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FAUNA OF THE GATUN FORMATION, ISTHMUS OF PANAMA.

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The collection of fossils studied in this paper was made by one of us (Brown) during two visits to the Isthmus in April and in August, 1910. With the exception of a tooth of a shark¹ and a few specimens of *Oliva* from Monkey Hill, all come from the excavations for the locks at Gatun. The *Oliva* taken at Monkey Hill is the same species found plentifully at the Gatun excavation. The specimens were collected from dumps and fills along the railway as well as from the dumps in the vicinity of Gatun.

A rapid reconnaissance of the stratigraphy along the line of the railway from Colon to Empire and along the canal from Colon to Gatun seemed to indicate that the formations, from the highest exposures at Monkey Hill (Mount Hope) to the lowest that contain molluscan remains at Bohio, form one stratigraphic unit, the base of which is to be found at Bohio and the top at Monkey Hill. This was the impression formed by a study of the stratigraphy on the ground. As shown below, the study of the fossils collected, and a survey of the literature on the Isthmian formations, bears out his impression formed in the field. The thickness of this Gatun formation is probably not much above 400 feet, judging from exposures and borings at Gatun. It is dredged from the canal at more than four miles north of Gatun, being here encountered at 18 feet below water level.

If this is correct that the mollusk-bearing formations from Bohio to the sea at Colon form one stratigraphic unit (and they appear to be one faunal unit), the Gatun Formation will include beds that have been variously called Bohio, Gatun, Monkey Hill, Culebra and Vamos-Vamos.

The recognition of Eocene in the Isthmian section rests upon fossils from the "Vamos á Vamos or Gatun beds" collected by Robert T. Hill and examined by Dr. Wm. H. Dall. These fossils occur as "pseudomorphs in calcite in a tough matrix, and difficult to extract in good condition." The following Eocene (Claiborne) species were "noted on a rapid examination"² by Dr. Dall:

¹ *Carcharias megalodon* Ag.

² *Bull. Mus. Comp. Zool.*, vol. 28, p. 273. The genera noted without specific identifications are such as are found in the Oligocene beds.

Lupia perovata Conrad.

Solarium alveatum Conrad.

Natica eminula Conrad.

To which the following were subsequently added:

Corbula alabamiensis Lea.

Corbula gregorioi Cossmann.

The shell identified as *Lupia perovata* may turn out to be "*Amaura*" *guppyi* Gabb, of the Santo Domingo Oligocene, a species which resembles the Eocene form so closely that very well-preserved examples are necessary for their discrimination.

The genus *Glyptostyla*, represented by *G. panamensis* Dall, is known elsewhere only from the Upper Tejon Eocene of California, where a species very distinct from the *Vamos á Vamos* form occurs.

The condition of the calcite pseudomorphs at Gatun is often not favorable for exact determination, and it seems possible that some of the identifications with Claibornian species might be modified by the study of perfect examples.³ The presence of a few Claibornian species belonging to genera not characteristically Eocene in a fauna predominantly Oligocene does not, it seems to us, justify a reference of the formation to the Eocene. Until a longer list of Eocene species including some characteristic forms is made known, we are disposed to regard all of the known tertiary beds of the Canal Zone carrying molluscan fossils as Oligocene and as constituting one formation. The exact position of the Gatun Formation among Antillean Oligocene formations cannot be fixed without a more complete list of the contained fossils than we now possess, but its approximate place is clear. As Dall has shown, the Jamaican (Bowden) marl, by the absence of *Orthaulax* and the greater proportion of modern species, is probably somewhat later than the Santo Domingo beds. The Gatun formation, as now imperfectly known, has decidedly more in common with the older and more remote Santo Domingan than with the later and geographically nearer Bowdenian.

It contains many species common to both beds, and a few show greater affinity to Bowden forms. Some of the difference between the Isthmian and Santo Domingo faunas is doubtless due to local specific differentiation; possibly this factor may account for all the differences; yet on the whole we conclude that the Gatun fauna is slightly later than the Santo Domingo and earlier than the Bowden.

³ We express this possibility in view of the imperfection of the material and with all respect for Dr. Dall's opinion, which is justly considered authoritative in such matters.

Gatun species identical with those of Santo Domingo.....	22
Gatun species identical with those of Bowden.....	13
(Eight of the species are common to the Santo Domingo and Bowden beds.)	
Gatun species more closely allied to those of Santo Domingo and Bowden than to any other known forms.....	20
Gatun species identical with those of Chipola.....	4
Gatun species identical with recent forms.....	6
Gatun species as yet known only from that formation.....	67

It will be noted that at least 40 per cent. of the 104 Gatun species now known are either identical with, or very closely related to, Santo Domingo forms. A considerable proportion of the remaining species are certainly allied to those of Santo Domingo, but without exhaustive studies of the groups, their nearest affinities cannot readily be determined.

Of the 6 species identical with recent forms, 4 are Antillean, one inhabits both coasts and one the Pacific coast only. It is obvious that in the Antillean and Isthmian Oligocene the ancestral stocks of a large part of the modern Antillean and Panamic faunas are present, genera now characteristically Panamic being especially well-developed, such as *Cymia*, *Solenosteira*, *Strombina*, *Malea*, *Trachycardium* of the *belcheri* group, *Clementia*, *Acila*, *Tesseracme*, *Cadulus* of the *dentalinus* group, etc. None of them are deep-water forms, and all are absent or rare in the curiously impoverished littoral Antillean fauna of the present time.⁴

In the following list we have included all species reported from the Gatun beds. Species marked with an asterisk (*) were not included in the collections we have studied. With a few exceptions noted in the text, the other species listed are in the collection of the Academy.

Acknowledgments are due to Professor Wm. B. Scott and Mr. Gilbert Van Ingen for the privilege of studying a small series of Gatun specimens in the museum of Princeton University, collected in 1908 by Mr. Ward H. Farrington. We would also acknowledge the courtesy of Dr. Wm. H. Dall, in giving access to material in the U. S. National Museum.

Genera reported by Toulas and Hill without specific identifications have not been inserted in the following list.

⁴ Hill's statement (Bull. Mus. Comp. Zool., vol. 28, p. 265) that Pacific forms do not exist in the Antillean Oligocene is clearly at variance with the facts. An important element in the littoral fauna of the Panamic province is directly traceable to Antillean Oligocene faunas, as the above list demonstrates.

ribs on each whorl, the threads obsolete on their summits. The imperfect shell figured measures, length 9, diam. 2.8 mm., of $6\frac{1}{3}$ whorls.

CONIDÆ.

Conus concavitectum n. sp. Pl. XXIII, figs. 5, 6.

A cone about twice as long as wide. Spire very concavely conic or mucronate, the inner whorls forming a very steep, acute cone, its whorls carinate below the middle of each, sloping and usually marked with a faint impressed spiral line or two above the carina, or having several striæ on the lower part of the slope, where the carina lies in the suture. The last 3 or 4 whorls revolve nearly in a plane, are markedly concave, with the outer edge raised in an erect flange or keel, the concavity marked with one or several spiral threads and distinct, arched growth-striæ. Last whorl slightly convex below the shoulder-angle, straight and slender below, marked below the middle with unequal, low spirals, most of them beaded. Length 37.5, diam. 19 mm. Incomplete adult shells are much larger, diam. 28 mm., with about 15 whorls.

This species differs from *C. domingensis* Gabb by having the outer edge of the later whorls raised in a flange and by the smooth, not tuberculate early whorls. None of the larger specimens is complete.

Conus haytensis Sowb.

Conus haytensis Sowb., Journ. Geol. Soc. Lond., VI, p. 44.

A perfect, but small specimen, length 26 mm., agrees with Santo Domingo examples.

Conus domingensis Sowerby (?).

C. domingensis Sowb., Journ. Geol. Soc. Lond., VI, p. 45.

A fragment, the spire only, agrees well with this species, so far as it goes.

Conus consobrinus Sowb.

Conus consobrinus Sowb., Journ. Geol. Soc. Lond., VI, p. 45.

A Gatun specimen is about 30 mm. long, of the highly sculptured typical form.

Conus granozonatus Guppy.

C. granozonatus Guppy, Quart. Journ. Geol. Soc. Lond., XXII, p. 287, Pl. 16, fig. 5.

C. gracilissimus Guppy, t. c., p. 288, Pl. 16, fig. 4.

Not uncommon at Gatun. While closely related to *C. consobrinus*, this seems to be a distinct species. In our series from Bowden the *C. gracilissimus* does not seem distinguishable specifically.

Conus æmulator n. sp. Pl. XXIII, fig. 9.

A cone related to *alveatus* Conr. and *imitator*, differing from both in the very concavely conic spire. Whorls slightly concave above, with about 3 spiral striæ; not tuberculate, last whorl decidedly convex below the shoulder, its lower half spirally striate, the striæ unequal, not beaded. The outer lip is much less retracted above than in *alveatus*.

Length 22.5, diam. 12.8 mm.; whorls about 9.

The single specimen is a pseudomorph in calcite. It differs from *C. domingensis* by the non-tuberculate early whorls.

Conus imitator n. sp. Pl. XXIII, fig. 4.

A cone about twice as long as wide, the spire forming about one-fourth of the length. The spire is concave and acuminate in the upper third, the first 3 whorls smooth, the next 4 or 5 whorls having a smooth carina projecting above the suture, the first $2\frac{1}{2}$ of them tuberculate, after which the carina is smooth; following whorls less steeply sloping, very slightly concave, marked with fine growth-lines and a few weak spiral striæ, slightly prominent at the sutures. Last whorl acutely carinate, the slope below the angle almost straight, but just perceptibly convex in the upper, concave in the lower half, which is sculptured with about 16 rather strong spiral cords. The outer lip arches strongly forward and is deeply retracted at the upper end.

Length 35, diam. 17 mm., whorls 12.

This small, inornate cone is probably a descendant of *C. alveatus* Conr. of the Vicksburgian, but in that species the spire is more strongly striate, more whorls are tuberculate, and the keel edging the whorls is directed upward, whilst in *C. imitator* it is rather outward.

It is rather abundant at Gatun. Also occurs in Santo Domingo.

Conus gaza Johnson and Pilsbry, n. sp. Pl. XXIII, figs. 2, 3.

"The shell is biconic, diameter over half the length, the spire is nearly one-third the total length, concavely conic, attenuate towards the apex. Post-embryonic whorls about 9, slightly concave, the lower edge of each angular, projecting a little; the angle tuberculate in the first post-embryonic whorl, smooth in the rest; sculptured with deeply arcuate, narrow, low and widely spaced riblets and striæ; no spiral striæ. Last whorl acutely angular at the shoulder, barely convex below the angle, the outline becoming concave in the lower part; sculptured with 20-22 strong, smooth, flattened spiral cords, separated by wider intervals which are sharply striated by growth-striæ. Aperture very narrow.

"Length 24, diam. 13.1 mm." (Johnson and Pilsbry).

Oligocene of Santo Domingo, Gabb. Also of Gatun, A. P. B.

This beautiful cone bears some resemblance to the longer *C. cruzianus* Dall from Santa Cruz, the horizon of which is uncertain.

The single specimen from Gatun has fully two tuberculate post-embryonic whorls. In the Santo Domingo types this stage is shorter, and generally inconspicuous or lost by erosion. We have quoted the description from Pilsbry and Johnson's MS. work on the Santo Domingo Oligocene. The figures represent the type specimens from the same place.

Conus molis n. sp. Pl. XXIII, fig. 1.

A large, ponderous cone resembling *C. prometheus* in figure, the ratio of diameter to length as 1 : 1.7.

Spire but little raised except at the center, where the early whorls project in a short acute cone. Whorls about 13, the earlier 6 flat, later whorls concave, spirally striate with about 5 striæ between the seamlike sutural margins; crossed by weak growth-lines, which are not very deeply arcuate. The shoulder of the last whorl is subacute. Side strongly convex below the angle, then straight, finely striate spirally throughout, the lower third coarsely striate. Aperture as in *C. haytensis* Sowb.

Length 124, diam. 71.2 mm.

This cone resembles *C. haytensis* Sowb. of Santo Domingo, but differs by being longer in proportion to its width, in the plain, not coronated early whorls, which form a smaller mucro, the more acute shoulder, below which the side is more convex, *more distinctly striated*; the striæ at the base are more nearly equal and closer, not widely spaced with smaller striæ in the intervals, as they are in *haytensis*.

The type is No. 5,502 coll. Princeton University, collected by Ward H. Farrington, 1908.

This species is also represented by several internal casts in the Princeton and Academy Gatun collections, and there is a fine example in the U. S. National Museum from Monkey Hill, near Colon. Toula also mentions a cast, probably referable to the same species (Jahrb., p. 754).

TURRITIDÆ (PLEUROTOMIDÆ).

Pleurotoma albida Perry.

The specimens agree well with those of the Bowden beds. It is a conservative species, ranging from Eocene to recent.

**Corbula gregorioi* Cossmann.

C. gregorioi Cossm., Dall, Trans. Wagner Inst., III, p. 843.

A Claibornian Eocene species reported by Dall from the Gatun beds.

**Corbula heterogenea* Guppy.

C. heterogenea Guppy, Dall, Trans. Wagner Inst., III, p. 850.

Vamos-a-Vamos (Dall).

**Corbula viminea* Guppy.

C. viminea Guppy, Dall, Trans. Wagner Inst., III, p. 850.

Vamos-a-Vamos (Dall).

TEREDIDÆ.

Teredo dendrolestes n. sp. Text fig. 3; Pl. I, fig. 10.



Fig. 3.

The thin-walled tubes are crowded, run with the grain of the wood, as usual, curving outward at the orifice. They have a diameter of about 5 mm., the longest (broken) reaching a length of about 60 mm. The terminus of the tube is hemispherical. It encloses a very delicate shell shaped like the annexed outline figure. There are long apophyses. The exterior of the shell is unknown, being cemented to the calcified tube.

SOLENIIDÆ.

**Solecortus gatunensis* Toula.

Solecortus gatunensis Toula, Jahrb., p. 732, Pl. 28, fig. 12.

**Solecortus strigillatus* (L.).

Solecortus (Macha) strigillatus L., Toula, Jahrb., p. 731, text fig. 11, Pl. 27, fig. 12.

**Thracia gatunensis* Toula.

Thracia gatunensis Toula, Jahrb., p. 757, text fig. 15.

REFERENCE TO PLATES XXII-XXIX.

PLATE XXII.—Fig. 1.—*Terebra wolfgangi* Toula.

Fig. 2.—*Terebra gatunensis* Toula.

Figs. 3-6.—*Terebra wolfgangi* Toula.

Fig. 7.—*Terebra subsulcifera* n. sp., × 2.

Figs. 8, 9.—*Terebra gansapata* n. sp., two views of the type, fig. 8, × 5.

Fig. 10.—*Arca dariensis* n. sp.

Fig. 11.—*Teredo dendrolestes* n. sp.

PLATE XXIII.—Fig. 1.—*Conus molis* n. sp.

Figs. 2, 3.—*Conus gaza* n. sp. (Santo Domingo).

Fig. 4.—*Conus imitator* n. sp.

Figs. 5, 6.—*Conus concavilectum* n. sp.

Fig. 7.—*Drillia jusinus* n. sp.

- Fig. 8.—*Drillia zooki* n. sp.
 Fig. 9.—*Conus amulator* n. sp., $\times 2$.
 Figs. 10, 11.—*Drillia isthmica* n. sp.

- PLATE XXIV.—Figs. 1, 2.—*Cancellaria dariena trachyostraca* n. subsp.
 Figs. 3, 4.—*Cancellaria dariena* Toula.
 Figs. 5, 6.—*Cancellaria decaptyx* n. sp., two views of the type.
 Fig. 7.—*Mitra*, sp. undet., part of the columella.
 Fig. 8.—*Mitra*, sp. undet., internal cast, No. 5,515, coll. Princeton University.
 Fig. 9.—*Mitra dariensis*, n. sp.
 Fig. 10. *Marginella gatunensis* n. sp.
 Fig. 11.—*Mitra longa* Gabb, Gatun specimen.
 Fig. 12.—*Marginella coniformis* Sowb., var.
 Fig. 13.—*Marginella leander* n. sp.
 Fig. 14.—*Solenosteira dalli* n. sp.

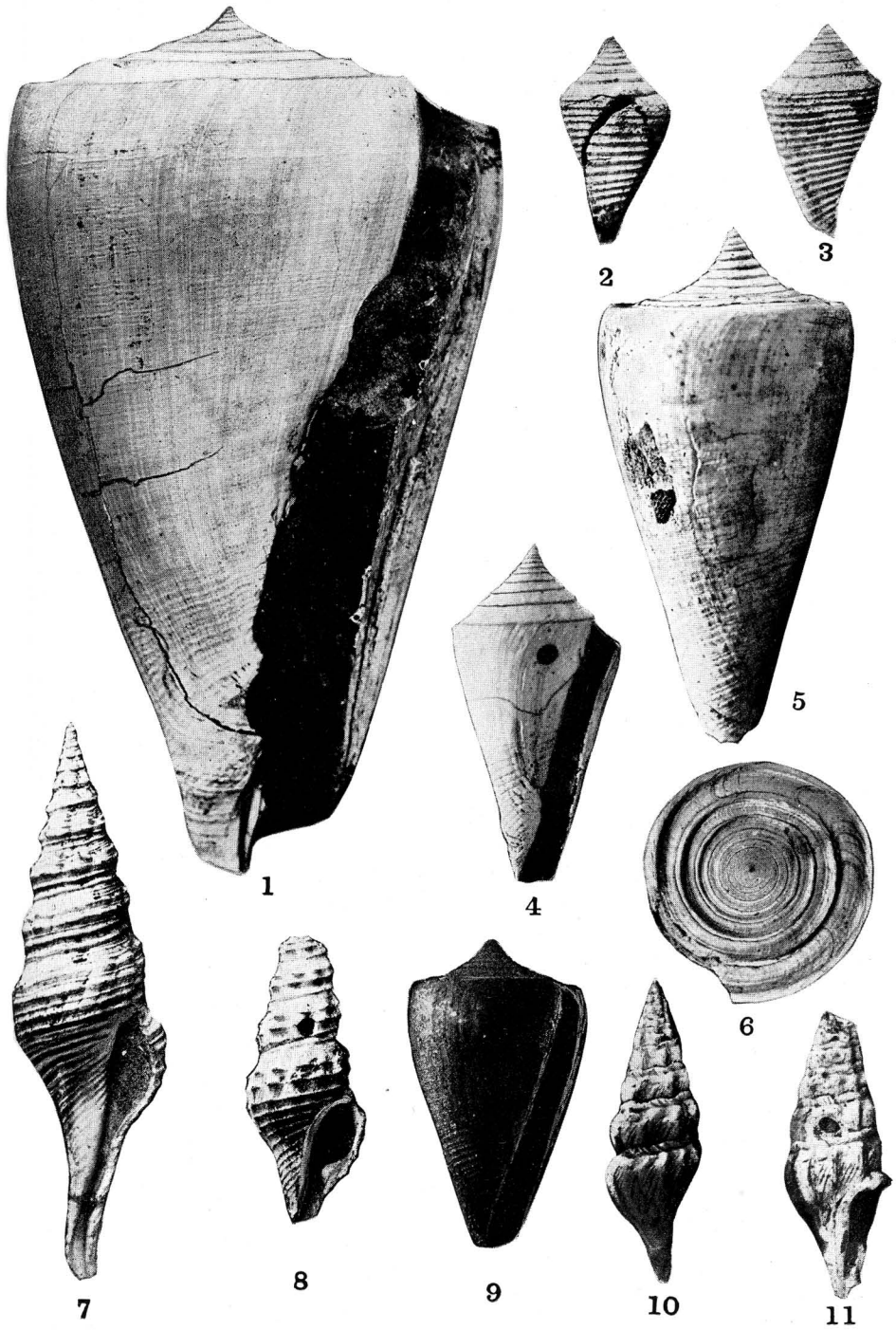
- PLATE XXV.—Figs. 1, 2.—*Phos gatunensis* Toula.
 Fig. 3.—*Phos subsemicostatus* n. sp.
 Fig. 4.—*Metula gabbi* n. sp.
 Fig. 5.—*Anachis fugax* n. sp.
 Figs. 6, 7.—*Strombina cyphonotus* P. and J., n. sp., Santo Domingo.
 Fig. 8.—*Metula gabbi* n. sp.
 Figs. 9, 10.—*Strombina prisma* J. and P., n. sp., Santo Domingo.
 Figs. 11, 12.—*Strombina lessepsiana* n. sp.

- PLATE XXVI.—Fig. 1.—*Murex polynematicus* n. sp.
 Fig. 2.—*Murex gatunensis* n. sp.
 Fig. 3.—*Strombus gatunensis* Toula.
 Figs. 4, 5.—*Strombus gatunensis* Toula, No. 5,512, coll. Princeton University.
 Fig. 6.—*Typhis gabbi* n. sp.
 Fig. 7.—*Strombus* (?) sp., internal cast.
 Fig. 8.—*Distorsio gatunensis* Toula.
 Figs. 9, 10.—*Cypræa henikeni* Sowb., smoothish var., No. 5,511, Princeton University.

- PLATE XXVII.—Fig. 1.—*Turritella mimetes* n. sp.
 Figs. 2, 3.—*Turritella atilira* Conrad.
 Figs. 4, 5.—*Turritella gatunensis* Conrad.
 Figs. 6, 7.—*Natica*, sp. undet. Internal cast.
 Fig. 8.—*Leda balboæ* n. sp.
 Fig. 9.—*Turritella gatunensis* Con. Pseudomorph in calcite.
 Fig. 10.—*Turritella sapotensis* n. sp., Sapote, Costa Rica.
 Figs. 11, 12.—*Nucula (Acila) isthmica* n. sp.

- PLATE XXVIII.—Fig. 1.—*Clementia dariensis* Conr.
 Fig. 2.—*Pecten scissuratus* Dall. Typical form from Santo Domingo.
 Fig. 3.—*Pitar cora* n. sp.
 Fig. 4.—*Pecten effossus* n. sp.
 Fig. 5.—*Pecten scissuratus* Dall. Santo Domingo.
 Fig. 6.—*Pecten effossus* n. sp.
 Fig. 7.—*Pecten toulw* n. sp.
 Fig. 8.—*Chione tegulum* n. sp.
 Fig. 9.—*Glycymeris carbasina* n. sp.
 Fig. 10.—*Glycymeris canalis* n. sp.
 Fig. 11.—*Cardium striatum* n. sp.

- PLATE XXIX.—Figs. 1, 2.—*Ostrea gatunensis* n. sp.



BROWN AND PILSBRY: GATUN FOSSILS.