
Fauna of the Gatun Formation, Isthmus of Panama: II

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FAUNA OF THE GATUN FORMATION, ISTHMUS OF PANAMA—II.

BY AMOS P. BROWN AND HENRY A. PILSBRY.

The collection reported in this paper was obtained by Professor William B. Scott in 1911.¹ It comprises materials from the following sources:

1. *Fossils from the oyster-shell areas in the Black Swamp near Mount Hope (Monkey Hill).* This material consists of coral and coralline fragments, with a considerable molluscan fauna, including the oysters which are the distinguishing shells of these shell areas. The bed lies about 4 feet above the present sea level, and is doubtless the same as that encountered in digging for sewers, etc., in the streets of Colon. Among the Mollusca the recent species predominate, though some species found in this assemblage seem to be extinct. It must be remembered, however, that the recent fauna of this part of the coast, aside from the strictly littoral forms, is very imperfectly known, and hence some of these supposedly extinct forms may be found living. In any case, it does not seem probable that this bed can be older than Pleistocene. The species will be considered, along with those of lot 2, in another paper.

2. *From the oyster-shell areas in the black, unconsolidated mud, unconformable on the Gatun Formation, found at the lower end of the Gatun Locks.* This mud extends from a few feet below sea level to about 10 feet above it. The specimens collected consist of shells of *Ostrea* with a large number of specimens of *Congerina* and many barnacles. The other mollusks are not so plentiful as in lot 1, there are no corals or corallines, but it is evident from the impressions on the shells that the oysters grew on mangroves or similar plants. The species will be considered in another paper along with those of the preceding collection.

3. *Fossils from the Gatun beds in the excavation of the Lower Locks at Gatun.* This bed was the source of most or all of the material described in our former paper.² A number of additional species

¹ Acknowledgments are due to Mr. D. F. MacDonald, geologist of the Canal Commission, who collected a large part of the material and supplied the data concerning it.

² Fauna of the Gatun Formation, Isthmus of Panama, *Proc. A. N. S. Phila.*, 1911, p. 336.

are here added. In this bed, especially in the part below sea level, the fossils are beautifully preserved, and the fauna, if it ever becomes completely known, will doubtless prove to be a very rich one. We have already discussed its position in the series in the paper noted above. The new species found in this lot are as follows (including 3 species of *Natica* collected by Brown, 1910):

Volvula micratracta n. sp.
Ringicula hypograpta n. sp.
Pleurotoma (Gemmula) vaningeni n. sp.
Drillia enneacyma n. sp.
Glyphostoma dentiferum Gabb.
Fasciolaria gorgasiana n. sp.
Turbonilla bartschiana n. sp.
Turbonilla gatunensis n. sp.
Natica bolus n. sp.
Natica canalizonalis n. sp.
Natica canrena (Linn.).
Sigaretus (Eunaticina) gabbi n. sp.
Pecten (Cyclopecten) oligolepis n. sp.
Corbula (Cuneocorbula) hexacyma n. sp.
Echinochama antiquata Dall.

4. *Fossils from the excavation of the Spillway, Gatun Dam.* This is in the Gatun Formation, here a rather soft, somewhat lignitic material, largely composed of volcanic ash. Besides the species noted below, it contains fragments of wood, nuts, and other remains of land plants, converted to lignite coal. The list of species observed in this Spillway material is as follows:

Conus concavitectum B. and P.
Cypræa henikeni Sowb.
Turritella altilira Conrad.
Pecten (Amusium) luna n. sp.
Pecten (Euvola) reliquus n. sp.
Cardium (Trachycardium) dominicense Gabb.
Cardium durum n. sp.
Tellina æquiterminata n. sp.
Dosinia delicatissima n. sp.
Clementia dariena (Conrad).
Petricola millestriata n. sp.
Thracia (Cyathodonta) isthmica n. sp.
Solen near amphistemma Dall.

5. *Fossils from the Cuts along the Relocation of the Panama Railroad in the Quebrancha Hills, nearly one mile south of Gatun.* This is in the Gatun Formation, and Mr. MacDonald notes that these

beds appear to be higher in the formation than those at the Spillway excavation. The fossils are pelecypods mostly and are similar to those in the upper part of the excavations for the Locks at Gatun as well as those from the Spillway. The material in which the shells are imbedded is mostly volcanic ash, often hardened by the calcium carbonate from the shells, which in their turn are partly dissolved and softened, falling out of the rock as casts of the interior of the shell and leaving a more or less perfect mould. The species identified are as follows:

Turritella altilira Conrad.
Turritella gatunensis Conrad.
Arca dariensis B. and P.
Cardium stiriatum B. and P.
Cardium dominicense Dall.
Chione tegulum B. and P.
Chione ulocyma Dall.
Calloccardia gatunensis multifilosa Dall.
Clementia dariena (Conrad).
Cyclinella gatunensis Dall.

6. *Fossils from the fossiliferous layers near Tower N, Las Cascades, Culebra Cut.* At Las Cascades the Culebra Cut passes through a hardened volcanic ash or tuff, interbedded with which are several thin, fossil-bearing layers. The uppermost of these is some 85 feet above the bottom of the cut, as it was at the time this collection was made. It is a thin limestone bed, often not more than a few inches thick. This we have called the Pecten bed, from the numbers of *Pecten* and *Amusium* which it contains. This Pecten bed was seen by Professor Scott to extend along the cut to about a mile south of Empire, or at least two miles along the cut. The material of the bed is largely ash which is cemented to a firm stone by the calcium carbonate derived from the shells, which in many cases are dissolved, leaving a mould or cast. The list of species found in this Pecten bed includes several species found at the Spillway as well as at the Lock excavations at Gatun, along with several new species. The list of species identified from the Pecten bed is given below.

At 65 feet below the Pecten bed, and also at some 20 feet still lower, or what was the bottom of the cut when this collection was made, are black lignitic clays interbedded with the gray tuff which carry a fauna of small molluscan forms. These represent a dwarfed or "runt" fauna such as is often found in connection with lignitic formations. There are also remains of crustacea,

crabs, in the lower layer. It was in these lignitic layers that the oxidation of pyrite produced a heating of the shale, resulting in the generation of steam and gas that was reported in the daily press as the breaking out of a volcano in the Culebra Cut. The fossils are largely pseudomorphs of calcite, and when they are wetted the shell crumbles and falls apart. It is very difficult to clean the shells in this bed from the adhering shale on this account. The number of species is considerable, but only a few can be extracted in sufficiently clean condition to be determined or described. A list of the species that could be studied is given below:

SPECIES OBSERVED IN THE PECTEN BED AT TOWER N, LAS CASCADES.

Balanus sp.

Murex (*Phyllonotus*) *gatumensis* B. and P.

Pyrula micronematica n. sp.

Arca sp.

Pecten (*Amusium*) *sol* n. sp.

Pecten (*Amusium*) sp. indet. A fragment of an *Amusium* with even ribs.

Pecten (*Æquiptecten*) *oxygonum canalis* n. subsp.

Ostrea gatumensis B. and P.

Tellina vetula n. sp.

Semele chipolana Dall.

Chione (*Lirophora*) *ulocyma* (Dall.).

Dosinia delicatissima n. sp.

Crassitellites mediamericanus n. sp.

Kuphus incrassatus Gabb.

Schizaster schertzeri Gabb.

SPECIES OBSERVED IN THE LIGNITIC LAYERS NEAR TOWER N, LAS CASCADES.

Callianassa scotti n. sp.

Nassa (*Hima*) *præambigua* n. sp.

Bittium scotti n. sp.

Turritella altilira Conrad.

Arca dalli n. sp.

Spondylus scotti n. sp.

DESCRIPTIONS OF NEW SPECIES.

Callianassa scotti n. sp. Pl. XXII, figs. 1-3.

The propodite is quadrate, its width nearly or quite equal to the length, the upper face evenly convex, its surface granular, at least near the base of the fixed finger. The proximal margin is abruptly

depressed. Lateral margin on the side of the fixed finger is acute and crenulated, the opposite edge being less acute and apparently smooth. The palm is convex in the middle, a little concave towards the crenulated margin. There is a submedian row of three small tubercles on the distal half. The fixed finger is quite slender and shorter than the palm.

Measurements (in Millimeters).

	Length exclusive of fingers.	Width in the middle.	Thickness.
a.	29	27	12
b.	24	21	10.3
c.	22	19	9.5

About 65 feet below the base of the Pecten bed at Tower N, Culebra Cut.

This species, one of the largest Callianassas, is rather abundant, represented in the collection by ten chelæ and some fragments. Named in honor of Professor William B. Scott. It is evidently what Herr Toulà figured as *Krabbenscheren, l.c.*, p. 512, Taf. XXX, fig. 14.

In a few specimens the hand is longer, length of palm 30, width 24 mm.

In the Gabb collection from Costa Rica there is an imperfect hand evidently referable to the same species.

Volvulella micratracta n. sp. Text fig. 1.

Bulla (Volvula) cf. oxytata Bush, Toulà, *l.c.*, p. 709, pl. 28, fig. 4, 1909.

The shell resembles *V. minuta* Bush, from which it differs by the noticeably longer posterior spine-like extension and more swollen shape. The spiral sculpture is decidedly stronger, consisting of distinct, continuous, widely spaced grooves, of which three are at the anterior and two at the posterior end. On the convex portion there is some appearance of very shallow longitudinal plication. There is a narrow umbilical slit.

Length 1.5, diam. 0.7 mm.

The type from Gatun is probably conspecific with a series of five specimens from Monkey River, British Honduras. These are larger, up to 2 mm. long, and have more of the distinct grooves at the ends. They were found in mud brought up on an anchor.

V. oxytata is a much more cylindrical species.

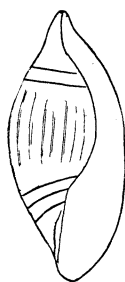


Fig. 1.

Ringicula hypograpta n. sp. Text fig. 2.

Shell globose-conic, solid, composed of four moderately convex whorls. Apex obtuse. Surface smooth above, minutely engraved spirally below the periphery with about 10 lines; growth-lines visible but weak. The last whorl terminates in a thick and strong, rounded lip-varix. Outer lip is thickest in the middle, where it bulges forward and inward. Columella has a strong upper and thinner basal lamella. Parietal callus thick, provided with a small median fold.

Length 2.1, diam. 1.5 mm.

Gatun bed, Lower Locks at Gatun.

Pleurotoma (*Gemmula*) *vanningeni* n. sp. Pl. XXII, fig. 4.

The shell is composed of about 13 whorls, of which the first $2\frac{1}{2}$ are smooth and convex; next whorl also convex, with sculpture of close, regular, axial ribs. At the beginning of the following whorl the sculpture changes abruptly. A strong, rounded cord appears immediately below the suture, and a stronger, wider one occupies the middle of the exposed part of the whorl, its summit bearing tubercles which are noticeably longer in the axial direction. On the last three whorls there are several spiral threads in the sulci above and below the median tuberculate ridge, and the tubercles upon the latter become somewhat more compressed. The last whorl has about ten major spirals and numerous unequal spiral threads below the peripheral ridge, the upper three spirals larger than the lower ones. There are also on the last three or four whorls rather close-set, retractive axial threads above the beaded ridge.

Length 19.5, diam. 7.3 mm.

Excavation at Gatun Locks.

This handsome species is named for Dr. Gilbert Van Ingen, of the Princeton University Museum.

Drillia enneacyma n. sp. Text fig. 3.

The shell is small, fusiform, composed of about 8 whorls, the first three smooth, the rest having sculpture of strong, rounded, slightly protractive, smooth, axial ribs, about as wide as their intervals and nine on each whorl. On the last whorl the ribs stop rather abruptly where the convex portion of the whorl passes into the short, tapering

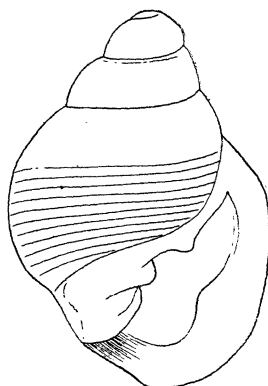


Fig. 2.

anterior end, which has sculpture of spiral cords only. The intervals between ribs are crossed by low spiral cords separated by narrower grooves, which extend part way up the slopes of the ribs, but are wholly absent near and at their summits. On the last whorl about 9 spirals may be counted in each intercostal interval. The aperture is narrow, with a distinct but not deep posterior sinus.



Fig. 3.

Length 6, diam. 2.1 mm.

From excavation of the lower locks at Gatun.

***Fasciolaria gorgasiana* n. sp.** Pl. XXII, fig. 5.

This species is represented by the last two whorls minus the anterior canal. A fusiform shell with the anterior extension quite narrow is indicated. The surface slopes rather steeply from the suture to the subangular shoulder and is ornamented on the last whorl with about 10 low, unequal spiral cords. The shoulder bears conic tubercles, a little compressed vertically, about 8 tubercles on each whorl. A cord at the shoulder and two others below it override tubercles and intervals, but are stronger on the tubercles. Below the shoulder the whorl is at first convex and sculptured with strong alternating with weak cords, then becomes concave, passing into the anterior canal. The columella has a group of three strong plaits. The diameter of the last whorl is about 21 mm.

Gatun bed.

This small species is related to the much larger *F. intermedia* Sowb. of the Santo Domingo Oligocene, but on comparison with a good series of that species it is seen that the coronal tubercles of *F. gorgasiana* are more acutely conic and radiate more horizontally; the last whorl also contracts more rapidly downwards. *Fusus quinquespinus* Dall has much resemblance to this species, but there are only five spines on the last whorl. The type is fragmentary, but so characteristic that there can be no difficulty in recognizing it. Named in recognition of the services to the State of Col. William C. Gorgas.

***Nassa (Hima) præambigua* n. sp.** Pl. XXII, figs. 6, 7.

The shell resembles *N. ambigua* Mont., being acutely ovate-conic, the outlines of the spire straight, suture narrowly impressed, whorls not conspicuously convex except the last, which is rather ventricose. The apex is acute, first $2\frac{1}{2}$ whorls smooth, subsequent

whorls with sculpture of rounded axial ribs nearly as wide as their intervals, crossed by spiral cords. On the last whorl there are 13 or 14 ribs, the last one larger, forming the lip-varix. The ribs are continuous from whorl to whorl as in some related forms. Spiral sculpture of low cords which are more prominent on the ribs, weak in the intervals, and to the number of eight on the last whorl above the basal sulcus. On the penultimate whorl there are three of these cords, lower than those on the last whorl, or sometimes 4 when the upper one is split. The aperture is small, apparently not unlike that of *N. ambigua*, but filled with coarse material in all the specimens.

Length 5.3, diam. 3.3 mm.

From a lignitic clay below the Pecten bed at Tower N, Culebra Cut. The specimens were taken from 65 to 80 feet below the Pecten bed. It is rather abundant.

In *Nassa ambigua* there are more spiral cords than in this species, and they are stronger in the intercostal intervals; the whorls of the spire are more convex. In *N. præambigua* the spire is straight-sided as in *N. vibex* Say. *N. bidentata* Emmons has fewer spirals and wider, fewer axial ribs. The recent *Alectrion (Hima) catallus* Dall, from deep water in the Gulf of Panama, is a more elaborately sculptured shell of the same group. *N. præambigua* is probably an ancestor of the Pliocene and recent members of the *Hima* group on both sides of the isthmus.

Pyrula micronematica n. sp. Pl. XXII, fig. 8.

The shell has the usual shape. Sculpture of small, slender spiral cords which are noticeably knotted where the rather wide-spaced axial threads intersect them. Minute secondary spiral threads divide the wide spaces of the primary cords. Faint traces of most minute spiral threads of a third order may be perceived. The spacing and number of spirals is the same as in the recent *P. decussata* Wood.

Length of the imperfect specimen figured 28.8 mm.

Found in the Pecten bed in the Culebra Cut near Tower N, Las Cascades.

This species agrees with *Pyrula decussata* Wood of the recent Panamic fauna in having only half as many major spirals as the Antillean *P. papyracea* Say and *P. pilsbryi* B. Smith. The essential differences between the two collateral phyla (represented in the recent fauna by *P. papyracea* and *P. decussata*), were therefore

well established in the Oligocene. *P. micronematica* is a much smaller species than *P. decussata* (of which it is probably an ancestor), with smaller, very slender primary spirals. In young *P. decussata* the spirals are much larger and closer together. Both of the specimens found are in the hard tufaceous rock of the Pecten bed. Neither shows the early or embryonic whorls.

Natica bolus n. sp. Pl. XXII, fig. 9.

The shell is rotund, solid, composed of $4\frac{1}{2}$ whorls, the earlier ones slowly, the last two rapidly enlarging. The spire is very low, conic, narrow, and small, suture but little impressed; last whorl is a little depressed below the suture and smooth throughout. The aperture is semicircular as usual. The parietal margin is heavily calloused, chiefly in the upper angle, a short rounded ridge emerging just below it. A larger bluntly triangular lobe projects at the upper edge of the umbilicus, and a less conspicuous pad terminates a cord spirally entering the umbilical cavity.

Alt. 9, diam. 9.5 mm.

Gatun bed A. P. B., 1910.

This species differs from *N. canrena* by its much less deeply impressed suture, absence of tangential plication above, and various details of the columellar region.

Natica canrena (Linn.).

Several specimens, the largest having a diameter of 28 mm., were taken by one of us in the Gatun bed. They belong apparently to an early race of the *N. canrena* stock, such as that occurring in the Bowden bed. No opercula were obtained.

Natica canalizonalis n. sp. Pl. XXII, fig. 10.

The shell is hemispherical with a very small low-conic, subacute spire of $4\frac{1}{2}$ whorls, the last two rapidly enlarging, last whorl somewhat depressed below the suture, which is very little impressed. The inner lip is very heavily calloused posteriorly, the part above the umbilicus very short, emerging a little, projecting at the upper margin of the umbilicus, the face of the projection transversely dented. The umbilicus is ample, rendered lunate by a flat median callus which terminates a cord spirally entering the umbilicus.

Alt. 8, diam. 8.3 mm.

Gatun bed, A. P. B., 1910.

The ample umbilicus, heavy, transversely dented parietal callus and appressed suture characterize this species, of which only one specimen was taken.

Sigaretus (*Eunaticina*) *gabbi* n. sp. Pl. XXII, fig. 13.

The shell is narrowly umbilicate, semiglobose, with very short, narrow spire of $3\frac{1}{2}$ whorls. The first two whorls, which compose the embryonic shell, are convex, smooth, and glossy and increase slowly. After that the shell abruptly becomes dull, with sculpture of close, fine, spiral striæ. The last whorl is most convex below the periphery. The aperture is nearly as long as the shell, ovate. Columella somewhat thickened and a little rolled back.

Greatest length 6.5, diam. 6.5 mm.; length of aperture 6 mm.

Gatun Locks.

S. multilinéatus Gabb from Sapote, Costa Rica, is a larger shell with more conic, elevated spire.

Bittium *scotti* n. sp. Pl. XXII, figs. 11, 12.

Shell turreted, with very slightly convex outlines, tapering to a minute, acute apex. Whorls about 12, the first 2 or 3 smooth. Subsequent whorls have sculpture of axial ribs about equal to their intervals, crossed by numerous unequal spiral threads. On the penultimate whorl there are about 15 axial ribs crossed by about 6 spiral threads and some minute striæ. On the last whorl there are one or two rounded varices, broader and more prominent than the ribs, which are very weak in their vicinity, and do not extend below the periphery. The base has 4 or 5 strong, continuous spiral cords.

Length 10.5, diam. 3.8 mm.

" 9.5 " 3.6 "

" 8.5 " 2.8 "

About 65 to 80 feet below the Pecten bed at Tower N, Culebra Cut, near Las Cascades.

This shell stands close to *Bittium boioplex* Dall, of the Chipola Oligocene, which differs chiefly by its more slender contour. *B. priscum* Dall, of the Tampa Silex bed, seems to be an allied form with fewer spirals. *B. Scotti* is extremely abundant in the friable ignitic bed at Tower N, Culebra Cut, but most of the specimens are calcite pseudomorphs and cannot be extricated from the similar material in which they are imbedded.

Turbonilla (*Chemnitzia*) *bartschiana* n. sp. Text fig. 4a.

The shell is minute, slender, with a bulimoid embryonic shell of about 2 smooth whorls, the last strongly convex and nearly half immersed in the first neanic whorl; post-embryonic whorls 6, convex, with sculpture of smooth, rounded, vertical, axial ribs equal to their intervals. On the penultimate whorl there are 17 ribs.

On the last half of the last whorl the ribs become smaller; the concave intervals do not extend below the periphery and are rounded at their lower ends.

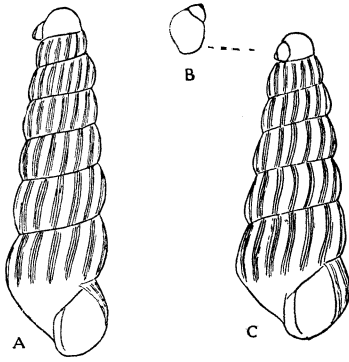


Fig. 4.

Length 2, diam. 0.6 mm.

Excavation at Gatun Locks.

Turbonilla (Chemnitzia) gatunensis n. sp.
Text fig. 4b, c.

The shell is minute, rather rapidly tapering, the diameter at the last whorl about double that of the first post-embryonic whorl. Embryonic shell bulimoid, of about 2 whorls, the last very globose, nearly half immersed. Post-embryonic whorls $5\frac{1}{2}$, convex, the

greatest convexity just above the suture, which is deeply impressed. Sculpture of rounded, slightly protractive, axial ribs, equal to their intervals, 14 on the last whorl; the concave intervals gradually effaced at the periphery of the last whorl.

Length 1.7, diam. 0.65 mm. Length of embryonic shell 0.3, diam. 0.2 mm.

Excavation at Gatun Locks.

Related to *T. bartschiana*, but more rapidly tapering, with the whorls more swollen below and the riblets noticeably protractive.

Arca dalli n. sp. Pl. XXIII, fig. 4.

A small, very obese ark, with beaks at the anterior fourth of the length, full and well incurved; hinge-line rather short. Valves equal, similarly sculptured with about 28 ribs wider than their intervals, those of the median and anterior part strongly and closely tuberculate, as in *Arca chiriquiensis* Gabb, the posterior ribs nearly smooth. Interior unknown.

Length 20, alt. 16, diam. 15.7 mm.

From a lignitic clay at the bottom of the Culebra Cut, near Tower N; a bed below the Pecten bed at the same place.

Pecten (Euvola) reliquus n. sp. Pl. XXIV, fig. 3.

"*Pecten* sp. (vielleicht n. sp.)" Toulou, Jahrb. k.k. Geol. Reichsanst., 1908, LVIII, p. 755, text figs. 12, 13.

The left valve is strongly convex, the right almost flat, being very gently convex towards the beaks, concave on each side of the middle. Sculpture of about 24 strong ribs. In the left valve they

are a little flattened on the summits, have very steeply sloping sides, and are parted by intervals decidedly narrower than the ribs. Over all there is a fine concentric sculpture of delicate laminæ, which remain much more prominent in the intercostal spaces. In the right valve the ribs are noticeably narrower, about equal to their intervals, and they are almost obsolete in a rather wide band at the anterior end. The anterior ear is ribless. The concentric sculpture is less developed than in the convex valve. The height is 52 mm. in the largest co-type—a right valve.

Gatun Formation at the Spillway.

This scallop may be readily recognized, even in fragments, by its finer sculpture, which is unlike other Isthmian species.

Pecten oxygonum canalis n. subsp. Pl. XXIII, fig. 3.

We refer to this subspecies a series of scallops from the *Pecten* bed at Tower N, Culebra Cut, Canal Zone, which agree with the Costa Rican *P. o. optimum* in the main, but differ by having the radial striæ almost equal, without an enlarged one on the ridge of each rib. The number of ribs is the same as in *optimum*. The figured specimen measures, alt. 45.5, length 44 mm. Some are larger, up to 55 mm. in length.

This is a very abundant and characteristic fossil of the upper bed of hard limestone near Tower N. The shells cannot be extricated from the rock, in which they are exposed by breaking it up. While this *Pecten* is obviously close to Costa Rican and Haitian forms, it seems advisable to signalize the minor differences of the races by subspecific names.

Pecten oxygonum optimum n. subsp. Pl. XXIII, fig. 2.

Pecten paranensis d'Orb., Gabb, Journ. A. N. S. Phila., VIII, p. 347. pl. 45, fig. 24. Not of d'Orbigny, Voyage dans l'Amér. Mérid., Palæontologie, p. 132.

The shell is larger than *P. oxygonum* Sowb., of the Santo Domingo Oligocene, with lower ribs. There are at least 19 ribs, several at each end, narrow, low, and slender, the rest rounded, broad, and rather low, parted by somewhat narrower intervals. Both ribs and intervals bear unequal radial striæ or threads, of which one on the summit of each rib is somewhat larger, giving the ribs a carinated appearance. There is also an enlarged thread in the middle of some of the intercostal valleys. About 11 striæ may be counted between the summit of one rib and the next. Auricles strongly striated radially. The whole surface (except near the beaks) bears

a dense and minute sculpture of raised concentric threads or growth-laminae, which are not emphasized in passing over the striae.

Length 62, altitude 57, semidiameter 13 mm.

Reventazon River, Costa Rica. Type a right valve. Collected by Wm. M. Gabb, Coll. A. N. S. P.

This specimen was referred by Gabb to *P. paranensis* Orb., which, while doubtless related, differs decidedly in the secondary sculpture. We are equally unable to refer the Costa Rican species to *P. madisonius*, which has higher and usually fewer ribs. The Santo Domingan specimens which Gabb identified as the unfigured *P. oxygonum* Sowb. are all smaller than the present shell, with somewhat more elevated ribs, which bear fewer radial striae.

Dall has proposed a *Pecten gabbii*³ for specimens from Antigua and Santo Domingo, which have the general form of this shell, but differ by having "narrower interspaces each filled with one imbricated riblet." In *P. optimum* there are 4 or 5 striae in each interval, and when one is larger it is not conspicuously so. Dall includes Gabb's Costa Rican shell in his references, but does not refer to it in the text. Gabb does not report *paranensis* from Santo Domingo.

***Pecten (Cyclopecten) oligolepis* n. sp.** Text fig. 5.

Pecten app. *subhyalinus* Smith, Toulal, J. B. der k.k. Geolog. Reichsanstalt, 1911, Bd. 61, p. 492, pl. 31, figs. 1a, b, c.

This shell is very close to the West Indian *Cyclopecten simplex* Verrill, but differs in details of sculpture. The right valve has

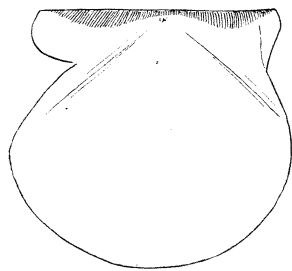


Fig. 5.

concentric sculpture of excessively faint and fine striae, scarcely visible, and only under the compound microscope, and there are slightly more distinct radial threads near the edges. The left valve has rather widely spaced low concentric threads and more delicate radial threads, chiefly seen near the margins. In *C. simplex* the right valve is the more strongly sculptured, according to Verrill. The

internal structure is substantially as figured for *C. simplex* (*Trans. Conn. Acad.*, X, pl. 19, figs, 1, 2).

Length 2.8, height 2.7, diam of right valve .8 mm.

From the excavation of the lower locks at Gatun.

³ *Trans. Wagner Free Inst. Sci.*, III, p. 717, pl. 29, fig. 3.

Pecten subhyalinus E. A. Smith, from the west-coast of Patagonia, is somewhat higher than long, the hinge line is shorter and the valves somewhat less convex than in *P. oligolepis*.

Pecten (Amusium) sol n. sp. Pl. XXIV, figs. 1, 2.

The shell is subcircular, thin, but slightly convex, nearly smooth (the growth-lines being very faint) except near the beaks, where there are radial riblets, low, rounded, but very distinct for a distance of about 10–14 mm., then gradually becoming weak and disappearing. In the left valve the beak is depressed, almost flat, and the auricles are marked off by a small ledge, but no decided change in the general curvature of the surface. In the right valve the beak is somewhat convex and separated from the more distinctly demarcated auricles by a groove. Internally the shell has radial ribs in pairs, the interval between the ribs of a pair being about one-third the width of the interval between pairs.

Two valves, cotypes, measure 83 mm. from beaks to basal margin. Some specimens represented by internal casts are larger, up to 90 mm. in altitude in the case of a large one. This valve measured 90 mm. in length.

From a bed with *Pecten oxygonum optimum* in the Culebra Cut, near Tower N, Las Cascades.

This species and *Pecten oxygonum optimum* are characteristic fossils of what we have called the Pecten bed, at Tower N.

This *Amusium* differs from *Pecten toulæ*, of the Gatun bed, *P. papyracea* Gabb, of Santo Domingo, and the North American *P. mortoni* by having strong radial sculpture in the early neanic stage; those species agreeing with the recent Oriental forms in having no external radial sculpture at any stage. *P. lyonii* Gabb, described from Sapote, Costa Rica, agrees with *P. sol* in having radial beak sculpture, but it differs by having more distinctly defined auricles and by the internal sculpture of numerous equidistant ribs. While the ribs of one valve are not perceptibly twinned in the Oriental *Amusiums*, they are about equal in number in the two valves in *P. pleuronectes* L., in which this character of having one valve with equally spaced ribs and one with paired ribs is very pronounced. With the single exception noted below, all of the casts we have seen from the Pecten bed agree in having ribs in contiguous pairs.

In one incomplete cast the ribs are in pairs separated by intervals fully half as wide as the spaces between pairs (not crowded as in *P. lyonii* Gabb). This probably represents another species.

Pecten (Amusium). *luna* n. sp. Pl. XXIII, fig. 1.

A species resembling *P. mortoni* Conr., from which it differs chiefly by the ears which are depressed below the plane of the valve and separated by a ledge. In *P. mortoni* the ears are nearly level with the adjacent part of the valve, from which grooves separate them. The hinge-line is short, not serrate above in the right valve, as in *P. mortoni*. The surface is smooth throughout except for the usual fine growth-lines and fine, indistinct radial striation, such as is seen in *P. mortoni*. The laterodorsal lines diverge more than in *mortoni*, forming a greater angle at the beak. The internal ribs run in pairs, spaced about as in *P. sol*. The shell is rather strongly convex for an *Amusium*, more convex than in *P. mortoni*.

Alt. 76, length 80 mm.; diam. right valve 12 mm.

Gatun Formation at the Spillway.

The type is a right valve, which we at first referred to *P. sol*, from which it differs chiefly by the unsculptured beak and the ledges defining the ears.

P. toulæ differs by its gray radii.

Spondylus *scotti* n. sp. Pl. XXV, figs. 1, 2.

A species of the *S. americanus* group, having the lower valve very convex, the upper valve moderately so; beak not much produced. Sculpture of about 17 narrow little-prominent radial ribs, some of them bearing very short, scale-like spines, irregularly placed, and on the lower half only; between these ribs there are fine, unequal longitudinal striæ, 4 to 8 in each space. They are crenulated by extremely fine, crowded laminæ along the growth-lines. There are some weakly developed foliations on one side of the lower valve.

Breadth 51 mm., length (alt.) of lower valve 65, of upper 58 mm., diam. 41 mm.

From the lignitic bed below the Pecten bed at Tower N, Culebra Cut.

Well distinguished from the recent Antillean *S. americanus* Hermann by the delicacy of the sculpture and more convex lower valve. It is also somewhat related to *S. gumanomocon*⁴ of the

⁴ *Spondylus gumanomocon* n. sp. A species resembling *S. varians* Sowb. (*S. delessertii* Chenu). The upper valve is Pectiniform, orbicular, of moderate thickness, with low radial ribs, the principal ones irregularly spinose, spines short; cardinal area small and short, as in *S. americanus*. Lower valve very ponderous, with a long, level (not receding) cardinal area, and a very long, straight (or sometimes laterally curved) beak, the cavity of which is deeply excavated in young shells, nearly solidly filled in old ones. Sculpture like the upper valve, except that it is more or less extensively foliated towards the beak.

Length (alt.) of a lower valve 175 mm.; breadth 108 mm.; weight 32½ oz.

Santo Domingan Oligocene. This is the form identified by Gabb as *Spondylus americanus*.

Santo Domingo Oligocene, but that is a far more ponderous and long-beaked species.

Crassatellites reevei Gabb. Pl. XXIII, fig. 5.

Crassatella antillarum Reeve? = *C. reevei* Gabb, Topography and Geology of Santo Domingo, p. 252.

The shell is rather long, length over $1\frac{1}{2}$ times the alt., anterior end rounded, posterior end long, tapering, obliquely truncate at the end. Beaks at the anterior third of the length. Ridge from beak to post-basal angle is moderately prominent, broad and rounded, and with the posterior slope above it has sculpture of growth-lines only. A distinct angulation runs from beak to the upper posterior angle. The escutcheon is moderately deep and flat, defined by a ridge. A broad, shallow concavity terminating in a sinuation of the basal margin precedes the post-basal ridge. The rest of the surface is convex, closely, almost regularly costate concentrically, the riblets about equal to their deep intervals. This sculpture extends without irregularity upon the beak, which is rather flattened.

Length 56, alt. about 37, semidiameter 11 mm.

This specimen was first identified by Gabb as perhaps *C. antillarum* Reeve, a recent species differing conspicuously in sculpture and shape. No description has been published hitherto, Gabb's notes being quite insufficient for identification.

The type, Coll., A. N. S. P., is a right valve, collected by Gabb in Santo Domingo.

Crassatellites mediamericanus n. sp. Pl. XXV, figs. 3-5.

Crassatella mactropsis Con., Gabb, Journ. Acad. Nat. Sci. Phila., VIII, p. 345, pl. 44, fig. 20. Not *Grateloupia mactropsis* Conrad.

The shell closely resembles *C. reevei* Gabb, from which it differs in the following particulars. The posterior end is broader, tapering much less; the terminal truncation is less oblique; no angulation runs to the upper posterior angle of the valve. Finally, there are a couple of concentric waves of much greater amplitude defining the umbonal area, which bears about 5 small waves. In *C. reevei* there is no such irregularity in the sculpture.

Length about 53, alt. 41, diameter .25 mm.

Sapote, Costa Rica, in a bed considered Miocene by Gabb. Co-types Coll., A. N. S. P.

Two imperfect individuals from Gabb's collection are figured, pl. XXV, figs. 3, 4. We refer also to this species a shell, pl. XXV, fig. 5, imbedded in hard matrix from the Pecten bed at Tower N, Culebra Cut.

So far as exposed, this fossil resembles the Costa Rican form, but its condition does not admit a positive identification. As this form is intimately related to *C. reevei* Gabb, of Santo Domingo, we subjoin some account of that species.

Cardium (Trachycardium) duran n. sp. Pl. XXIII, fig. 6.

This species is represented by a cast of the right valve with the inner layers of shell adhering. It is strongly convex with prominent, very full beaks. Twenty-five strong, angular ribs are indicated, those of the posterior margin terminate in teeth. There is some indication that the ribs had lateral ridges. The posterior slope shows a wide, shallow radial concavity.

Length 39, alt. 41.5, semidiam. 19 mm.

Gatun Formation at the Spillway.

This is a longer shell than *C. stiriatum* B. and P., the valve-margins being not far from circular, while in *C. stiriatum* the outline is conspicuously oblong.

Dosinia delicatissima n. sp. Pl. XXVI, fig. 1.

Dosinia (Artemis) cf. Acetabulum Conr., Toulou, l.c., p. 727, pl. 27, figs. 8, 8a.

Specimens from the Spillway agree well with Dall's account and figures of *D. liogona* Dall (*Trans. Wagner Inst.*, III, p. 1230, pl. 53, figs. 4, 7; pl. 54, fig. 11), except that the shell is remarkably thin for a bivalve of this genus. A valve at least 60 mm. in length is only 1.3 mm. thick in the thickest part. Moreover, the sculpture does not rise in "sharp fine lamellæ towards the ends of the shell," as described for that species. Towards the ends of the shell the concentric ridges between the grooves are more raised than in the middle of the valves, but they are rather too thick and blunt to be called lamellæ. The specimens are all in poor condition so that the sculpture of the beaks is a little in doubt, but from a small area exposed in one specimen the very young shell would appear to be smooth.

Length 48, alt. 46, semidiameter about 11 mm. Less perfect specimens than that figured are larger, up to 55 to 60 mm., or even more.

Very plentiful in the Gatun Formation at the Spillway.

It occurs also in the Pecten bed at Tower N.

The Miocene *D. acetabulum* Conr. is a decidedly more solid shell, noticeably differing from *D. delicatissima* in sculpture.

Petricola millestriata n. sp. Pl. XXVI, fig. 2.

The shell is short, the height contained about $1\frac{1}{3}$ times in the length,

beaks at the anterior $\frac{1}{11}$ of the length, prominent; anterior end rounded, posterior end wider, rounded in its lower half, obliquely truncate above; basal margin evenly arcuate. The surface is marked with unequal and mostly inconspicuous concentric wrinkles and fine, close, radial threads, narrower than their intervals.

Length 27, alt. 21, semidiam. 7.5 mm.

Gatun Formation at the Spillway.

A short, Tapes-like species with fine but distinct sculpture. On the internal cast figured, the radial striæ are obsolete towards the two ends, but judging from an incomplete mould of the exterior, the striæ extend undiminished nearly to the anterior end. The interior is unknown. The shell was apparently quite thin.

Tellina æquiterminata n. sp. Pl. XXVI, fig. 5.

Known by a cast of the left valve, not differing much from *T. radiata* in outline, but rather wider posteriorly and not twisted. Beaks submedian; anterior end rather broadly rounded; posterior end more tapering, but well rounded distally. The cast retains vestiges of the external sculpture of concentric rather regular growth-wrinkles. A low ridge indicates an impressed pallial line. The capacious pallial sinus extends well beyond the beaks, and is apparently confluent with the pallial line below, its upper line being well arched.

Length 44.5, alt. 24, diam. of left valve 5.5 mm.

Gatun Formation at the Spillway.

Tellina (Eurytellina) vetula n. sp. Pl. XXVI, fig. 6.

This species, known only by mutilated and imperfect remains, is yet readily distinguishable by the sculpture of minute, crowded concentric threads, narrower than their intervals, and about 12 to 15 in the space of 5 mm. in the lower half of the valve.

There seems to be a rather emphatic radial sinuosity posteriorly; the basal margin is well arched and the form rather broad. The best-preserved example, which is imperfect anteriorly, has a length of 43, alt. 29 mm.

Pecten bed near Tower N, Culebra Cut.

Semele chipolana Dall.

Trans. Wagner Free Inst. Sci., III, p. 986, pl. 37, fig. 3.

Pecten bed near Tower N. A nearly perfect mould of the left valve, which agrees very well with Dall's account of this species in shape and sculpture. The ample pallial sinus extends past the middle of the valve.

In *S. sayi* Toulà the concentric sculpture seems to be decidedly closer.

Thracia (Cyathodonta) gatunensis Toulà. Pl. XXVI, fig. 3.

Thracia gatunensis Toulà, Jahrb. k.k. Geol. Reichsanst., 1908, LVIII, p. 757; text fig. 15.

The shell resembles *Cyathodonta spenceri* Dall⁵ in contour, except that it is apparently not quite so high. The right valve is rather strongly convex, with sculpture of concentric ripples which are as wide as their intervals or slightly wider. The ripples terminate on the rounded ridge which defines the nearly smooth posterior area of the valve. There is a minute irregularly granulose lineation along growth-lines, over the wave sculpture.

Length 28.5, alt. 21, diam. of right valve about 8 mm.

Spillway, Gatun Dam.

While evidently akin to *T. spenceri* Dall, this species differs by its sculpture, the former having concentric ripples narrower than their intervals. The specimen figured is a right valve, the edge partly imperfect, and the interior concealed by the hard rock. Toulà's specimen was larger, 52 mm. long, and the concentric ribs are closer near the beaks.

Corbula (Cuneocorbula) hexacyma n. sp. Pl. XXVI, fig. 4.

Known from the right valve only. The shell resembles *C. viminea* Guppy externally. The distinctly prosogyrate beaks are at the anterior third of the length, smooth at the tip, posterior end produced, terminating in a short, strongly oblique, straight truncation, the lower point projecting and acute, the basal margin is rather deeply sinuated near the posterior end, elsewhere strongly arcuate. Dorsal margin formed of two straight slopes meeting at an angle of about 130 degrees. The posterior adductor impression rests upon a thick raised ledge which extends obliquely across the posterior end of the interior. There is no lunule. Externally a rather strong keel runs from back to post-basal angle, and an inconspicuous angulation runs to the upper angle of the posterior truncation, defining a lanceolate depressed area. There are irregularly spaced fine growth-wrinkles above the keel. The rest of the valve has a sculpture of very fine, delicate radial threads, and 6 concentric waves, the upper two weak, the others very strong. The region of the beak has no concentric waves. A shell 7 mm. long would show radial striation only.

⁵ *Trans. Wagner Free Institute of Science*, III, p. 1527, Oligocene of Guadaloupe.

Length of right valve 18.7, alt. 11, diameter 4.8 mm.

Gatun Formation, from the excavation at the lower locks at Gatun.

This species has much in common with such species of the sub-genus *Bothrocorbula* as *C. viminea* Guppy and *C. radiatula* Dall, and *C. synarmostes* Dall, but the total absence of any trace of a lunular pit at once distinguishes the Gatun form. The small number of concentric waves of the exterior separates *C. hexacyma* from various species of *Cuneocorbula*, which otherwise resemble it more or less.

EXPLANATION OF PLATES XXII-XXVI.

PLATE XXII.—Figs. 1-3.—*Callianassa scotti* n. sp.

Fig. 4.—*Pleurotoma* (*Gemmula*) *vaningeni* n. sp. × 3.

Fig. 5.—*Fasciolaria gorgasiana* n. sp. × 3.

Figs. 6, 7.—*Nassa* (*Hima*) *præambigua* n. sp. × 4.

Fig. 8.—*Pyrula micronematica* n. sp. × 2.5.

Fig. 9.—*Natica bolus* n. sp. × 3.

Fig. 10.—*Natica canalizonalis* n. sp. × 3.5.

Figs. 11, 12.—*Bittium scotti* n. sp. × 3.5.

Fig. 13.—*Sigaretus Eunaticina*) *gabbi* n. sp. × 3.5.

PLATE XXIII.—Fig. 1.—*Pecten* (*Amusium*) *luna* n. sp.

Fig. 2.—*Pecten oxygonum optimum* n. subsp. (Costa Rica).

Fig. 3.—*Pecten oxygonum canalis* n. subsp.

Fig. 4.—*Arca dalli* n. sp.

Fig. 5.—*Crassatellites reevei* Gabb.

Fig. 6.—*Cardium* (*Trachycardium*) *durum* n. sp.

PLATE XXIV.—Figs. 1, 2.—*Pecten* (*Amusium*) *sol* n. sp.

Fig. 3.—*Pecten* (*Euvola*) *reliquus* n. sp. detail of sculpture.

PLATE XXV.—Figs. 1, 2.—*Spondylus scotti* n. sp.

Figs. 3, 4.—*Crassatellites mediamericanus* n. sp. (Costa Rica).

Fig. 5.—*Crassatellites mediamericanus* n. sp. Pecten Bed, Las Cascades, C. Z.

PLATE XXVI.—Fig. 1.—*Dosinia delicatissima* n. sp.

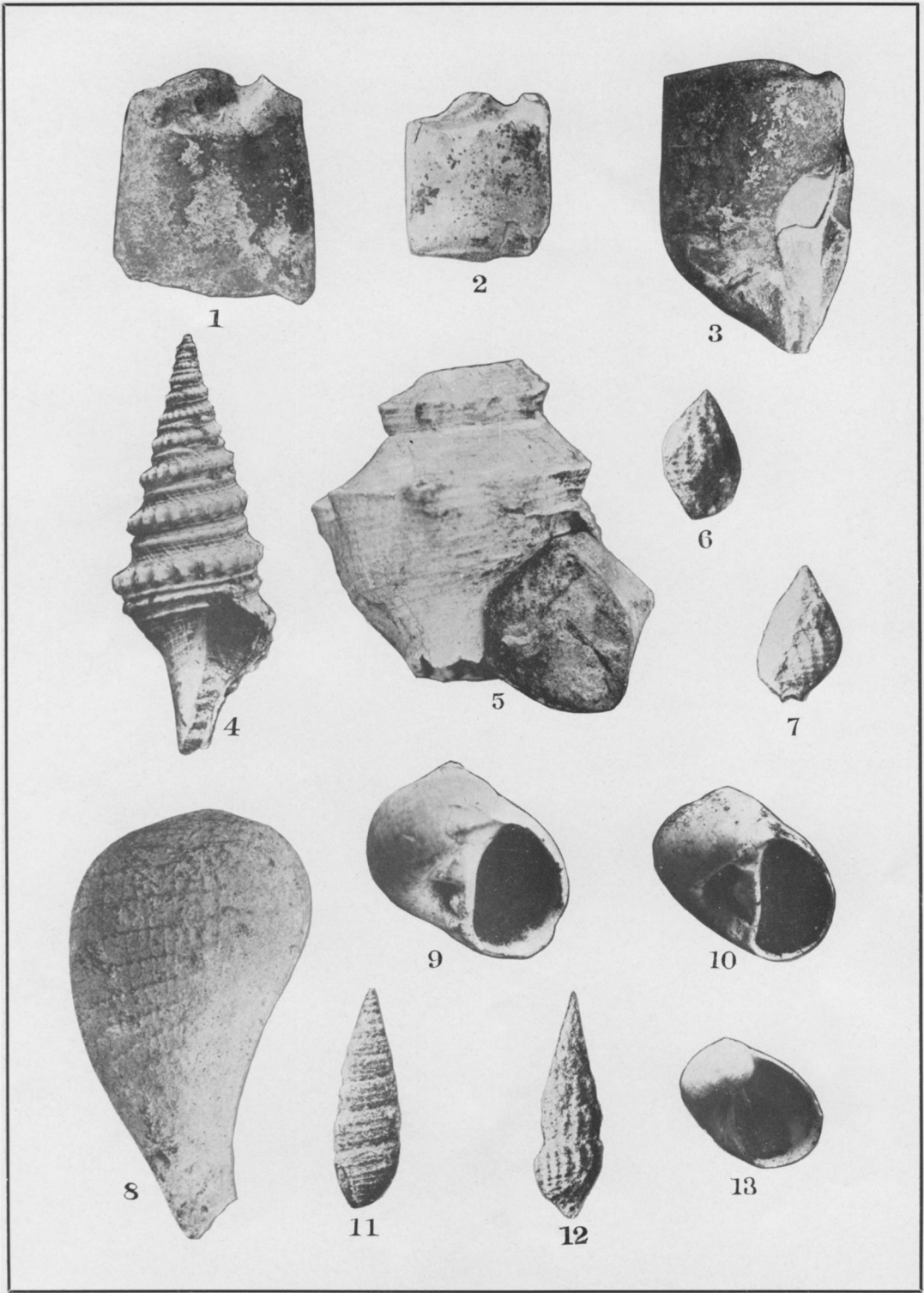
Fig. 2.—*Petricola millestriata* n. sp.

Fig. 3.—*Thracia* (*Cyathodonta*) *gatunensis* Toul.

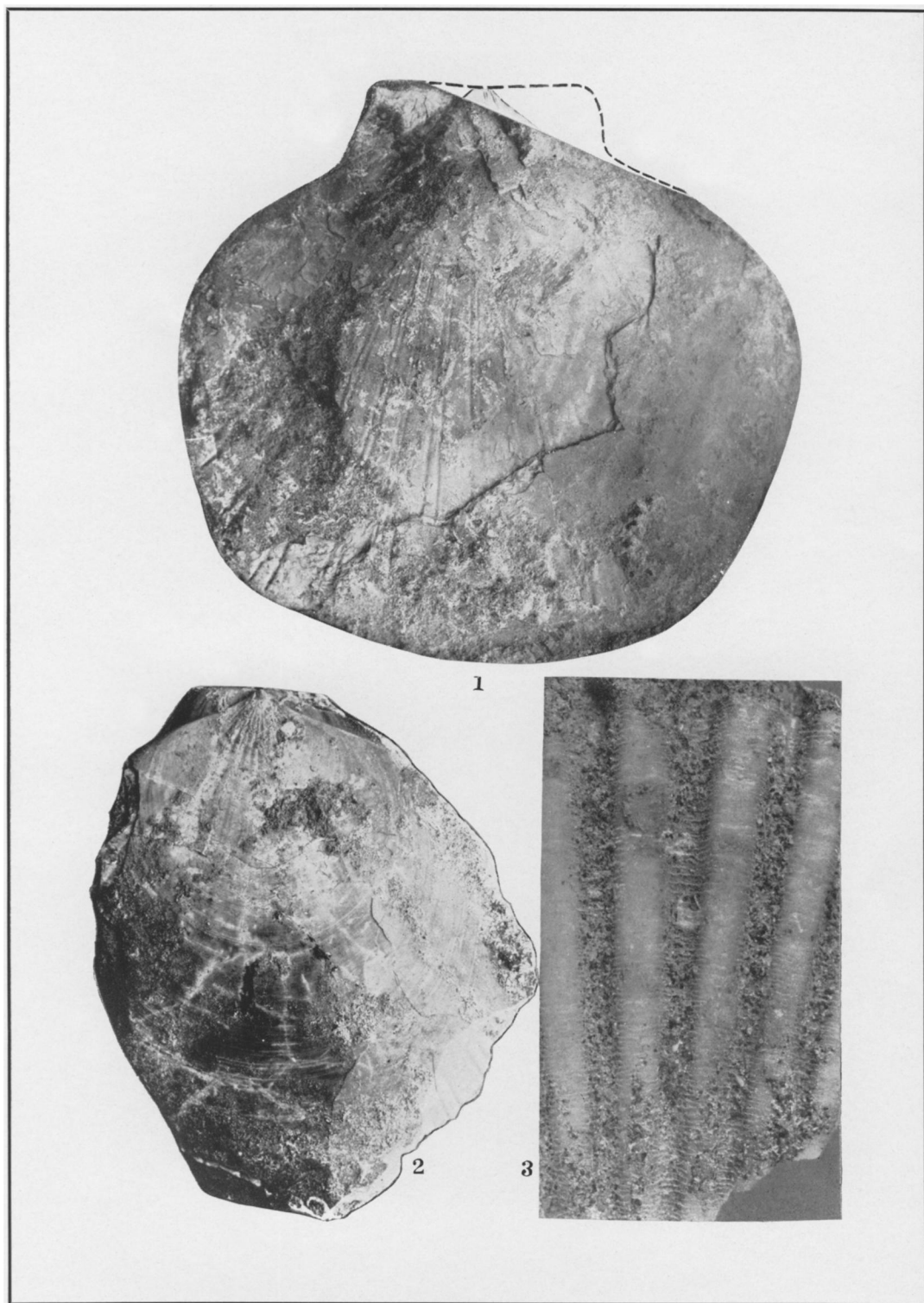
Fig. 4.—*Corbula* (*Cuneocorbula*) *hexacyma* n. sp.

Fig. 5.—*Tellina æquiterminata* n. sp.

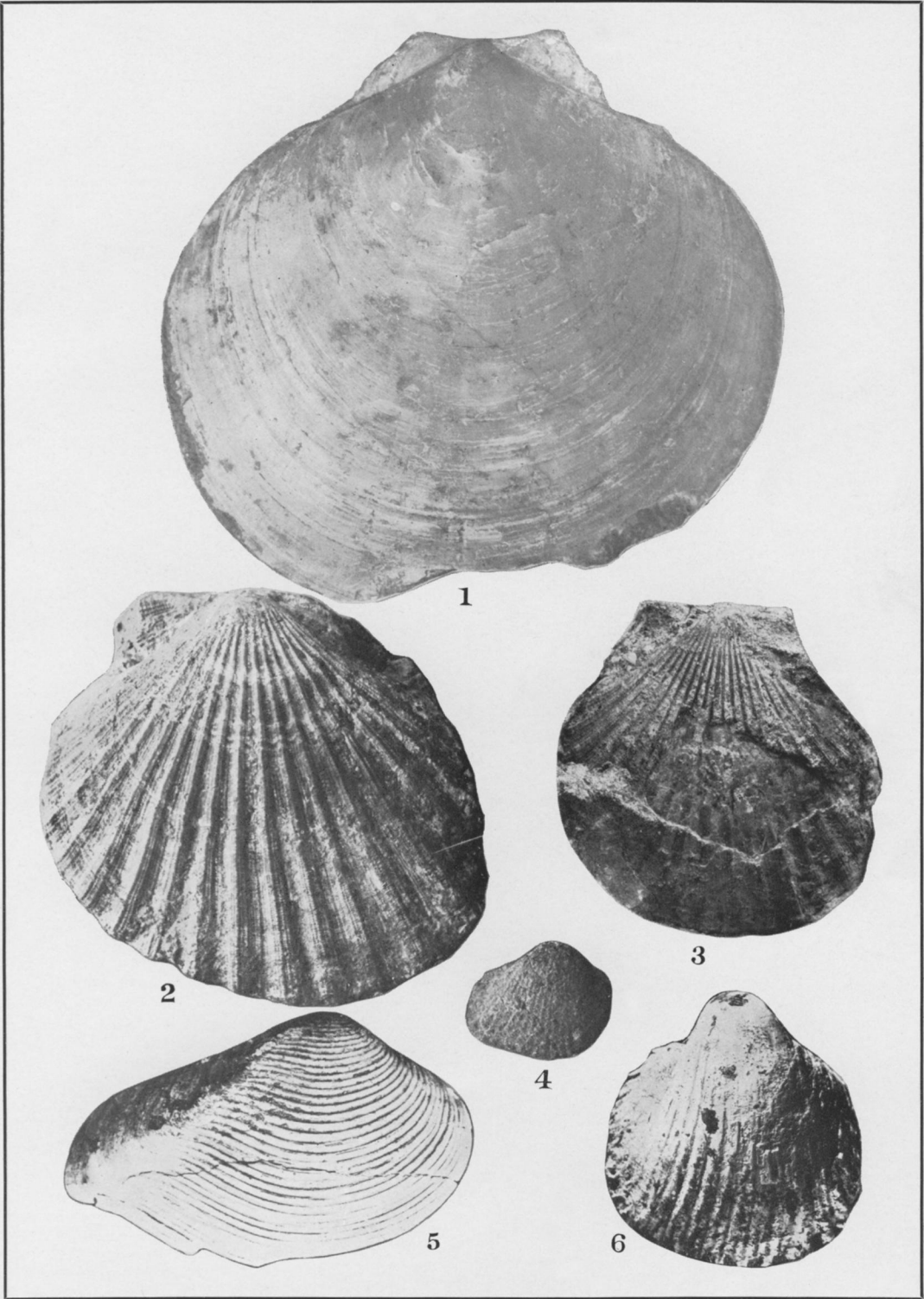
Fig. 6.—*Tellina* (*Eurytellina*) *vetula* n. sp.



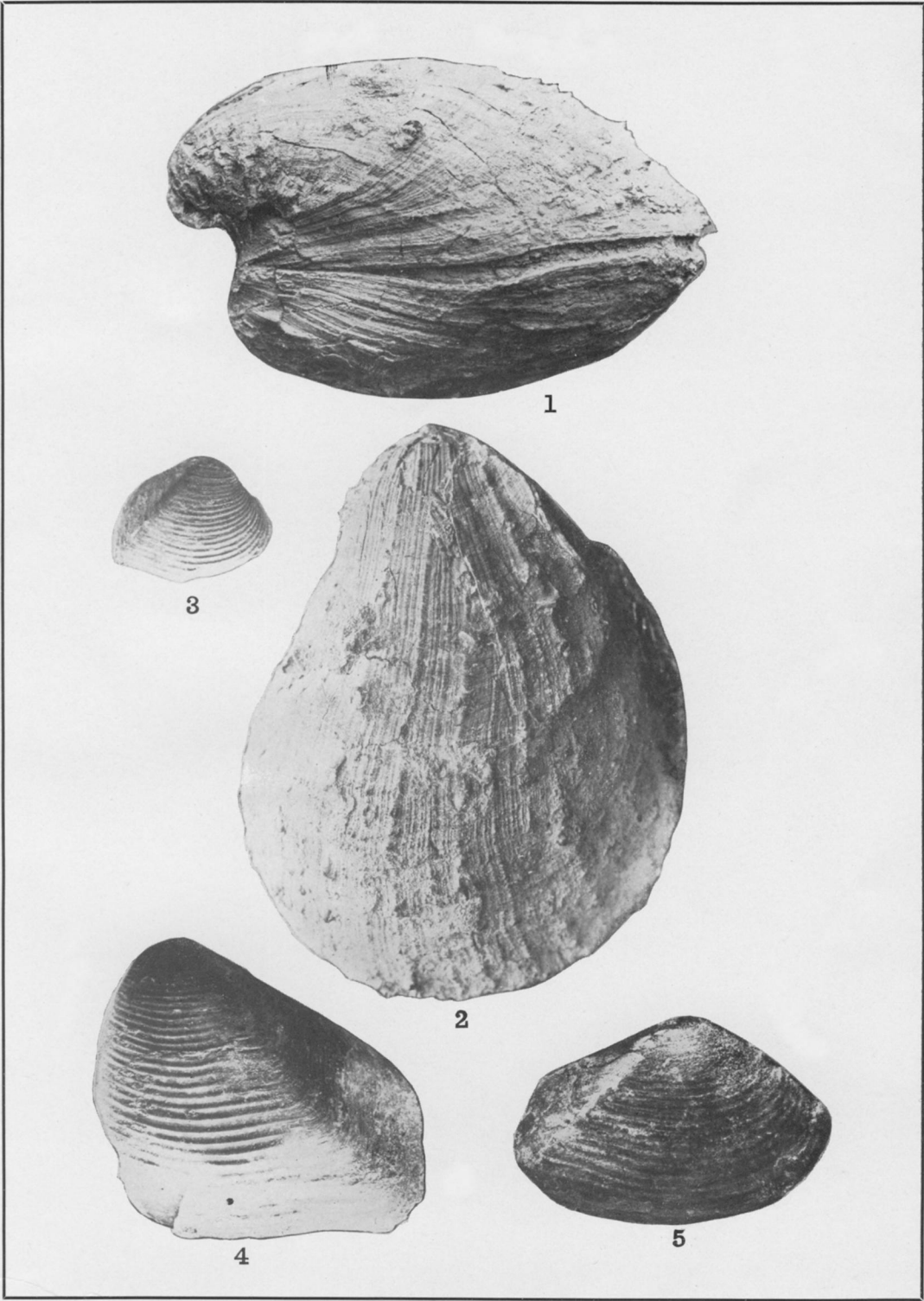
BROWN AND PILSBRY: FAUNA OF THE GATUN FORMATION.



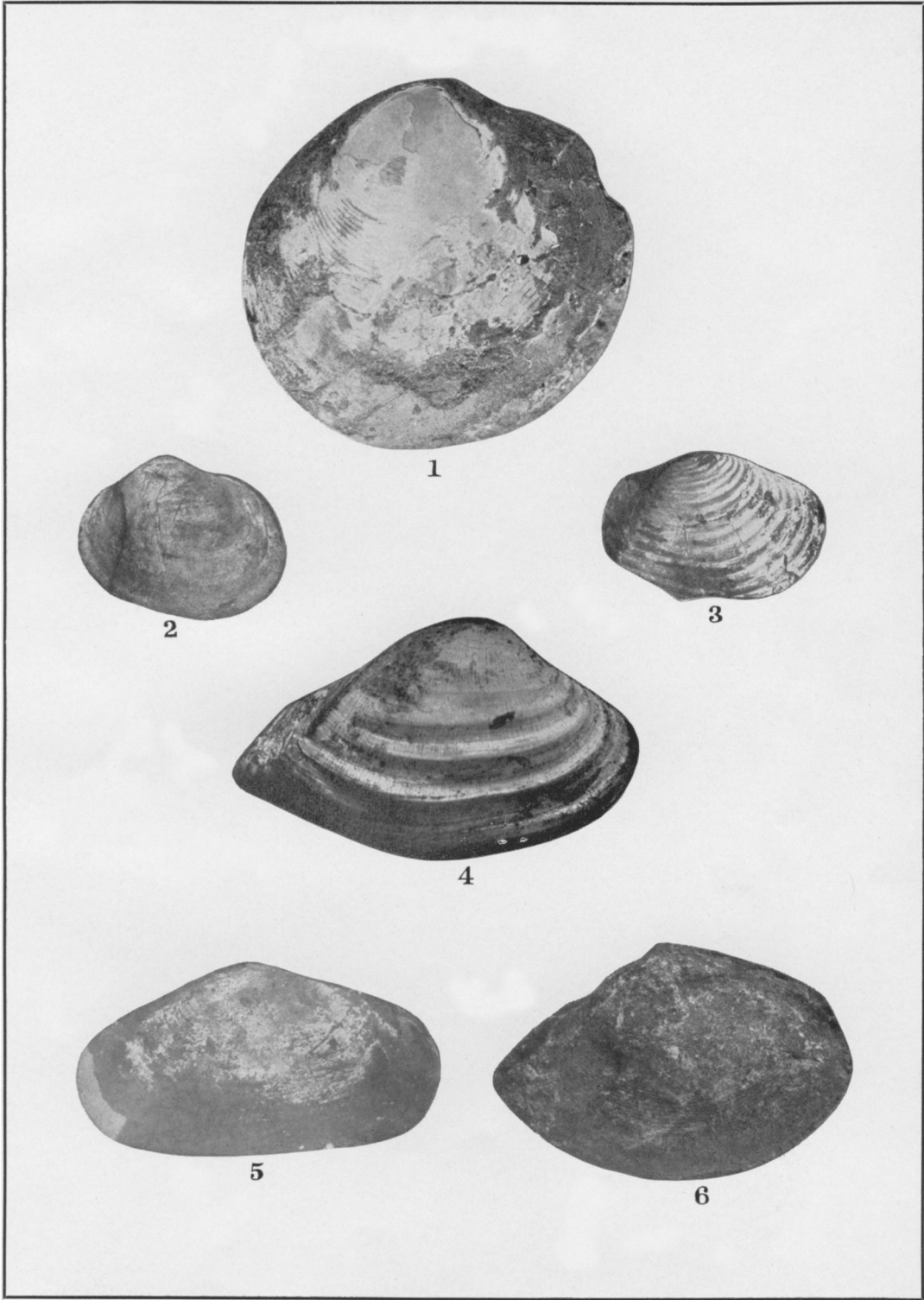
BROWN AND PILSBRY: FAUNA OF THE GATUN FORMATION.



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