

SOUTH AUSTRALIAN SHELLS. (Including descriptions of new genera and species)

PART VIII.

(By BERNARD C. COTTON & F. K. GODFREY).

SCAPHOPODA.

The name signifies scoop-footed. "Tusk Shells" or "Tooth Shells," from their suggestive shape, are immediately distinguishable from the shells of all other living molluscs, being straight or slightly curved tubes, without a spire. Bilaterally symmetrical molluscs with the shell (and mantle) a long, more or less curved, tapering or fusiform tube, open at both ends, the concave side dorsal; anterior orifice larger, contracted by a muscular thickening of the mantle, and giving egress to the cylindrical head and the long, pointed foot, which is capable of being enlarged and variously modified in shape distally; the smaller (posterior) orifice of the mantle and shell giving exit to the refuse of digestion, respiration and the genital products. Head with terminal mouth surrounded by a rosette of lobes; no eyes; otocysts present; no tentacles, but a close cluster of thread-like, distally enlarged appendages known as captaculae, springs from the base of the snout. Jaw and radula present; liver two-lobed, symmetrical; gut strongly convoluted, the anus opening rather far forward in the mantle cavity, kidney openings near it. Gonad simple, opening through the right nephridium. No gills, respiration being performed by the general integument. Heart rudimentary, with only one chamber, auricles and reno-pericardial ducts wanting. Nervous system with well-developed ganglia, the cerebral, pleural, pedal, visceral and buccal ganglia symmetrical. Marine burrowing molluscs, living partially embedded in sand or mud on the sea bottom, with but, as a rule, the posterior extremity projecting. They feed on the lowest organisms. Sexes distinct. The tubular shell, open at both ends, is characteristic of the group, and occurs nowhere else in the mollusca. Growth takes place at the larger end and on the inside of the tube, and at the same time the shell is absorbed at a slower rate from the smaller end. The slits and notches in this end are therefore formed by absorption, being wholly different in genesis from similar structures of the peristome in Gastropods. In some forms upon the practical cessation of growth and absorption upon the

attainment of maturity, there is a supplementary tube built out from the edge of the anal orifice. The shell contains a very slight organic basis, leaving no appreciable amount when dissolved in acid. It is formed of three distinct layers. The inner layer (hypostracum) composed of long prisms, rounded at the angles and tapering at the ends. This layer is thinnest at the aperture, thickest towards the apex. The thick middle layer (ostracum) built up of short prisms in bundles lying at right angles with each other. The outer layer (periostracum) thin and wholly sculptureless. It covers the sculpture, ribs, etc., of the shell. The radula is short, early rigid and curved, and incapable of being used as a rasping organ as in other molluscs; its function is probably largely as a crushing plate, like the gizzard-plates of *Bullaria*. The formula of teeth is 1. 1. 1. 1. 1. (Pilsbry). The posterior aperture of the shell is emarginated by a ventral sinus, and is furnished interiorly with a dorsal and ventral valve, which are capable of being applied to one another. The Scaphopods seem to form an actual link connecting the bivalves with the univalves. In most points they agree with the bivalves; in only two respects—the shell and the radula—do they agree with the univalves, and even in the matter of the shell they begin life as bivalves, for in the embryo this consists of two plates which later become united to form a tube.

The shelled foraminifera found in the stomach of a Scaphopod are perfect, and the sarcode must be extracted from them by some secretion referable to the gastric juice of the Vertebrata. Eyes are absent as they would be useless to an animal always buried in sand. There are no external organs of generation; but impregnation is effected by the male emitting the spermatozoa, and the female her ova at the same time, in the water. The process may be partly compared to the chance shedding of pollen in the air by dioecious plants. Lacaze-Duthiers closely studied *Dentalium vulgare* (France) and noticed that the spermatozoa lived six hours after performing the act of fecundation. The egg is at first oval, afterwards pear shaped, and ultimately divided into segments like those of an Annelid. In the first stage of development the germ is motionless; in the second stage it is propelled by vibratile cilia, which are set round a large lobe in front, similar to that observable in the larvae of many mollusca, and it swims rapidly; in the third stage it crawls by means of a disc-like foot. In swimming it does not come to the surface of the water, as do the fry of the oyster and other mollusca. The shell is formed during the third period, but is only detected by its iridescent lustre, being exceedingly thin and transparent, a

mere film. This state continues till the fifth and occasionally the sixth day after birth. The embryonic period lasts from thirty-five to forty days. Lacaze-Duthiers observed a current of water passing through the shell from the opening at the smaller end. He discovered *Dentalium* at low water mark, where its presence was betrayed by a small groove in the sand, and he easily procured 200 live specimens at a single low spring tide. They prefer certain spots, especially patches of coarse sand mixed with broken shells and interspersed with *Zostera*. The same observer kept some alive in a flask of sea water with a little sand for more than eighteen months. It is much more active at night, being sensible of light. The foot acts as a piston in expelling at the other end the eggs and seminal fluid, as well as perhaps the faeces and exhausted water. The point of a young shell is pear-shaped, and is broken off when too small to contain the terminal tube or process of the mantle; and this part of the shell is continually rubbed away as the animal increases in size, until at last it becomes truncated, and a short pipe is formed with an oblique slit in front to accomodate the terminal tube. The slit is extended in certain species, although this distinctive character is confined to adult specimens. The inside of the shell is white as porcelain, and brilliant as varnish. The periostracum is slight and easily abraded. The microscopical texture of the shell is scarcely different from that of *Patella*. It is most complicated, being composed in a great measure of prisms, interlacing fibres, and anastomosing canals—not of cellular elements (Jeffreys).

The class *Scaphopoda* includes but two families—the *Dentaliidae* and the *Siphonodentaliidae*. The distinctions between them are based upon (a) differences in the median tooth of the radula, (b) the form of the foot, (c) certain quite definite shell characters.

The *Dentaliidae* has the median tooth of the radula twice as wide as long; a pointed conical foot surrounded by an epipodial process resembling a wingshaped sheath, which is interrupted or slit, like the break in a fold, on one side; a shell with greatest diameter at aperture. The shell is almost always, to some extent, sculptured.

In the *Siphonodentaliidae* the width of the median tooth of the radula is much less than double its length, generally less than its length. The foot lacks any epipodial processes, and is either a slender vermiform organ or is expanded on the end into a symmetrical disk with fluted or indented border. The shell, except in one restricted group, wholly lacks sculptural features, being smooth and glassy in texture, and it is generally contracted at the aperture. (Henderson).

DENTALIIDAE.

Shell tubular, curved, with the greatest diameter at the anterior aperture, and tapering evenly to the posterior aperture. Distribution—All seas, from the littoral to moderate depths. Fossil—Ordovician, but most abundant from the Cretaceous where very large species occur. Animal having the foot conical, with a laterally and dorsally interrupted encircling sheath. Differences between this family and *Siphonodentaliidae* have been outlined under class *Scaphopoda*.

Dentalium Linne 1758. An elongate tube open at both ends, increasing in diameter from apex to aperture, section of maximum diameter being coincident with the peristome; almost straight to strongly curved; usually with longitudinal riblets or engraved lines, especially near the tip; these may vary in number from six to sixty or more; ribs or riblets in the apical portion often increased later by addition of others intercalated between them; sculpture frequently disappears in the anterior portion; sometimes fine transverse lirae occupy the spaces between the ribs or even cross them; or the intercostal surface may present a fine reticulate plan of excessively minute sculptural elements; in some groups there are no sculptural features whatever; embryonic portion of apex very minute and fragile, and nearly always lost in very young specimens; apical section remaining may be round or angular in section; apical opening usually modified by a slit or notch of varying width or depth and variously placed in different groups; or the opening may be simple without notch or slit; shell varies from minute needle-like forms to those of four or five inches in length, in thickness from fragile to heavy and solid; in texture from soft and chalky to hard porcellanous or glassy; in colour from greenish, reddish, or yellowish species to pure white, the latter greatly predominating; the shells may be translucent to opaque, dull lustreless to the most highly polished and glistening surface. Type—*D. elephantinum* Linne (Amboyna)

Animal shaped like its shell, elongate, wrapped in a mantle open at both ends; from larger end a pointed cylindrical foot may be protruded or almost wholly withdrawn; without tentacles or eyes; just back of the mouth is a cluster of thread-like appendages enlarged into spoon-shaped terminals (captaculae)—the exact function of these is not definitely understood, but they are supposed to catch and hold the food, consisting largely of foraminifera and other minute organisms; the liver is two-lobed, the gonad simple; heart of one ventricle; without gills; excretory openings in the forward part of the mantle cavity, but the escape

of faecal and sexual products is through the smaller end of the shell; nervous system consists of symmetrically placed central, pleural, pedal, visceral, and buccal ganglia.

Dentalium has been subdivided into a number of subgenera based chiefly upon apical characters of the shell. The actual value of these apical characters for the purpose of classification, and therefore the value of subgenera chiefly based upon them, is not altogether assured, but in a genus embracing so many species some form of division is useful, even though it be somewhat artificial. Any one character, if relied upon to distinguish the larger groups, answers well enough for a time, but it always seems eventually to invite trouble. The shell characters that may be used better in combination for the larger or the smaller groups are: Type of sculpture, the form of the tip, the degree of curvature, the size and thickness of the shell, the position and form of the apical slit. We present our suggestions of subgeneric locations for Flindersian species.

Dentalium Linne 1758, in the restricted sense, does not occur in South Australia. The nearest approach are the species, *cheverti* Sharp & Pilsbry, *katowense* Brazier, *robustum* Brazier, *duodecimcostatum* Brazier, *intercalatum* Gould, *bednalli* Pilsbry & Sharp, *decemcostatum* Brazier, *tasmaniensis* Tenison-Woods, *thetidis* Hedley, *octopleuron* Verco, *francisense* Verco, *hemileuron* Verco: for these we propose:—

Paradentalium subgen. nov. with *intercalatum* Gould 1859, as type. White shells with six to fourteen strong ribs at the apex, continuing to the aperture or becoming obsolete, the intervals either smooth, with several striae, or a median riblet; apex small; and orifice simple without terminal pipe, slit, or notch (with very few exceptions where a short slit occurs).

Laevidentalium Fischer 1895 (Subgenus). A long fissure on the convex side in the posterior portion of the shell; surface longitudinally striate. Type—*D. ergasticum* Fischer 1882 (Atlantic). Mainly deep water species, of all temperate and tropical seas, distinguished chiefly by the large size and solidity of the shell with numerous longitudinal riblets; apical slit is a frequent but not invariable feature. *D. zelandicum* Sowerby, belongs here.

Fissidentalium Cossman 1888 (Subgenus). Shell smooth or showing growth lines only; slightly oval or round section; apex simple (as defined by Cossman) or with a shallow broad notch on the convex side (as expanded by Pilsbry & Sharp). Type—*D. incertum* Deshayes 1826, an Eocene fossil of the Paris Basin. The principal subgeneric character is the wholly sculptureless shell which is even smooth on the tip. Here we locate *D. lubricatum* Sowerby.

Eudentalium subgen. nov. Shell small; tube square at and near the apex, angular at the aperture; primary ribs serrate, intervals ribless. Type—*D. quadricostatum* Brazier, a South Australian shell, although also reported from north-east Australia and New Guinea.

Episiphon Pilsbry & Sharp 1897 (Subgenus). Shell very small, slender, rather straight, needle-shaped, slightly tapering, thin, fragile, glossy, smooth, and without longitudinal sculpture; apex with a projecting pipe or is a simple orifice; no slit, rarely a notch. Type—*D. sowerbyi* Guilding 1834, from the Caribbean Sea. Here we place *D. virgula* Hedley, *D. hyperhemileuron* Verco.

D. intercalatum Gould 1859 (= *D. octogonum* Angas 1878, not Lamarck). "The Intercalated Dentalium." Strongly curved and conspicuously tapering in its earlier half, the latter half nearly straight and less tapering; white, lustreless; at and near the apex, hexagonal in section, the angles rather sharp and a little projecting, intervals nearly flat; not far from apex a secondary riblet arises in each of the two faces on the outer curve, and somewhat later the lateral faces and those on the concave side are similarly divided; the secondary riblets gaining rapidly in strength, and on the latter part of the shell equal to the six primary ribs; apical orifice circular, about half as wide as the truncated apex. Length 19, diam. at aperture 2.25, at apex 0.9 mm. General, and not uncommon, beach and down to 300 fathoms, chiefly in muddy bottoms. Also Western Australia—King George Sound to Geographe Bay. (Type locality—China Seas). Exceedingly variable. Length may reach 37 mm. The amount truncated varies so that a stouter, older shell, may not be so long as another which is evidently younger and has not suffered so much truncation. Curvature varies; since the posterior end is progressively removed, the mature shell appears different from that of the immature, being nearly straight and bluntly truncated instead of well curved and posteriorly acuminate. Usually the ribs become more numerous with age, the increase being effected by intercalation and by rib splitting. Generally in the centre of an interspace a riblet arises, and gradually enlarges until it equals the original ribs. The stage of growth at which intercalation begins varies not only in different shells, but in the several interspaces of the same shell. Besides the secondary riblets, eventually tertiary riblets may arise in their interspaces and further multiply the costations. In any position, two equal riblets, instead of only one, may develop simultaneously in an interspace. Further a groove begins to form a rib, and gradually

grows in depth and width until it divides it into two. This groove may begin on the centre or on any part of the side of the rib. The ribs so formed may subsequently be cut up by other grooves. Sometimes two or three of such furrows may appear on the same rib at the same time and enlarging at an equal rate form three or four subequal riblets. The contour of the ribs may vary greatly, they may be narrow and comparatively high throughout their length, or they may almost fade out and leave the anterior part of the shell nearly smooth. The shape of the ribs may also change; they may have concave interstices so as to resemble a fluted column, then the ribs may widen out and become convex, while their interstices become reduced to narrow, shallow grooves between broad, approximate, rounded ribs. Pilsbry suggests the typical form is hexagonal; usually there are more than six costae. The anal appendical tube usually wanting, even during life; when present it may be two or three millimetres long; it is central, but not always in the axis of the shell; it is probably an outgrowth subsequent to truncation, and not merely a residual inner layer of the shell after the outer portion has been absorbed.

D. duodecimcostatum Brazier 1877. "The Twelve-ribbed Dentalium." Straight, thin, shining, six-sided, white; longitudinal ribs rounded, the base with twelve, and from the centre to the apex six, interstices smooth; apex tapering, entire, with minute perforation; aperture large. Length 22, diam. apex .5, base 2 mm. Gulf St. Vincent, 22 fathoms. (Type locality—Darnley Island, Torres Straits, 30 fathoms, sandy mud). South Australian specimens do not exceed 18 mm. and are probably subspecifically distinct.

D. cheverti Sharp & Pilsbry 1898 (= *D. septemcostatum* Brazier 1877, preocc.). "The Chevert Expedition Dentalium." Slightly arched, white; ribs seven, somewhat sharp, having finer ones between, extending from base to centre, interstices with fine transverse silk-like striae; apex perforated, perforation with a minute notch-like fissure on dorsal margin; aperture circular, entire. Length 14, diam. apex .5, base 1.5 mm. Gulf St. Vincent, 22 fathoms. (Type locality—Evan Bay, Cape York, North Australia, 6 fathoms, sand).

D. katowense Brazier 1877. "The Katow Dentalium." Thin, transparent, slightly arched near the apex; white; ribs seven throughout, fourteen from the centre to the base, those above being most conspicuous; interstices with minute lengthened striae; apex thickened, perforation small, entire; aperture circular. Length 14, diam. apex 1, base 2 mm. Gulf St. Vin-

cent, 15-22 fathoms, greatest length 22.5 mm. (Type locality—Katow, New Guinea, 8 fathoms, sandy mud and coral). Brazier in the definition of his species writes "interstices with minute lengthened striae." If the specimens of *D. intercalatum* Gould, from South Australia are examined under a lens when their larger end is towards the light they will show their transverse accermental striae very plainly, but when they lie with their side toward the light these are quite indistinct, and fine axial striae are visible. The relative validity of these axial and accermental striae varies in different examples. They are seen in our specimens labelled *D. katowense* (Verco).

D. thetidis Hedley 1903. "The Thetis Dentalium." Rather thin, tapering, very little curved; white; longitudinal ribs seven, the whole length, those on concave side stronger and wider apart than the others; each interspace grooved by a dozen fine, even striae, faintly crossed by growth lines; towards the aperture one or two interstitial riblets arise; posterior orifice simple. Length 8, diam. of aperture 1 mm. Dredged—Gulf St. Vincent 6-22 fathoms, Cape Jaffa 130-300 fathoms. (Type locality—63-75 fathoms off Port Kembla N.S.W.). A South Australian specimen measures 20 x 2.25 mm. "In the two fresh specimens from 130 fathoms, close to the posterior end, in the furrow on each side next to the central furrow on the convex surface, are four minute holes in an axial line. These are probably only accidental. They may be bore-holes of predaceous molluscs. Still it is a curious coincidence to find them in two specimens in identically the same position; and the coincidence is more striking since they occur only in these two instances, among several hundred *Dentalium* shells. These are often bored, but generally only in one or two holes and in other parts of the shell. However it would be perilous to construct another species to include these two examples, which in all other respects resemble the rest under this name." Verco (Trans. Roy. Soc. of S.Aus. vol. 35. 1911. p.205).

D. bednalli Pilsbry & Sharp 1898. "Bednall's Dentalium." Shell soiled or Isabella-whitish, moderately curved, the curvature posterior; longitudinal rounded ribs, seven, strong, separated by deeply concave and decidedly wider intervals; passing anteriorly the ribs become lower and wider, and tend to split by the appearance of progressively deepening sulci on their side slopes, so that at the aperture there are about ten very low ribs of unequal prominence, besides some incipient ones; intervals shallow and narrower than the ribs; growth striae fine and rather inconspicuous throughout, no longitudinal striation; aperture subcircular, retaining a slightly hexagonal form, as long as wide; apex rather large, orifice small, oval, longer than wide, with thick walls;

no slit or notch. Length 19, diam. aperture 2.8, apex 1.3 mm. Gulf St. Vincent, 15-22 fathoms. (Type locality—Gulf St. Vincent, South Australia). Many specimens dredged with seven ribs posteriorly and a varying number anteriorly. Probably the *D. octogonum* of Adcock's list, a synonym of *D. octangulatum* Donovan.

D. octopleuron Verco 1911 (not *D. octagonum* Lamarck [Angas, Proc. Zool. Soc., 1878, p.868]). "The Eight-ribbed Dentalium." This shell is like *D. bednalli* Pilsbry & Sharp, except that it has eight ribs at the posterior end instead of seven. In four specimens the eight costae run throughout the shell, which may measure 20 mm. in length. But in all the others riblets arise; it may be in only one or in two, or up to all the intercostal spaces. These riblets may number as many as four in a space; they may equal in size the primary ribs, if they are few, or they may remain small, especially if numerous. (Type locality—Gulf St. Vincent, 15-22 fathoms). Verco dredged 88 in good condition in this locality. This variety is the most common in our shallower waters, and this would be the form found by Angas on Henley Beach and named by him *D. octagonum*.

D. robustum Brazier 1877. "The Robust Dentalium." Nearly straight, thick, dull white; axial ribs nine, rounded, wide apart, narrow toward the apex, interstices flattened, smooth; apex with small perforation, entire; aperture thickened, regular. Length 20, diam. apex .75, base 2.5 mm. Gulf St. Vincent, 15-22 fathoms. (Type locality—Kato, New Guinea, 8 fathoms, sandy mud and coral). Some specimens dredged in Gulf St. Vincent have nine ribs posteriorly and more than nine anteriorly.

D. decemcostatum Brazier 1877. "The Ten-ribbed Dentalium." Tapering, thin, slightly arched, white; axial ribs ten, somewhat sharp, interstices nearly flat; transverse striations fine; apex with a small perforation; basal aperture large, circular. Length 20, diam. apex .5, base 3 mm. Gulf St. Vincent 15-22 fathoms. (Type locality—Kato, New Guinea, 8 fathoms, sandy mud). Some specimens dredged in Gulf St. Vincent have ten ribs posteriorly, and more than ten anteriorly.

D. francisense Verco 1911. Pl. 1, figs. 1 and 1a. "The St. Francis Island Dentalium." Moderately solid, narrow, curved, less anteriorly, translucent white; ribs fourteen, broad, low, round, extending throughout, separated by distinct linear inter-spaces; growth lines microscopic; anterior aperture circular, margins thin, scarcely scalloped; posterior end truncated, aperture small, border thick, shape oval, elongate antero-posteriorly. Length 28, diam. ant. 3.2, post. 1.6 mm. St. Francis Island; Gulf St. Vincent; Cape Borda; 15-55 fathoms. Also Western Aus-

tralia—beach—Bunbury, Rottnest Island; dredged—Hopetoun, Geographe Bay, Fremantle, 6-35 fathoms. (Type locality—15-20 fathoms, Petrel Bay, St. Francis Island, South Australia). This shell varies. A much younger individual than the type measures 13.5 x 2.4 x .8 mm, is much more curved and has a slightly projecting appendical tube. There may be only eleven ribs throughout; or eleven posteriorly, and more anteriorly up to twenty-two from intercalated riblets; there may be twelve ribs throughout and these may be typically broad and round, or rather narrow and flat; there may be thirteen, fifteen, or very rarely eighteen ribs throughout. Verco writes, "I am inclined to think that even this species is but an extreme variant of *D. intercalatum* Gould. It would seem as though the more initial ribs are present at the posterior end, the fewer interstitial ribs arise, which is easily understood; and the more likely they are to be round and broad and encroach on the intercostal spaces. Still one may meet with an occasional specimen starting with eleven ribs which increase up to twenty-four, and are rather narrow; or with one which starts with only a few ribs, seven or nine, and these become broad and rounded.

D. hemileuron Verco 1911. Pl. 1, fig. 2. Long, narrow, rather thick, very slightly curved, mostly at the hinder part; white opaque when dead, translucent when fresh, and glistening; axial ribs ten, valid, narrow, about one fourth the width of their interspaces, less valid and less distant on the convex side, well developed in the posterior half, then becoming quickly obsolete and absent from the anterior third; ribs do not increase in number with age; transverse scratch marks, close, and circles of varying opacity; anterior aperture round; posterior aperture round, but on the convex surface it has a sinus about as deep as wide with convex margins. Length 30, greatest width 2.4, smallest .4 mm. Cape Jaffa; Beachport; 130-300 fathoms. (Type locality—300 fathoms off Cape Jaffa, South Australia). Some examples have nine ribs, some eight, some eleven. There are no axial interstitial riblets as in *D. thetidis* Hedley, nor increase in the number of ribs by splitting or intercalation, as in *D. intercalatum* Gould, and the anterior part is ribless.

D. tasmaniensis Tenison-Woods 1876. "The Tasmanian Dentalium." Solid, slender, slowly increasing, slightly curved, white; axial ribs eight, interstices often subcostate; apex entire. Length 10.5, diam. apex .5 mm. Port Adelaide River. (Type locality—Northwest coast of Tasmania). A gracefully tapering shell, curved slightly, with valid ribs and often smaller ones in the interstices. *D. aratum* Tate and *D. nanum* Hutton, of the South Australian and New Zealand tertiaries relatively, are allied

D. zelandicum Sowerby 1860 (= *D. pacificum* Hutton 1873). "The New Zealand Dentalium." Large, slightly arcuate, rather slowly tapering, with numerous unequal ribs, apex mostly with a slit; white, banded with pale grey and tawny; longitudinal ribs of unequal strength, narrow, scarcely raised, eighteen to twenty at posterior end, thirty to forty-five at anterior extremity, about twenty of which being stronger than the others; ribs crossed by distinct, dense, oblique growth lines; posterior orifice narrow, circular, sometimes with a simple, narrow, ventral fissure about 4 mm. long; aperture oblique, dorsal lip somewhat advancing, circular; peristome thin, sharp. Length 57, diam. 8 mm. Dredged—Cape Jaffa, also Beachport, 110-200 fathoms. (Type locality—New Zealand). The smaller ribs arise by intercalation. The fissure is not always present.

D. lubricatum Sowerby 1860. Pl. 1, figs. 4 and 4a. "The Slippery Dentalium." Elongate, lightly curved, polished, subpellucid, white; slightly slit, gradually increasing. Length 36.5, greatest diam. 3.25 mm. Dredged Beachport, Cape Borda, Cape Jaffa, Neptune Islands, 40-150 fathoms. Also Western Australia—Hopetoun, 35 fathoms. (Type locality—off Port Jackson Heads, 45 fathoms, hard sand bottom [Brazier]). With reference to the slit, South Australian examples show that in the very early stage of growth there is no slit, but a central posterior aperture; length of slit may vary from a mere notch to a fissure of 8 mm. The slit is always on the convex or ventral aspect. In some specimens the dorsal part near the posterior end is spotted or blotched with opaque white. Rarely, specimens show the extreme posterior end, which is an elliptical bulb with a very short slightly-contracting round tubular posterior prolongation set somewhat obliquely to the axis of the bulb and directed toward the convex side of the shell. Opaque transverse rings appear in the first 1.5 mm. of the shell.

D. quadricostatum Brazier 1877. "The Four-ribbed Dentalium." Very slightly arched, white; four angled, keel or rib at each angle, rounded, finely serrated, interstices flat, marked with transverse lines; apex perforated, perforation entire; aperture angled. Length 16, diam. base 2 mm. Beachport, 110 fathoms. (Type locality—Princess Charlotte Bay, North-east Australia, 13 fathoms). If this species is laid upon its side it forms a true square; when resting with the arched part of the apex down, it forms four angles, with a serrated rib on each angle.

D. virgula Hedley 1903. *Virgula*, a little twig, refers to the supplementary tube at the narrow end. Shell small, a little curved, slightly tapering, slender in section, circular, polished,

with minute growth rings at irregular intervals, solid at apex, thin at aperture; milk-white opaque rings alternate with pale-orange translucent ones; supplementary tube a small round pipe eccentric to the direction of the shell and arising in the centre of the apex. Length 10.5, diam. at aperture 1.1, at apex .62 mm; diam. of tube .2 mm. Dredged—Cape Borda, Cape Jaffa, Neptune Islands, Beachport, 60-200 fathoms. (Type locality—Numerous examples were taken in 63-75 fathoms off Port Kembla N.S.W.). Some South Australian examples have slight annular constrictions at intervals of 3 mm: here the shell is less opaque-white, and the opacity gradually increases anteriorly. The appendix is visible in very early life, when the shell is extremely narrow. When the appendix is absent in the early stages of growth the shell is not unlike juvenile *D. lubricatum* Sowerby, but does not increase so rapidly, and has more marked transverse striations.

D. hyperhemileuron Verco 1911. Pl. 1, figs. 3 and 3a. Long, narrow, very slightly curved, mostly at hinder part, rather thin; white when dead, translucent when fresh, and glistening; axial ribs, twelve, invalid, narrow, no increase in number with age, becoming obsolete early, so as to leave the anterior two-thirds of shell smooth but for very fine accremental scratch lines; interstices nearly flat, slightly concave; anterior orifice round, margin thin and simple; posterior end truncated, with a long narrow diaphanous appendix directed eccentrically dorsally; the growth lines on the appendix form a convexly bordered sinus on the ventral surface about as wide as deep, and a scarcely depressed margin on the dorsal surface. Length 20.5, greatest width 1.8, least .7 mm., length of appendix 2.2, diam. .4 mm. Western Australia—King George Sound, 12-14 fathoms, 200 examples, several alive, (Type locality), also Geographe Bay, Fremantle, 10-15 fathoms. Some individuals with perfect posterior ends run down to a diameter of .3 mm., and are there diaphanous and ribless, and have only growth striae; others more mature and with a posterior end of 1 mm. in diameter, and without an appendix, are here bevelled internally and thinner on the convex side, where there is a shallow triangular notch. The largest example is 30.75 x 2.3 mm. The ribs may vary in number from ten to sixteen in different individuals. The species closely resembles *D. hemileuron* Verco, in the ribless anterior portion and the never increasing ribs of the posterior end, and in their extension to within 2 mm. of the end in very young individuals and in the ventral notch at the hinder extremity; but the latter

has no appendix, the ribs are more valid and do not so soon become obsolete, and it is not found in such shallow water. The absence of the appendix may be only an accidental circumstance, and the shallower water in which the Western Australian species lives may account for the other differences, and that this is only a local variety. One individual from Geographe Bay, measuring 4 x .5 mm., has the apical end complete.

SIPHONODONTALIIDAE

(=*Siphonopoda* Sars: = *Gadilinae* Stoliczka: = *Siphonopodidae* Simroth). Shell small and generally smooth, often contracted towards the mouth. Distribution—All seas, from the tidal zone to the abyssal depths. Animal having the foot either expanded distally in a symmetrical disc with crenate continuous edge, with or without a median finger-like projection, or simple and vermiform, without lateral processes. Characteristics which differ from *Dentaliidae* are referred to under class *Scaphopoda*.

Cadulus Philippi 1844. Small, more or less arcuate, generally swollen, or with an inflated bulging area in the middle portion of the shell or near the anterior aperture; white; without any sculpture; aperture more or less contracted and usually very oblique; apical aperture proportionately quite large as compared with that of *Dentalium*, and either simple or cut by two or four slits; section round or flattened; occasionally an internal circular rib is developed just within the apical orifice. Type—*Dentalium ovulum* Philippi (Mediterranean). The genus is represented in all depths. The mollusc lives in sandy and muddy stations and often in great individual quantity. Species not usually very widely distributed but certain exceptions are notable. The idea of variation of individual species is exaggerated by breakage of the ends causing the shortened specimens to appear more inflated. Texture of shells is vitreous and more or less translucent; there may be circular deposits of shelly material, causing alternate rings of more or less translucency which are not, however, specific characters, but appear to be wholly individual and possibly pathologic. The concave side is commonly accepted as dorsal, and the convex ventral. The important specific characters of the *Caduli* are the slits and lobes about the edge of the apical orifice, the general shape of the shell, the ratio of length to breadth, the localised or general type of swelling, the compression of the shell, the obliquity of the aperture, and, lastly, the size. A good way to identify material is to examine first the apical characters in order to place the shells in their proper subgeneric groups; then seek among figured species of similar size for those with median

or submedian equators (section of maximum diameter), or with equators more anteriorly placed; after which the oval or round section, the small or large apical orifice, and the obliquity of the aperture, follow. Subgenus *Cadulus*, in the restricted sense, includes species which are somewhat cask-shaped, short, obese, conspicuously swollen in the middle, tapering rapidly toward both ends; convex on all sides, though less so dorsally; peristome simple, thin; anal orifice large, with simple edge contracted by a wide circular callus or ledge just within the opening. This subgenus does not appear to be represented in Flindersian waters.

Cadila Gray 1847 (subgenus). Decidedly curved, more or less swollen near the middle or towards the aperture; more tapering toward the apex; apical orifice not contracted by a callous ring, or with such callous ring, weak and far within; edges not slit. Type—*Cadulus gadus* Montague, of uncertain habitat. Species located here are usually small and slender. We include: *C. acuminatus* Tate, *C. angustior* Verco, *C. laevis* Brazier, *C. occiduus* Verco, *C. spretus* Tate & May.

Polyschides Pilsbry & Sharp 1898. (subgenus). Inflated anterior to the middle or not much bulging; apex cut into a number of lobes, generally four, by as many slits. Type—*Cadulus tetraschistus* Watson 1879, from Fernando Noronha. Our species *C. gibbosus* Verco, belongs here. We would remark that the chief characters of this subgenus are the deep slits and prominent apical lobes. Typical quadridentate forms appear numerous in the Eocene.

C. acuminatus Tate 1887. "The Acuminated *Cadulus*." Rather thin, moderately arcuate, not much swollen, fusiform, the greatest girth about the middle, thence very gradually tapering towards the ends, which are rather large; median bulging being about as obvious in a dorsal or ventral as in a lateral view of the shell; tube somewhat flattened antero-posteriorly throughout, the compression slightly greater at the ends; smooth, glossy, translucent whitish, with an opaque white ring a short distance from the smaller end, produced by a narrow internal callous ledge; both openings oval, their outlines more flattened on the convex than on the other side, and both cut the tube nearly at right angles; peristome simple. Length 6, diameter at middle 1, aperture .75 mm. Diameter of apex about two-thirds that of the aperture. Gulf St. Vincent, not uncommon in shell sand. (Type locality—Oyster beds of the Upper Aldinga series). The specific name is singularly inappropriate. Specimens vary in obesity. The white girdle near the smaller end is constantly conspicuous on the milky translucent colour of the rest of the shell.

This girdle is removed from the apex a distance about equal to the diameter of the latter. There is no thickening of the shell wall toward the aperture, and no appearance of striae under considerable magnification.

C. angustior Verco 1911. Pl. 1, figs. 5, 5a and 5b. "The Narrower *Cadulus*." Thin, slightly curved, chiefly in the posterior half, cylindrical, very gradually increasing from behind and very slightly narrowed at the front, scarcely compressed laterally; fractured at posterior end at right angles to the curve, and with a small triangular spine, 1 mm. long, projecting backwards from the convex side; anterior end open, sloping obliquely forwards from the convex side; margins simple, smooth; shell smooth, diaphanous; a transverse milky line present or absent near the front and sometimes near the posterior end. Length 4.6, breadth .6 mm., 26 fathoms 18 miles south-east of Newland Head, South Australia (type locality), also Cape Borda 62 fathoms. Also Western Australia—Hopetoun, King George Sound, Geographe Bay, 12-35 fathoms. From *Cadulus acuminatus* Tate, it is narrower and more cylindrical, with less bulging about the middle. Dredged by Verco; with the type, were many specimens which appear to show the three progressive stages of growth—first as a *Dentalium*-like shell, which becomes constricted when it reaches a certain age, then begins to form the proper *Cadulus* shell, from which it subsequently breaks off, leaving the tiny projecting spine beyond the line of fracture.

C. laevis Brazier 1877 (*Dentalium*) (not *D. laeve* Schlotheim). Strongly arched, half-moon shaped; light amber, sometimes white, glossy, smooth; basal margin pinched in about four millimetres long, forming somewhat like a shoulder, then slightly varicose, from that to the apex regularly tapering; apex with a minute perforation, entire. Length 28, diam. base at shoulder 2, below 1 mm. S.W. of Neptune Islands, 62-104 fathoms. (Type locality—Princess Charlotte Bay, Northeast Australia, 13 fathoms, sandy mud). The lower part of this shell resembles the spines of sea-urchins. The greater part of the specimens are encrusted over with a fine coating of coral-like substance (Brazier). South Australian specimens seem closely related to this species.

C. occidentus Verco 1911. Pl. 1, fig. 7. "The Western *Cadulus*." Rather solid; ventral curve nearly uniformly slightly convex; dorsal side nearly straight in the anterior fourth, slightly convex in the next quarter, and slightly concave in the hinder half; cut off perpendicularly to the axis behind, rather obliquely in front, where the slope is backward toward the convex side;



Cotton, Bernard C. and Godfrey, Frank K. 1933. "South Australian shells. Part VIII." *The South Australian Naturalist* 14, 135–150.

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