height of the shell, widest posteriorly, its posterior angle acute; outer lip moderately thick, sharp-edged, unarmored, produced anteriorly into the short, open, very slightly recurved canal; inner lip and

columella smooth, weakly sigmoid, covered by a rather thick callus the outer boundary of which is a rather sharp groove in the adolescent shell and a low ridge in the adult. Anal notch distinct, shallow, subjoining the suture; fasciole rather wide, marked principally by the inbowed lines of growth. Color generally a light golden brown, everywhere speckled with small, rounded, discrete, dark brown spots, in some areas showing a tendency to a certain regularity of arrangement; the holotype also shows a large, conspicuous, blackish brown spot over and immediately in front of the inner lip and there is considerable dark staining or a suggestion of banding in the outer wall of the chamber.

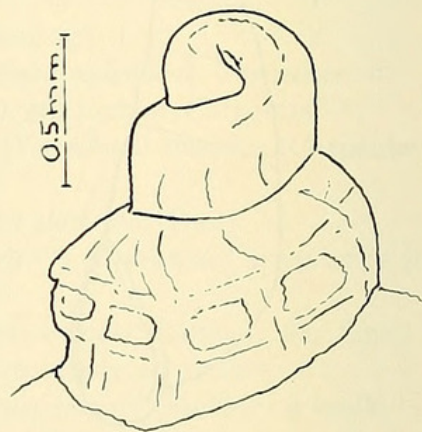


FIG. 9.—*Admete seftoni*, n. sp., camera-lucida sketch of apex of paratype; greatly enlarged.

Measurements: Holotype—altitude 29.5; maximum diameter 9.2; altitude of aperture 11.2; diameter of aperture 4.4 mm. Paratype—altitude 17.3; maximum diameter 6.5; altitude of aperture 7.3, diameter of aperture 2.8 mm.

Holotype: Berry Collection no. 23785. *Paratype*: Berry Collection no. 23584.

Type locality: 26–27 fathoms, Anacapa Passage, Calif.; 2 specimens, Orca, July 2, 1951.

Commentary: Even amid the graceful family of the turrids this is a trimly elegant species, characterized by the down-sagging (or anteriorly thrust) noded convexity of the whorls comprising the spire, by the eventual obsolescence of the originally sharp axial and spiral sculpture, and by the neatly speckled color pattern. These features separate it from all other members of the genus *Pseudomelatoma*, with which its present affiliation can be only tentative in the absence of any knowledge of the animal and particularly of its radula. The shells of both holotype and paratype were almost completely covered by a heavy whitish bloom, apparently limy and perhaps algal,

which proved exceedingly difficult of even incomplete removal.

The specific name is the Latin *sictus*, dotted, and has reference to the speckled color pattern of the shell.

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LOW-TEMPERATURE ALIGNMENT OF RADIOACTIVE NUCLEI PROVIDES DATA ON NUCLEAR DISINTEGRATION

Low-temperature research at the National Bureau of Standards has succeeded in aligning the nuclei of three radioactive elements—cerium-139, cerium-141, and neodymium-147. These results were achieved by cooling samples of the three materials to within a few thousandths of a degree of absolute zero. At such temperatures the effects of thermal agitation become so small that atomic nuclei can line up in a given direction within the crystal lattice. A corresponding directional effect can then be observed in the emitted radiation.

The nuclear alignment experiments¹ were carried out by Drs. E. Ambler and R. P. Hudson, of the Bureau staff, in cooperation with Dr. G. M. Temmer, of the Carnegie Institution of Washington. Initial phases of the work were sponsored by the Office of Naval Research.

Low-temperature alignment of nuclei promises to provide a new tool for studying the processes of nuclear disintegration. The nucleus may be regarded as a magnetic top spinning about an

axis. If this spinning magnet is radioactive, the orientation of the spin axis will determine the directions in which the nucleus emits radiation. Normally, when nuclei are randomly oriented, a radioactive specimen emits gamma rays with equal intensity in all directions. However, when the nuclei are aligned, the intensity of gamma radiation varies with angle of emission. By measuring the degree of this directional effect, valuable information can be obtained concerning the decay scheme of the nuclei, and an insight can be gained into the mechanisms controlling such processes. For example, the magnetic moment of the nucleus can be determined as well as the changes in angular momentum accompanying the emission.

In the Bureau's experiments, radioactive nuclei were incorporated into certain inorganic crystals formed by the elements studied, which were then cooled to temperatures as low as 0.003°K. Nuclear alignment was observed by measuring the angular distribution of the intensity of the gamma radiation emitted by the crystals.

Inasmuch as the crystals used were paramagnetic, the necessary low temperatures could be conveniently produced by the method of adia-

¹ For further details, see *Alignment of cerium-141 and neodymium-147 nuclei*, by E. AMBLER, R. P. HUDSON, and G. M. TEMMER, *Phys. Rev.* **97**: 1212. 1955; and *Alignment of three odd-A rare earth nuclei*, by the same authors, *ibid.* **101**: 1096. 1956.



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