DISTRIBUTION OF THE LAND AND FRESH-WATER MOLLUSKS OF THE WEST INDIAN REGION, AND THEIR EVIDENCE WITH REGARD TO PAST CHANGES OF LAND AND SEA.

By Charles Torrey Simpson.

Aid, Department of Mollusks.

The West Indian archipelago lies almost wholly within the tropics, and extends from latitude 10° to 27° 30′ north, and between longitude 59° and 85° west, and embraces an area of about 95,000 square miles. It presents an example of an astonishingly rich and diversified land snail fauna; in fact no other area of the globe of equal extent can be compared with it. Within this region there are about 1,600 species of terrestrial mollusks, belonging to some 65 genera, a number almost as great as that found on the mainland of the entire continent of America. The structure of the Greater Antilles is very different from that of the lesser archipelago,* or from that of the Bahama group. Each of the four large islands is believed to consist of a nucleus of igneous and metamorphic rock, that forms the summits of the higher mountains, which are flanked by Cretaceous, Tertiary, and Post Tertiary beds. The loftiest peaks of eastern Cuba attain a height of 8,400 feet; those of Haiti and Jamaica a little over 7,000, while Puerto Rico's greatest elevation is slightly less than 4,000 feet. These mountain chains run, for the most part, lengthwise of the islands, and from a glance at the map one can not help thinking that Haiti—which looks something like an enormous letter Y, with one arm pointing toward Cuba, the other in the direction of Jamaica, while the stem is directly in line with Puerto Rico—is a sort of connecting link in the great archipelago. The channel between Cuba and Haiti is 875 fathoms in depth, the one dividing the latter island from Jamaica is about 1,000, while that between Puerto Rico and San Domingo is 260 fathoms deep.

*In the following pages the term Lesser Antilles or Windward Islands will be used to include all the islands south of the Anegada Channel, beginning with Sombrero, Anguilla, and St. Martin, and including Trinidad. The islands lying north of and along the coast of Venezuela will be called the Leeward Group. Cuba, Haiti, Jamaica, Puerto Rico, the Isle of Pines, and the Virgin Islands are included in the general term Greater Antilles.

Between Cuba and Jamaica there is a great trough some 3,000 fathoms in depth, known as the Bartlett Deep. Running nearly due west from Cape Cruz on the south side of Cuba, and north of the profound abyss is a shoal on which are the Cayman Islands, but which deepens to 1,500 fathoms before reaching Belize. To the southwest of Jamaica a wide shoal extends to the coast of Honduras, forming the Mosquito, Baxonuevo, Savanilla, Rosalind, and Pedro banks, along which are scattered low islets, and which, with an elevation of 500 fathoms, would connect Jamaica with the continent. The western end of Cuba points directly toward Cape Catoche, from which it is separated by a strait 130 miles wide and 1,164 fathoms deep. The 100-fathom line would unite Cuba to the Bahamas. At the southeast the Greater Antilles are separated from the Lesser by the Anegada Channel, which carries in a depth of 1,100 fathoms from the Atlantic, ending in a deep basin between Santa Cruz and St. Thomas of 2,400 fathoms. East of this a ridge crosses it which comes within 900 fathoms of the surface.

The Lesser Antilles have not a central nucleus of igneous or metamorphic rock. In referring to this subject Alexander Agassiz says:*

> The position of the most recent Pliocene and Post Pliocene beds seems to indicate that some of the volcanoes now active in the West Indies date back to the Pliocene period, and others to the Post Pliocene. The islands to the north of Guadeloupe form two parallel chains, the western consisting of Saba, St. Eustatius, St. Kitts, Nevis, Redonda, and Montserrat, all of which are volcanoes of Post Pliocene date; while to the eastward is a chain of volcanoes of Tertiary age—Sombrero, Anguilla, St. Martin, St. Bartholemew, Barbuda, and Antigua. At Guadeloupe the recent islands are directly united with the volcanic chain, and the still more recent limestones are found on its western shores.

Agassiz and other authorities agree that the northern portion of the Lesser Antilles is of much more recent origin than the greater archipelago, and the volcanic chain no doubt rests upon a submarine plateau.

The Bahama group is also believed to be of somewhat modern origin. Agassiz thinks that it was formed on an extensive shoal, from the remains of marine animals deposited at a time when the current from the Gulf of Mexico flowed over the area of the present archipelago with very much less velocity than it does at present.† All the islands are low, and many of them are of coral formation.

Before entering into details as to the distribution of genera and species it may be well to say a few words as to the means of dispersal of the land and fresh-water mollusks. Where closely related forms or groups are found in lands separated by the sea, I think we may generally conclude that they have reached their present distribution by one or more of the following means:

First:—By former land connection which has existed within the lifetime of present species or groups.

Second:—By the sea, by means of oceanic currents, winds, or storms. It is very well understood now that many land, and some fresh-water

* Three cruises of the Blake, I, p. 109.

† *op. cit.*, p. 75.

plants and animals are carried across more or less wide spaces of ocean from shore to shore in various ways on the surface of the sea. In tropical countries especially, heavy rains swell the mountain streams to torrents, which tear up trees and masses of earth held together with a network of roots, and bear them swiftly to the ocean. These are often peopled with land snails, or carry their eggs, and in their course to the sea may frequently plow up mud from the bottom which contains fresh-water mollusks. Or fresh-water snails may inhabit the surface and crevices of such trees, that become stranded on their way down, or lay their eggs on them, the whole to be carried onward at the next flood. In many places, notably the northern shores of South America, the sea is constantly encroaching on the land, and large areas of forest bound together by matted roots and tangled vines are being undermined and swept away.

Of course if the distance from land to land is short, and there are winds that blow, or tides that run in the right direction, the probability of such mollusks being safely carried across is much greater than if they have far to travel, have head winds, or contrary currents. Darwin has shown that some of the land snails will live for considerable periods of time in sea water, and many of the fresh-water species will remain alive for some time in the air under favorable circumstances, and others are found living in water more or less brackish. One who has noticed much of the drift in the West Indian region—trees and bamboos, often carrying masses of earth and stones—can easily believe that they might bear with them snails for quite a voyage without wetting them to any considerable extent.* I think I shall be able to show that most of such migrations in and about the West Indies have been accomplished under favorable circumstances, that long stretches of unprotected sea, head winds, and contrary currents have generally proven fatal to dispersal by the ocean.

Third:—The agency of man. It is hardly necessary to mention the well-known instances where man is known to have been the means of carrying from one country to another different animals or plants. Many mollusks are known to have been transported through his agency. *Helix similaris* is a native of eastern Asia, but is now naturalized in most of the warmer parts of the world. *Helix aspersa* and *lactea*, common edible snails of Europe, are colonized in a number of foreign coun-

*The hollow stems of dead bamboos are a favorite retreat for many species of terrestrial and arboreal snails. These gigantic tufts of grass are particularly abundant along the streams in tropical countries, and are often washed out in time of floods, and scattered along the banks. Between rainy seasons the upper joints become more or less broken and decayed, and peopled with mollusks, and another freshet sweeps them with their living cargo into the sea. The lower joints, being more solid are perhaps air-tight, and serve to buoy up the whole mass; the roots weighted with earth and stones depress the lower end of the clump, and throw the upper and inhabited end out of water. I have seen just such floating rafts, and nothing could be more admirably contrived for transporting land snails safely across the sea.

tries, as well as *Rumina decollata*, and many others. I have little doubt that *Subulina octona* has been introduced into a number of the West Indian islands in this manner, for C. B. Adams mentions that in 1849 it was found only in a single locality in Jamaica, in a garden near Kingston,* while now one can not pick up a handful of shells anywhere on the island without finding it.

Orthalicus undatus, a Mexican species now found in south Florida, Cuba, Jamaica, and some of the Windward Islands, is another case in point, no doubt.†

Fourth:—By birds. Small mollusks or their eggs may be, and no doubt are, sometimes carried from one locality to another in mud attached to the feet or feathers of birds. And lastly, it is possible that such mollusks or their eggs might be transported moderate distances by windstorms, though such migrations are probably very rare.‡

A number of eminent biologists have regarded the Antillean region as an independent one, and among these are De Candolle, Schouw, Martins, Berghaus, Hinds, Woodward, Baird, Griesbach, Brown, Sclater, Wallace, Engler, Packard, Drude, Hartlaub, and Fischer. These men studied the plants, forests, animals in general, birds, and mollusks. Others, among whom are Agassiz, Heilprin, and Merriam, have regarded it as a subregion of the American tropical province, and still others have united it with the tropical American region. Whether the evidence of the land and fresh water mollusks of the Lesser Antilles goes to prove it a separate province may well be doubted, since it is peopled so largely with South American species and genera, but I believe that the character of this fauna in the Greater Antilles is very distinct from any other, and that the peculiar genera and subgenera of land mollusks have been developed in the localities where they now preponderate.

Bland, whose exhaustive studies of the distribution of the land shells of this region are well known, and whose conclusions are considered authoritative, says:§

* Contributions to Conchology, III, p. 48.

† Land and fresh-water mollusks may be often carried from one country to another in the cargoes or ballast of vessels. Ampullarias are frequently imported alive into Europe or North America in the crevices of mahogany logs and several African Achatinas have been carried with coffee plants to Mauritius and other islands of the Indian Ocean, where they flourish as vigorously as the native snails. No doubt many species are introduced on plants. It may be well to mention that it is known that the young of some of the Unionidæ attach themselves by hooks to the fins and gills of fishes, where they become encysted, and in this condition may be transported long distances.

‡ Small fresh-water bivalves have been found attached to the legs of flying aquatic insects and they may thus be borne from one body of water to another.

§ On the Geographical Distribution of the Genera and Species of the Land Shells of the West India Islands; with a Catalogue of the Species of each Island. Ann. Lyc. N. Y., VII, p. 335, 1861.

Seeing, moreover, the greater number of both genera and species, absolutely and proportionately in the islands under consideration, it may not unreasonably be suggested that the insular stamp has rather been impressed on the fauna of the continent than the reverse.

Since the time of Bland's studies the discovery of many new species, a better knowledge of their distribution, the great progress made in classification, and in the soundings of the Caribbean, the Gulf of Mexico, and the adjoining parts of the Atlantic, the added knowledge of the currents and winds, as well as the advances made in the study of the geology and paleontology of this general region go to confirm the above statement, and in the direction of proving that the land molluscan fauna of the greater archipelago is largly a peculiar one; that it developed in part in the region it now occupies, and that it has spread, to some extent, to Florida, the Bahamas, Mexico, Central and South America, and the Lesser Antilles, by some of the means I have mentioned above.

Some 28 genera and subordinate groups of land mollusks are confined strictly to the Greater Antilles, and no less than 24 more have here their metropolis, or greatest numerical development of species.

It has been claimed that there has never been land connection between the islands of this archipelago, and that the homogeneousness of its land and fresh water molluscan fauna could be accounted for by supposing that many of the species had been carried from island to island, by storms or currents, or that they had been transported by other means. While no doubt a small proportion of the forms have thus migrated, yet the number of species common to two or more islands is so small, and the distribution of many of the genera and subordinate groups is so peculiar, that I believe we are not justified in explaining the present distribution by such an hypothesis. Cuba, with nearly 700 species of land and fresh-water mollusks, has only 53 not confined to the island; Jamaica, with over 500 species, has 41; Haiti, with 270 species, has only 30; and Puerto Rico, with 130 species, has 34 stragglers to other localities.*

Now, it is very remarkable that while many species of non-operculate land snails are common to the Greater Antilles and the continent, as well as to several of the different Lesser Antillean islands, not a single operculate is known to inhabit both the greater archipelago and the mainland of tropical America. Two species, *Chondropoma dentatum* and *Helicina subglobulosa*, and possibly a third, *Ctenopoma rugulosum*, all Cuban forms, are colonized in the extreme southern end of Florida,

* Haiti—and under this name I include the whole island—has an area of 28,000 square miles, yet only about one-half as many terrestrial and fluviatile mollusks are known to belong to it as are found in Jamaica. With a very diversified surface, an abundance of forest and rainfall, and a large area of limestone, it is probable that when it is fully explored the number of its land and fresh water mollusks will be doubled, and many interesting points of geographical distribution will be brought to light.

and although nearly half the species of land snails of these four larger islands are operculates, not more than 9 or 10 of them are found outside of a single island. This might be taken as evidence that the non-operculate forms were of much more ancient origin than the others, many of them reaching back to a time of former land connection, while the operculate species were of more recent development, which I suspect may be the case; or that the former are better adapted to migration across the ocean than the latter.

The fact that the operculates form so large a proportion of the Antillean land snail fauna, that a majority of the genera are found on two or more of the islands and the mainland, while nearly every species is absolutely restricted to a single island appears to me to be very strong testimony in favor of a former general land connection.

I believe that all the evidence of the terrestrial and fluviatile molluscan fauna of this region indicates that in the early Tertiary Period, perhaps, there was a general land elevation of the Greater Antilles, and possibly of some of the adjacent area; that Wallace's theory of a land connection of the greater islands is correct; that during some part of this time a landway extended across to the continent;* that the species and groups of this then connected territory migrated to some extent from one part of it to another, and that a probable connection existed over the Bahama plateau to what was at that time no doubt the island of Florida. It would appear that at this time the volcanic islands of the Lesser Antillean chain were not yet raised above the sea, or that if there was land in that region it has since been submerged, and there seems to be no good evidence in favor of any land connection with the Greater Antilles since the lifetime of the present groups and species of West Indian land and fresh-water mollusks.

We have not as yet a sufficient knowledge of the geology and palæontology of this general region, or a large enough acquaintance with the distribution of the terrestrial and fluviatile mollusks in Central and South America to at all fully trace the past history of the region, or of the forms of life in question, and, therefore, most of these theories and speculations are advanced with the utmost caution, and rather as suggestions, subject to modification by future discoveries, than as absolute explanations of the facts. Yet enough is known to make many points reasonably certain.

Bland has divided the Greater Antilles into five different sub-provinces: †(1) Cuba, with the Isle of Pines, the Bahamas, and Bermuda;

* It is quite probable that at this time Mexico and most of Central America formed an island; that the sea flowed through what is now the Isthmus of Panama; and that there was connection by a strait from the Gulf of Mexico through or around to the northern end of the Gulf of California. In using the expression "a landway across to the continent" I mean to what is the continent now.

† "Geographical distribution of the West India land shells." Am. Lyc. Nat. Hist. of N. Y., VII., p. 346.

(2) Jamaica; (3) Haiti; (4) Puerto Rico. with Vieque, the Virgin Islands, Sombrero, Anguilla, St. Martin, St. Bartholomew, and St. Croix. The islands south of the latter, to and including Trinidad, he places in a fifth province. Fischer follows essentially this arrangement,* except that he places the Bahamas in a separate division and adds Bermuda to that of North America, though he thinks the latter group of islands shows about equal malacological affinities with Florida and the Antilles.

While the molluscan faunas of each of the four large islands of the Greater Antilles contain much that is peculiar, yet I believe that the relationship of the genera and species is much closer than has generally been supposed. Among genera that are restricted to this archipelago only five are confined to Cuba—*Glandinella*, *Diplopoma*, *Blæsospira*, and *Xenopoma*, each having but a single species, and *Polymita*, with four species; one is restricted to Haiti—*Rolleia*, with one species—and two to Jamaica—*Zaphysema*, with six species, and *Jamaicia*, with two. Of genera of wide distribution that are found only on a single island there are three in Cuba—*Cionella*, *Gundlachia*, and *Vivipara*, each with a single species—and four in Jamaica—*Carychium*, *Strobilops*, *Hemisinus*, and *Valvata*, each with one representative—while Puerto Rico has a single *Clausilia*, and three Peltellas.

Nearly all the peculiar genera, and those of wide distribution that are at all numerously represented, are found in three, if not all four, of the larger islands. The following table exhibits the distribution of all the terrestrial and fluviatile genera. The marine Neritinas, the semi-aquatic Auriculidae, and the Truncatellas, which are distributed in the same way as the ordinary salt-water Gastropods, are not included. There are no peculiar fresh-water molluscan genera in the West Indies. The lists of this paper are as accurate as I can make them. The fact that so many changes have recently been made in the literature and classification, and that no two authors agree as to specific and generic values, make it well nigh impossible to give lists that are correct.

* Manuel de Concholiologie, p. 269.

Distribution of genera of West Indian land and freshwater mollusks.

Genera and groups.	Cuba.	Haiti.	Jamaica.	Puerto Rico.	Elsewhere.
Glandina:					
Glandina		1			Mexico; Central America; a few species in South America and the Lesser Antilles; 1 in Southern Europe.
Oleacina	16			2	
Varicella	2		14		
Melia			9	3	
Volutaxis	1	1			Mexico, 10 species; Guatemala, 1.
Streptostyla	4	2		3	Mexico, 35 species; Central America, 12; Peru, 1.
Hyalinia	4	5	11	5	World-wide.
Selenites	1			3	American Continent.
Thysanophora	16	8	19	9	3 species in Mexico and Southern States
Sagda:					
Sagda			15		
Hyalosagda			4		
Odontosagda	1	2			
Zaphysema			6		
Polymita	4				
Polygyra	2		1		Mexico; southern United States.
Hemitrochus:					
Hemitrochus	11		1		A few in the Bahamas.
Cysticopsis	7	1			
Plagioptycha		8		1	Bahamas.
Dialeuca			6		
Cordya	8	1			
Jeanneretia	5			1	
Cepolis		4		1	1 in Central America; 1 in Peru.
Pleurodonte					Lesser Antilles; northern S. Am.
Pleurodonte			25		
Carocolus	1	5		2	
Thelidomus	10		2	2	2 in Lesser Antilles.
Polydontes	3				
Parthena		5		2	
Luquillia				3	
Eurycratera			1		
Strobilops			1		Mexico; United States.
Bulimulus	3	6	3	7	Tropical America; Lesser Antilles.
Simpulopsis		1		1	Mexico and northern South America.
Liguus	4	1			Florida, 1 species.
Orthalicus	1		1		Mexico to Brazil.
Cylindrella:					
Apoma	6		2		7 in Mexico; 4 in Guatemala; 3 in northern South America.
Thaumasia	1	22	25		
Callonia	2				
Gonglyostoma	91	4	6	2	
Mychostoma	6	5	6		
Strophina		1			
Anoma			8		
Trachelia	24	3		1	
Vendryesia*		2	7		
Macroceramus	34	14	3	3	1 in Guatemala; 3 in Mexico; 1 in Texas; 1 in Honduras; 2 in Florida.
Pineria	2			1	2 in Isle of Pines; 1 in St. Bartholomew; 1 in Guadeloupe.
Pseudobalea	2	1		1	
Peltella				3	Brazil.
Stenogyra	6	1	7	2	Warm regions in general.
Subulina	7	2	14	2	Warm regions.
Opeas	8	4	3	6	Tropical America; a few in East Indies.
Spiraxis	2	2	11	1	17 species on American Continent; a few in Old World.
Glandinella	1				
Melaniella	7				St. Thomas; Bahamas; Florida; Trinidad.
Leptinaria			1	3	South America, 6; Guatemala, 2; Lesser Antilles.
Pupa	2	3	5	1	World-wide.
Vertigo	5		2	1	Do.
Cerion	19	3		2	Bahamas; 1 in Florida; a few in Cayman Islands; 1 in Curacoa.
Geostilbia	1	1	2		
Clausilia				1	Europe; Asia; Peru.
Succinea	11	5	4	3	World-wide.
Vaginula	2	2	2	1	Widely distributed.
Cionella	1				Do.
Carychium			1		Do.
Limnæa	2	1	1	1	Do.
Planorbis	8	6	7	10	Do.
Ancylus	3	2	1	2	Do.

**Lia* and *Leia* are both preoccupied, and at the suggestion of Mr. T. D. A. Cockerell I gladly bestow on this beautiful genus the name *Vendryesia*, in honor of Mr. Henry Vendryes, of Kingston, Jamaica, who has made a lifelong study of the shells of that island.

Distribution of genera of West Indian land and freshwater mollusks—Continued.

Genera and groups.	Cuba.	Haiti.	Jamaica.	Puerto Rico.	Elsewhere.
Gundlachia	1	.....	.....	.....	Widely distributed.
Physa	2	.....	1	1	Do.
Aplexa	1	1	1	1	Do.
Potamopyrgus	1	.....	.....	1	Do.
Hydrobia	2	.....	2	.....	Do.
Vivipara	1	.....	.....	.....	Do.
Pachycheilus	4	.....	1	.....	American tropics.
Hemisinus	.....	.....	1	.....	Do.
Ampullaria	3	.....	1	.....	Do.
Valvata	.....	.....	1	.....	Widely distributed.
Neritina	4	3	5	2	Warm regions.
Proserpina	2	.....	4	.....	Mexico, 2.
Geomelania†	4	1	21	.....	
Neocyclotus:					
Neocyclotus	1	.....	1	.....	24 species on mainland from Mexico to Venezuela; Lesser Antilles.
Ptychocochlis‡	.....	.....	32	.....	
Rolleia	.....	1	.....	.....	
Crocidopoma	1	3	1	.....	
Megalomastoma	13	1	3	.....	Guatemala, 1.
Choanopoma	24	19	12	3	2 in Mexico.
Jamaicia	.....	.....	2	.....	
Ctenopoma	30	1	2	.....	1 in Florida; several in Bahamas.
Cistula	15	3	3	3	4 in Central America; 2 in Yucatan; 2 or 3 in South America (?); a few in Lesser Antilles.
Chondropoma	57	19	.....	4	Florida, 1; Equador, 1; Venezuela, 4; Mexico, 2; Central America, 3.
Diplopoma	1	.....	.....	.....	
Licina	1	3	.....	.....	
Tudora	7	5	17	.....	1 in Mexico; 1 or 2 in South America and the Leeward Islands.
Colobostylus	4	5	14	.....	1 in Honduras; 1 in Trinidad.
Blæsospira	1	.....	.....	.....	
Xenopoma	1	.....	.....	.....	
Adamsiella	1	.....	12	.....	2 in Guatemala; 3 in South America (?)
Eutrochatella	21	6	6	.....	1 in Honduras.
Alcadia	9	4	14	.....	A few in the Bahamas.
Helicina	58	23	16	9	World-wide in the tropics.
Lucidella	.....	1	4	.....	
Stoastoma	.....	1	80	1	
Sphærium	1	.....	1	1	World-wide.
Pisidium	2	.....	1	.....	Do.

† The species included in this genus, from Cuba and Haiti, were placed by Pfeiffer in *Truncatella* in a section which he called Montanæ (Mon. Pneum. Viv. Sup. II, p. 3), on account of their habitat in the mountains, away from the sea. Crosse has placed them in the sub-genus *Blandiella* (J. de Couch, XXX., p. 303) and states that, so far as is known, they differ from true Geomelanias only in the absence of a prolongation of the anterior part of the aperture. Some of the latter have this development at the base of the aperture, others at the right margin, and a few are scarcely, if at all, produced. *B. filicosta*, and *lirata* of Cuba are in the National Museum collection, and some specimens of these show this peculiarity to a slight degree, and I should pronounce them both to be Geomelanias on conchological evidence without the slightest hesitation.

‡ *Platystoma* Klein, applied by Fischer and Crosse in a generic sense to this group of peculiar Jamaican forms typified by *Neocyclotus jamaicensis* Chemnitz (Miss. Sci. au Mex. 7th part, p. 149), has been several times preoccupied. Klein was not a binomial author.

The name, therefore, can not stand, and I would substitute that of *Ptychocochlis* in place of it. The group on conchological characters seems to be nearly related to *Neocyclotus* Fischer and Crosse, in which, for the present, I think it had better remain as a subgenus.

It will be seen from the above table that no less than 37 genera are either peculiar to the Greater Antilles or have here their principal developement. These are *Thysanophora*, *Sagda*, *Zaphysema*, *Polymita*, *Hemitrochus*, *Pleurodonte*, *Cepolis*, *Liguus*, *Cylindrella*, *Vendryesia*, *Macroceramus*, *Pineria*, *Glandinella*, *Melaniella*, *Cerion*, *Proserpina*, *Geomelania Neocyclotus*, *Rolleia*, *Crocidopoma*, *Megalomastoma*, *Choanopoma*, *Jamaicia*, *Ctenopoma*, *Cistula*, *Chondropoma*, *Diplopoma*, *Licina*, *Tudora*, *Colobostylus*, *Blæsospira*, *Xenopoma*, *Adamsiella*, *Eutrochatella*, *Alcadia*, *Lucidella*, and *Stoastoma*, and they are represented in this region by

1,023 species. Seven of these genera are found in all four of the larger islands; *Thysanophora*, *Hemitrochus*, *Pleurodonte*, *Cylindrella*, *Macroceramus*, *Choanopoma*, and *Cistula*, with 514 species in this region; while twelve more, *Sagda*, *Cerion*, *Geomelania*, *Megalomastoma*, *Crocidopoma*, *Ctenopoma*, *Chondropoma*, *Tudora*, *Colobostylus*, *Eutrochatella*, *Alcadia*, and *Stoastoma*, represented by 401 species, are found in three or a majority of the islands.

Of the remainder of the Greater Antillean genera nine are found in two islands, *Cepolis*, *Liguus*, *Vendryesia*, *Pineria*, *Proserpina*, *Neocyclotus*, *Licina*, *Adamsiella*, and *Lucidella*, with only 84 species, and 9 are limited to a single island, *Zaphysema*, *Polymita*, *Glandinella*, *Melaniella*, *Rolleia*, *Jamaicia*, *Diplopoma*, *Blæsospira* and *Xenopoma*, with but 24 species.

Of the widely distributed genera whose metropolis is elsewhere, and which we may suppose have entered this region by some of the means I have previously mentioned, 16 are found in all four of the islands, represented by 371 species; 6 are met with in three of the islands, with 33 species; 10 in two of them, with 31 species, while only 7 genera are found limited to a single island, six of them having but 1 species each, and one having 13 species.

From the above figures the remarkably homogeneous character of the terrestrial and fluviatile molluscan fauna of the Greater Antilles may be understood, for out of 78 genera here represented by about 1,400 species, 22, nearly one-third of them, are met with in all four of the islands, having 885 species, or more than 60 per cent of the whole number; and 18 others are common to three of the islands, with 434 species. It will thus be seen that nearly all the important genera have a general distribution in this region, and are largely represented in species.

Now, while it is true that certain genera and minor groups are peculiar in some cases to a single island, as, for example, the typical Pleurodontes, *Zaphysema*, and *Ptychocochlis* to Jamaica, *Polymita*, and *Diplopoma* to Cuba, *Rolleia* to Haiti, or *Luquillia* to Puerto Rico, yet it is no doubt equally true that the relationship between them and certain groups found on other islands of this archipelago is quite close. The toothless or slightly toothed Pleurodontes of Jamaica are not very far removed from *Carocolus; Dialeuca*, also a Jamaican group, is very closely allied to the Cordyas of Cuba and Haiti, and Pilsbry has shown* that *Zaphysema*, *Thysanophora*, and *Sagda* are quite intimately related. Such alliances between the species of the different islands are very common, especially among the Helicidæ, *Cylindrella*, *Macroceramus*, the Alcadias, and Helicinas. In short, there can be but little doubt that all or nearly all the special groups confined to one or more of these islands are much more nearly related to other Greater Antillean groups than to those of any other part of the world.

This period of elevation in the West Indies was followed by one of

* Manual of Conchology, second series, IX, p. 60.

subsidence. It continued until only the summits of the mountain chains were above the level of the sea, and probably reached its culmination sometime in the Miocene period. During this time such groups of terrestrial and fluviatile mollusks as then existed were driven higher and higher up the mountain sides, and crowded into ever-narrowing quarters, and it is quite probable that some of the genera and many species were drowned out or perished for want of room and food. As Puerto Rico consists mostly of low, comparatively level land, with a single not very lofty mountain range, it is possible that the limited area left above the sea accounts for the absence of many genera found in the other islands, and which may have been abundant within its borders at the time of a former land connection.

During a visit to Jamaica the past winter the writer, in company with Mr. John B. Henderson, jr., of this city, obtained three large boxes of fossil marl, which we dug from a bed some two feet in thickness, in what is called the White Limestone Series of the Miocene at Bowden, near the east end of the island. This marl, which was brought to the Smithsonian Institution, has proven to be astonishingly rich in fossils, especially marine mollusca, and in it were found six species of land shells, consisting of a *Ptychocochlis*, a *Lucidella*, a *Pleurodonte*, a *Thysanophora*, an *Opeas*, and a *Succinea*. The first two and the last named were in good condition, and nearly perfect; the *Pleurodonte* was represented by two fragments, an apex with three whorls, and an aperture containing the teeth. The *Thysanophora* was in a crumbling condition and the two specimens of *Opeas* were broken. At Bogwalk, at the foot of a Miocene limestone ledge, the writer found fragments of fossil Sagdas, but not in a condition for identification. These shells were no doubt washed down by rains and streams and deposited in the marine strata, as we found in several cases an abundance of recent forms in the bays and thrown up along the shores. I consider the evidence of these fossil land shells with regard to the past history of the groups, and of the Greater Antilles, quite important. They show that in the Miocene period, at a time when perhaps all but the summits of these islands was submerged, several of the great characteristic groups of this region were in existence; that no change whatever has taken place in their characters beyond the differentiation of species; for, with the exception of the *Succinea*, which does not seem to differ from *S. latior*, an abundant species on this land, and the *Opeas* (*O. striata*, also very common) all these forms are probably extinct. The Bowden beds are believed to be the equivalent of the Chattahoochee formation of the southeastern United States, and were no doubt laid down in the earlier part of the older Miocene. The stratum from which these fossils were dug is only a few feet above sea level, and is overlaid with shales and marls to the summit of the hill, some 300 feet above. *Succinea* is world-wide as well as *Opeas*, and neither are distinguished in the West Indies by any special characters. *Thysanophora* is distributed throughout the Greater

Antilles, and has a few representatives on the mainland, the Bahamas, and the Lesser Antilles.

All the species of the subgenus *Ptychocochlis* agree very closely in their corrugated shells and the character of the operculu; and this group, together with the typical Sagdas and Pleurodontes, are confined to the island of Jamaica. It is not unreasonable to suppose that during the period of general elevation certain forms from the widely distributed genera of land and fresh-water mollusks crossed over to the Greater Antilles from the continent, that such genera as *Glandina*, *Streptostyla*, and others whose metropolis is on the mainland also migrated across, and that species of a number of genera whose greatest development is in this archipelago spread out and reached the shores of America. Most of the subordinate groups of *Glandina* and *Streptostyla*, and several of those of *Cylindrella* were then in existence, for we find their species to-day alike on the continent and the different islands of the archipelago. During the subsidence, which must have been gradual, Jamaica was first separated from the rest of the Greater Antilles, and between the time of separation and the date of laying down the Bowden marl it is probable that the typical Pleurodontes and *Ptychocochlis* were developed from some less differentiated, ancestral stock. The separation of Cuba, which occurred sometime after that of Jamaica, gave rise to the special Cuban groups, or no doubt to such of them as are dominant and abundantly represented on the island; while Haiti and Puerto Rico, being longer united, have a much more closely related fauna.

In his catalogue of the terrestrial and fluviatile mollusks of Haiti* Crosse divides the island into four subregions—one on the north, taking in the Sierra de Monte Christi; another south of this, extending from the Mole St. Nicholas through the island to Cape Engaño; a third embracing the southeast peninsula, and the fourth situated between the arms of the Y, and he remarks significantly:

> It is remarkable that the purely geographical considerations on which some authors regard Haiti as a link that formerly united the four islands are confirmed and corroborated by the existence in each of the four regions of a kind of small malacological fauna, independent of species which are scattered throughout the island and which comprise the common fauna.

Every species of *Colobostylus* known on the island, the group *Thaumasia* of the genus *Cylindrella*, and the representatives of *Vendreysia*, *Stoastoma*, and *Lucidella*, all of which have their metropolis in Jamaica, are found in the southwest peninsula, while the great Helices of Cuban groups are met with in the northwestern arm of the island, and the species of the east end show an alliance with the forms of Puerto Rico.

In the Miocene silex beds of Tampa, Florida, there have been found a number of land shells which probably belong to the same fauna as that which existed during that epoch in the Greater Antilles. These consist of six Helices of the section *Plagioptycha*, a group at present

* Jour. de Conch., XXXI, 1891, pp. 195, 197.

confined to Haiti, Puerto Rico, and the Bahamas, a *Cerion*, not differing greatly in appearance from *C. incana*, but wholly destitute of teeth, a *Cylindrella* much like some of the recent Cuban species, and four *Bulimulus*. The Miocene silex beds of Tampa and the Bowden marl are believed by Dr. Dall to be nearly or quite synchronous. These forms, or their ancestors, may have migrated from Cuba across the Bahama plateau and what is now the bed of the Gulf Stream. An elevation of 344 fathoms would join the Bahamas to Florida.

If, then, a land connection existed between the Greater Antilles and Central America during the period of elevation it would not be difficult for species of *Glandina*, *Streptostyla*, *Volutaxis*, *Polygyra*, *Bulimulus*, *Orthalicus*, *Neocyclotus*, *Ampullaria*, *Pachycheilus*, and *Hemisinus*—genera whose metropolis is on the continent—to pass from the latter to the former, or forms of widespread genera to migrate across to the islands. And on such a landway it seems more probable that the species of *Thysanophora*, *Cylindrella*, *Macroceramus*, *Megalomastoma*, *Choanopoma*, *Cistula*, *Chondropoma*, *Tudora*, *Colobostylus*, *Adamsiella*, and *Eutrochatella*, passed over to Mexico and Central America than that they were carried by currents or any of the other agencies I have mentioned.

In the present state of our knowledge it is a little difficult to tell how long the period of subsidence lasted, and we can not determine with certainty how much of the area of the islands was submerged. An elevation of some 3,000 feet above present sea level probably marks the limit in Jamaica, as the stratified Miocene rocks are believed to reach to about that height.

In another part of this paper I have attempted to show something of the close relationship of the molluscan faunas of the different islands of the Greater Antilles. Jamaica, by the evidence of its land snails, stands the most isolated of any of the islands; Cuba is the next most so, while those of Haiti and Puerto Rico are much more nearly related to each other than to those of either of the first two. About 20 genera and minor groups are confined to or have their metropolis in Jamaica; a like number belongs to Cuba, 7 to Haiti, and 1 to Puerto Rico. Of the special Jamaican groups, *Sagda*, *Pleurodonte* restricted, *Geomelania*, *Colobostylus*, *Tudora*, *Ptychocochlis*, *Adamsiella*, *Alcadia*, *Lucidella*, and *Stoastoma* are abundantly represented throughout the island, and highly characteristic, forming the major part of the land-snail fauna. In Cuba, *Liguus*, *Macroceramus*, *Cerion*, *Choanopoma*, *Ctenopoma*, and *Chondropoma* are generally distributed and characteristic; while *Carocolus* and *Parthena* stand in the same relation to the Haitian fauna.

Now, as bearing directly on this subject, it may be mentioned that the strait between Haiti and Jamaica is deeper than that between any of the other islands, being nearly 1,000 fathoms in depth, that between Cuba and Haiti is slightly more shallow, being only about 875 fathoms,

while the one between the latter island and Puerto Rico carries but 260 fathoms. Supposing these islands to have been united at a former time, then during a period of gradual subsidence, Jamaica would be separated sometime before the rest of the Antillian island would be broken up, then Cuba would be isolated, while Haiti and Puerto Rico would remain united for a longer time. The distribution and character of the land-snail faunas of these islands agree exactly with just what would be the result of such a subsidence and separation.

When this region was revisited with a period of elevation—a period which seems to be still in progress—a large area of limestone was uncovered, which, with a warm climate and an abundant rainfall, was soon overspread with forests and cut into innumerable gullies and ravines, furnishing the very best of conditions for the development of forms, and the multiplication of individual land-snails, and the genera and groups which had been huddled together on the reduced peaks of these islands gradually spread out and took possession of the new territory. I regard these facts as the probable explanation of the enormous development of terrestrial molluscan life in the Greater Antilles.

RELATIONS OF THE LAND AND FRESH-WATER MOLLUSCAN FAUNA OF THE GREATER ANTILLES WITH THAT OF MEXICO AND CENTRAL AMERICA.

It is, I believe, acknowledged that the terrestrial and fluviatile molluscan fauna of the Greater Antilles has certain rather intimate relationships with that of the adjoining mainland of Central America and Mexico. The great genus *Glandina*, which at present has its metropolis in the latter region, is represented in the archipelago by a number of species almost equal to that found on the continent. Only a single recent species exists outside of the warmer parts of America—*G. algira* of southern Europe and northern Africa—though the genus is abundantly represented in the Tertiary beds of Europe. Not only is it found in the Greater Antilles, but several of the minor groups are there represented. The section *Oleacina* is mostly Antillean, but has 4 species on the mainland; *Varicella* has 7 on the continent and 21 in the islands; *Melia* has two species in Mexico and 13 in the archipelago, and the section *Glandina*, which is abundantly represented on the mainland, has a single species in Haiti. *Streptostyla*, another Mexican genus, has 9 Antillean species—4 in Cuba, 2 in Haiti, and 3 in Puerto Rico. *Volutaxis*, a third group belonging to the American mainland, has 1 species in Cuba and another in Haiti, and *Orthalicus*, whose metropolis is in the warmer parts of America, has 1 species common to Cuba and Jamaica.

Fischer and Crosse* divide the Stenogyridæ into two subfamilies—

* Miss. Sci. au. Mexique, 7th part, p. 585.

Caecilianellinæ, with *Geostilbia* and *Caecilianella*, and Subulininæ, with *Azeca*, *Ferussacia*, *Loweia*, *Opeas*, *Rumina*, *Stenogyra*, *Pseudobalea*, *Melaniella*, *Spiraxis*, *Leptinaria*, *Subulina*, and *Glessula* as genera. Among these *Opeas*, though represented in the isles of the Indian Ocean, the East Indies, and Polynesia, has its greatest development on the American Continent from Mexico to Venezuela, but it also has several species in the Greater Antilles; while *Spiraxis*, another genus of this family, mostly American, is about equally represented in this archipelago and on the continent. The genus *Leptinaria*, as defined by Fischer and Crosse, is confined to America, and includes all the species of the Antilles hitherto placed in *Toruatellina*, the latter being by them restricted to the Old World. The former is about equally represented in middle America and the Greater Antilles. *Simpulopsis* is another genus with its metropolis in America, and with a distribution much like *Leptinaria*. To these may be added the continental *Bulimulus*, with 74 species in Central America and Mexico, which is well represented in Cuba, Haiti, Puerto Rico, and Jamaica, and *Polygyra* (restricted), with its metropolis in Mexico and the southern United States, but which inhabits Cuba and Jamaica.

On the other hand, we find that the peculiar terrestrial molluscan fauna of this archipelago has, as Bland has expressed it, "made a strong impression" on the mainland. The following table will show the continental distribution of these Antillean genera:

Distribution of genera of Antillean land mollusks.

Genus or group.	Species in Greater Antilles.	Species of Mexico.	Species of Central America.	Species found elsewhere.
Thysanophora	52	3?	.....	2 in Southern States.
Cepolis	5	.....	1	1 in Peru.
Hemitrochus	12	1?	.....	Several in the Bahamas.
Macroceramus	54	3	.....	2 or 3 in Lesser Antilles.
Cylindrilla	168	7	4	3 in northern S. Am. and Lesser Ant.
Proserpina	6	2	.....	
Neoeyclotus	34	2	2?	Northern South America. 20 sp.
Megalomastoma	17	.....	1	
Choanopoma	58	2	.....	
Tudora	29	1	.....	1 or 2 in South America; Leeward Islands.
Chondropoma	80	2	3	South America, 4.
Colobostylus	23	.....	1	1 in Trinidad.
Cistula	24	2	4	2 in South America(?); a few in Lesser Antilles.
Adamsiella	13	.....	2	3 in South America(?).
Eutrochatella*	33	.....	1	

* Several other species of *Pneumonopomata* are found in Mexico, Central and South America, which have been referred to *Adamsiella*, *Cistula*, *Tudora*, and *Chondropoma*, which doubtfully belong to these genera.

Among the fluviatile mollusks there are no genera common to the two regions whose metropolis is in either of them, save *Pachycheilus* and *Hemisinus;* but quite a number of species inhabit both the mainland and the archipelago. The same is true of a good many terrestrial forms. The following list gives these species and their distribution:

Land and fresh-water mollusks i ..biting the Greater Antilles and the continent.

Species.	Cuba.	Haiti.	Jamaica.	Puerto Rico.	Mexico.	Central America.	South America.	Elsewhere.
Thysanophora incrustata, Poey.	×	.....	.....	.....	×	.....	.....	Texas; Florida.
Thysanophora plagioptycha, Sh.	.....	.....	.....	×	×?	.....	.....	Vieque.
Thysanophora dioscoricola, Ad.	.....	.....	×	×	×?	.....	.....	Vieque; Florida.
Zonites indentatus, Say	.....	×	.....	×	×?	.....	.....	United States.
minuscula, Binn	×	.....	×	×	×	.....	.....	United States; Bermuda.
gundlachi, Pfr	×	×	×	.....	.....	×	.....	Florida; St. Thomas.
arboreus, Say	×	.....	.....	.....	×	.....	.....	United States; Guadelupe.
Bulimulus liliaceus, Fer	.....	×	.....	×	×	×	.....	St. Kitts.
Macroceramus gossei, Pfr	×	.....	×	.....	×	.....	.....	Texas; Florida.
pontificus, Gld	×	.....	.....	.....	×	.....	.....	Florida.
Pupa contracta, Say	.....	.....	×	.....	×?	.....	.....	Texas; United States.
pellucida, Pfr	×	.....	×	×	×	.....	.....	Texas; Florida; Vieque; St. Thomas; St. John.
Vertigo ovata, Say	×	.....	.....	.....	×	.....	.....	United States.
Orthalicus undatus, Brug	×	.....	×	.....	×	×	×	Trinidad.
Subulina octona, Ch	×	×	×	×	×	×	×	Lesser Antilles.
Spiraxis subula, Pfr	×	.....	×	×	×	.....	.....	Mobile; Florida; Martinique; St. Thomas; Cochin China.
Opeas caracasensis, Reeve	.....	×	.....	.....	×	×	×	Grenada; Trinidad; Lesser Antilles.
Limnæa cubensis, Pfr	×	.....	×	×	×	×	.....	St. Croix; United States, as *L. umbilicata*, Adams.
Planorbis caribæus, Orb	×	.....	.....	×	×	.....	.....	
tumidus, Pfr	×	.....	.....	×	×	×	.....	Texas; Florida.
havanensis, Pfr	×	.....	.....	.....	×	×	.....	Bahamas.
Potamopyrgus coronata, Pfr.	×	.....	×	.....	×	×	.....	Guadelupe.
Neritina reclivata, Say	×	.....	.....	.....	×	×	.....	Texas; Florida.
punctulata, Lam	×	.....	×	.....	×	×	.....	
Carychium exile H. C., Lea	.....	.....	×	.....	×?	.....	.....	United States.
* Pisidium abditum, Hald.	×	.....	.....	.....	×	×	.....	Do.
Sphærium cubense, Pme	×	.....	.....	.....	×?	.....	.....	Texas; Florida.
Unio scamnatus, More	×	.....	.....	.....	.....	×	.....	
gundlachi, Dkr	×	.....	.....	.....	.....	×	.....	

*This species is distributed over nearly all the United States and as far south as Honduras: Prime states (American Corbiculidæ, p. 76), that *P. consanguineum*, Prime, of Cuba can scarcely be separated from *P. abditum* Hald., and on carefully comparing authentic specimens in the National Museum I believe them to be the same.

I am not prepared to believe that so extensive a relationship—the exchange of so many genera, subordinate groups, and species—could have been brought about merely by ocean currents and winds. Since the gulf stream was turned into its present course—probably during the later miocene, when the Isthmus of Panama was elevated—its tendency would be to sweep any species that might fall into it, from the Antilles or the continent, up into the Gulf of Mexico, and away from either shore. The prevailing winds of the region have no doubt been from the east-north-east in the past, as in the present, and would favor the landing of Antillean species in Yucatan, though their effect would be largely neutralized by the current. We find that very nearly as great a migration has taken place from the mainland to the archipelago as in an opposite direction. The depth of the Yucatan Channel would seem to preclude the likelihood of a former landway running west from Cuba, but the presence of *Streptostyla*, with eight species scattered through Cuba, Haiti, and Puerto Rico, and *Volutaxis* with two

species, one each in Cuba and Haiti, while neither of the genera are found in Jamaica, appears to favor a more northern as well as a southern landway.

RELATIONS OF THE GREATER ANTILLEAN LAND SNAIL FAUNA WITH THAT OF THE BAHAMAS.

I next pass to the relationship of the land snail fauna of the Greater Antilles with that of the Bahamas. On this extensive archipelago, with some 3,000 islands and an area of nearly 6,000 square miles, there are only about 80 species of land snails known. The climate of the islands is warm, the structure of most of them is coral limestone, and there is a plentiful rainfall, with sufficient vegetation to furnish shelter and food for an abundance of snail life; in fact the number of individuals is in many cases great. All the groups with the exception of the Mexican genus *Schasicheilus*, represented by a single species, are Cuban and Haitien, or are such as are found in those islands; and a number of the species are common to the Greater Antilles. In many genera, especially *Hemitrochus* and *Cerion*, there is an almost endless amount of variation, with few breaks sufficient for the proper separation of species. The islands of the Little and Great Bahama Banks being nearest to Cuba, and lying in the course of the currents that flow by that island, partake most largely of its fauna, while those to the north of Haiti bear more strongly the impress of its forms. Yet when we come to carefully consider the manner in which this archipelago must have been colonized with land snails, we need not be surprised at its comparative poverty of species, or that it has no peculiar genera. Whether in time past this area arose above the sea and had land connection with Cuba and Florida does not matter so far as its present terrestrial molluscan fauna is concerned. As the highest point in the archipelago is only about 300 feet above sea level it is quite probable that the entire Bahaman region was submerged during the general period of subsidence, and whatever species may have existed were doubtless destroyed. We may suppose that during the period of elevation which followed, as soon as these islands began to appear above the sea, and were fitted for the abode of land snails, those nearest to Cuba, Haiti, and the gulf stream received occasional stragglers which drifted across the not very wide channel.*

*The north-east trade winds, and the drift of the water of the Atlantic to the westward, force a strong current along between Haiti and the small, southernmost islands of the Bahamas. Part of this is carried through the windward passage between Haiti and Cuba into the Caribbean, the rest is pressed on past Great Inagua, and up the old Bahama Channel, and finally it mingles with the gulf stream. No doubt part of the water of that great ocean river, crowded in between Cuba, the Bahama Bank, and Florida, spreads out more or less to the eastward among the islands. Thus land snails washed into the sea on the north side of Cuba or Haiti would probably in some cases be carried out and landed among the Bahamas.

This migration by currents and in some cases, no doubt, by winds from the Greater Antilles to the Bahamas, has not been of long continuation, for the reason that the last elevation of this latter archipelago above the sea has been comparatively a recent one and therefore there has not been time for the formation of new genera or subordinate groups, and only for few valid species. Many of the forms are so slightly differentiated that they can not be separated with any degree of accuracy, and others have broken into endless variations, which may be taken as an indication that the region has not been very long colonized and that species are multiplying.

Had this land been connected with Cuba or Haiti since it was last elevated above the sea it is probable that it would now be far richer in genera and species than it is.

THE TROPICAL LAND AND FRESH-WATER MOLLUSCAN FAUNA OF SOUTHERN FLORIDA, AND ITS RELATION TO THAT OF THE GREATER ANTILLES, MEXICO, CENTRAL AND SOUTH AMERICA.

In southern Florida some 28 or more species of land and freshwater mollusks occur, nearly all of which are now living in Cuba, while a few belong in Mexico, 1 possibly in South America, 2 are found in the Bahamas, and 1 perhaps came from Trinidad.*

This terrestrial and fluviatile population of southern Florida is in all probability the result of recent migration, mostly by means of winds and currents. Most of the species are confined to the lower chain of keys or the extreme southern part of the peninsula. *Chondropoma dentatum* extends a short distance north of Cape Sable, *Bulimulus multilineatus* reaches Caximbas, and *Liguus fasciatus* has been doubtfully reported as far north as the Caloosahatchee River. *Guppya gundlachi* and the two *Macroceramus* no doubt extend their range to at least the middle of the State. *Bulimulus dormani*, *Polygyra cercolus*, *Planorbis tumidus*, and *Sphærium cubense* probably inhabit the entire peninsula, and *Ampullaria depressa*, which is a form of *A. caliginosa*, extends into Georgia.

*The following is a list of the species: *Thysanophora cæca*, Gup., Trinidad; *Thysanophora vortex*, Pfr., Cuba, Haiti, Puerto Rico, St. Croix, St. Thomas, Bermuda; *Thysanophora dioscoricola*, C. B. Adams, Jamaica, Puerto Rico, Mexico, Vieque; *Strobilops hubbardi*, Brown, Jamaica; *Hemitrochus varians*, Mke., Bahamas; *Polygyra cercolus*, Muhl, Bahamas, Bermuda, Cuba?; *Guppya gundlachi*, Pfr., Cuba, Puerto Rico, St. Thomas; *Orthalicus undatus*, Brug., Mexico, Jamaica, Trinidad, Central America; *Orthalicus melanochcilus*, Val., Mexico; *Liguus fasciatus*, Mull., Cuba; *Melaniella gracillima*, Pfr., Cuba, St. Thomas, Bahamas; *Subulina octonoides*, Orb., Cuba, Jamaica, Puerto Rico, Vieque, St. John, Barbados, Grenada, St. Thomas; *Spiraxis subula*, Pfr., Jamaica, Cuba, Barbados, Antigua, Puerto Rico, St. John, St. Thomas; *Macroceramus gossei*, Pfr., Cuba, Jamaica, Texas, Mexico; *Macroceramus pontificus*, Gld., Cuba, Mexico; *Bulimulus mariclinus*, Poey, Cuba; *Bulimulus dormani*, W. G. B., New Grenada?: *Bulimulus multilineatus*, Say, Yucatan, Guatemala, northern South America; *Cylindrella poeyana*, Orb., Cuba; *Cylindrella jejuna*, Gld., Cuba; *Cerion incana*, Binn., Cuba; *Helicina subglobulosa*, Poey, Cuba; *Chondropoma dentatum*, Say, Cuba; *Ctenopoma rugulosum*, Pfr.?, Cuba; *Planorbis tumidus*, Pfr., Cuba, Mexico, California; *Ampullaria caliginosa*, Rve., Mexico; *Gundlachia ancyliformis*, Pfr., Cuba; *Sphærium cubense*, More., Cuba; Mexico, Texas.

It scarcely seems necessary to enter into any argument to show that these tropical forms now found in Florida are not the lineal descendants of the Helices and *Bulimulus*, the *Cylindrella* and *Cerion* or other species of the Miocene silex beds of Tampa. The living land and freshwater mollusks of Florida of tropical origin are absolutely identical with forms at present found in Cuba, Jamaica, and the continent, while those of the Tampa beds are all extinct, and we can not for a moment suppose that their descendants would be specifically identical with Antillean and Mexican forms that had come from another line of descent. I believe that the present species have been colonized but a short time in Florida, and the fact that, although the soil, contour, and climate of the country are quite different from those of tropical America, not a single introduced form has as yet changed specifically, and only one possibly varietally, is strong evidence in this direction.

It is most likely that tropical land snails have been cast on the shores of the peninsula with the jetsam and flotsam of the sea ever since the Gulf Stream has had its present course, an amply sufficient length of time for the development of species from some of the original wanderers, as that great ocean river was probably turned into the Gulf of Mexico and past the State of Florida during the latter part of the Miocene, when the Isthmus of Panama is believed to have been raised and North and South America were joined together. I would suggest that the reason why no such new species exist there might be that in all probability any forms that were colonized on the peninsula prior to the time of the Glacial Epoch were destroyed by the change of climate, which swept out of existence, and drove to the southward so much of the animal and vegetable life of North America.* The presence of a great cap of ice coming down to the latitude of 40°, within 10° or 600 miles of the northern part of the State, would, especially at certain times in winter during the prevalence of northerly winds, be likely to destroy by cold such species as might be landed by the Gulf Stream. Even now, with a much milder climate than this region possessed during Glacial times, an occasional unusually severe winter almost annihilates the tropical fishes of this region, and kills in part, or even entirely, many forms of West Indian vegetation as far south as Cape Sable. Several of these Cuban land snails are only met with on the lower keys, an area practically free from frost.

We know that a very slight difference in latitude or climate may often set a bound on the distribution of different forms of animal and vegetable life. Thus, nearly all the immigrant West Indian vegetation now found in Florida is confined to the southern half of the peninsula, though there are no apparent reasons so far as soil, food, and moisture

* It may be claimed that the continual addition of fresh individuals from Cuba by the currents has kept the species already landed in Florida from becoming specifically changed. But the same addition of fresh specimens must have occurred in the Bahamas and yet we there find a number of new species and countless varieties.

are concerned why it should not extend north indefinitely. The tropical land snails of Mexico come north in the low lands for the most part only to the northern border of that Republic, and many other instances of a like restriction by climate could be given. It is probable that a decrease of a very few degrees in temperature would destroy the Antillean land and fresh-water mollusks in Florida.

It is believed by many of our ablest glacialists that the Ice Age lasted down to within from 6,000 to 10,000 years of the present, and the period which has elapsed since its close would probably be too short to allow for any considerable variation in mollusks. The Bahamas being protected on the north and west by the Gulf Stream, and lying generally in a lower latitude, no doubt enjoyed during the Glacial Epoch a milder climate than Florida, and have been peopled longer with immigrant forms; a sufficient time to allow for the development of numerous varieties and species, but no groups or genera.

I think there need be no difficulty in accounting for the presence of tropical land and fresh-water mollusks in Florida by means of the transporting agency of the sea. The Gulf Stream sweeps up past northern South and Central America, part of it eddying around in the Gulf of Mexico. A branch of it, however, flows along the north shore of Cuba, and by the shoal in latitude 24° is thrown in close to the lower chain of Florida Keys. Alexander Agassiz says:*

> The curve of the Florida reef along the Gulf Stream is due in great measure, as Hunt shows, to a counter current along the reef running westward. This current is known to all navigators, and though ill defined at Cape Florida becomes stronger and wider as it goes west. It has a width of at least 10 miles at Key West and 20 miles at Tortugas. This is clearly shown by the mass of surface animals driven along upon this westerly current by the southeasterly winds. The tides set strongly across the reefs and through the channels between the keys, the flood running north and the ebb south.

Mollusks washed down with trees, bamboos, or masses of drift from the northern shore of Cuba would be swept along by the strong current of the Gulf Stream to the eastward and northward, and many of them, carried by the southeast winds into this counter current, might be landed by the inflowing tide among the lower keys within a few days after leaving their native island. Species from Honduras might at long intervals be drifted by westerly winds across to the eastern part of the Gulf Stream, and so be carried around and landed in the way I have described; or they might possibly sometimes survive a passage around the eddy in the gulf. The fact that there are more forms from Cuba found in Florida than there are from Middle America, and that only a single very doubtful South American species is known in that state,† illustrates the comparative difficulty which these wanderers

*Three cruises of the Blake, I, p. 57.

†*Bulimulus dormani*, W. G. Binney, is thought to be the same as *B. maculatus*, Lea of Cartagena, Colombia, but this is not certain. *B. multilineatus*, Say, formerly believed to be an immigrant from South America, is now known to be found in Central America and Yucatan.

experience in being drifted to our shores. I may mention in passing that every strictly Cuban species—I think without exception—now known to be living in Florida is an inhabitant of the western end of the island, and most of them are known to have a general distribution throughout the western part of it, and especially on its northern shore.

RELATIONS OF THE TERRESTRIAL AND FLUVIATILE MOLLUSCAN FAUNAS OF THE GREATER ANTILLES AND THE WINDWARD ISLANDS.

A careful examination of the lists of genera, subordinate groups, and species of these two areas will reveal the fact that while there is a relationship between the two faunas it is not nearly so close as the one between the faunas of the former region and the continent.

Land Snails common to Puerto Rico and the Lesser Antilles.

Species.	St. Kitts.	Barbuda.	Antigua.	Guadeloupe.	Dominica.	Martinique.	St. Lucia.	St. Vincent.	Barbados.	Tobago.	Grenada.	Trinidad.
Vaginula occidentalis, Guild	....	....	....	×	....	×	....	×	....	....	....	....
Thysanophora vortex, Pfr	....	....	....	....	....	....	....	....	×	....	....	....
Bulimulus lilacinus, Fer	×	....	....	....	....	....	....	....	....	....	....	....
fraterculus, Fer	×	....	....	×	....	....	....	....	....	....	....	....
virgulatus, Fer.*	....	....	....	....	....	....	....	....	....	....	....	....
exilis, Gm. †	....	×	....	×	×	....	....	....	×	....	....	....
Pineria viequensis, Pfr	....	....	....	....	....	....	....	....	....	....	....	×
Opeas subula, Pfr. ‡	....	....	×	....	....	....	....	....	×	....	×	....
goodalli, Mill	....	....	....	×	....	....	....	....	×	....	....	....
Subulina octona, Chem	....	....	×	×	....	....	....	....	×	....	....	×
octonoides, C. B. A	....	....	....	....	....	....	....	....	....	....	×	....
Leptinaria antillarum, Shutt	....	....	....	×	....	....	....	....	×	....	....	....
Pupa pellucida, Pfr	....	....	....	....	....	....	....	....	×	....	....	....
Succinea approximans, Shutt	....	....	....	....	....	....	....	....	....	....	....	....

* Also found in the island of Buen Ayre, of the Leeward Group.
† French Guiana also.
‡ Several of these Stenogyridæ and some other species have probably been introduced through the agency of man.

Fresh-water Mollusks common to Puerto Rico and the Lesser Antilles.

Species.	Guadeloupe.	Martinique.	Dominica.
Planorbis guadaloupensis, Sowb	×	×	....
schrammi, Crosse	×	....	....
lucidus, Pfr	×	....	....
Ancylus beani, Bourg	×	....	....
Aplecta sowerbyana, A. d'Orb	×	....	....
Potamopyrgus coronata, Pfr	....	....	×

From the above lists it will be seen that there are 14 species of terrestrial and 6 fluviatile mollusks common to Puerto Rico and one or more islands of the Lesser Antilles, while no less than 24 land mollusks belong to that island and some of the other Greater Antilles, and 13 fresh-water species. The following tables show the specific relationship between these molluscan faunas of Puerto Rico and the other islands

of the more northern group; all of them being found in the last-named island:*

Land Mollusks common to Puerto Rico and other Greater Antillean Islands.

Species.	Cuba.	Haiti.	Jamaica.	Elsewhere.
Vaginula occidentalis, Guild	×	×		Guadelupe; Martinique; St. Vincent.
Zonites gundlachi, Pfr	×	×	×	Florida.
minusculus, Binn	×		×	United States; Mexico.
Glandina terebraformis, Shutt		×		
Thysanophora vortex, Pfr	×	×		Florida; Barbados.
dioscoricola, C. B. Adams.			×	Florida.
euclasta, Shutt	×			
Pleurodonte margmata, Gmel	×	×		
Bulimulus nitidulus, Pfr	×	×	×	
liliaceus, Fer		×		
exilis, Gmel		×		
Pseudobalea domingnensis, Pfr	×	×		
Cylindrella pallida, Guild			×	
Opeas subula, Pfr	×	×	×	Lesser Antilles; Florida.
goodalli, Mill	×		×	Lesser Antilles.
Subulina octona, Cham	×	×	×	Mainland; Lesser Antilles.
octonoides, C. B. Adams	×	×	×	Florida; Mexico; Lesser Antilles.
Spiraxis paludinoides, d'Orb	×		×	
Stenogyra terebraster, Lam	×			
Pupa pellucida, Pfr	×	×	×	Texas; Mexico; Florida; Lesser Antilles.
hexodon, C. B. Adams			×	
Cerion striatella, Fer	×	×		
microstoma, Pfr	×	×		
Succinea riisii, Pfr		×		
Helicina phasianella, Sowb		×		

Fresh-water mollusks common to Puerto Rico and other of the Greater Antilles.

Limnæa cubensis, Pfr	×			
Planorbis guadelupensis, Sowb	×			Mexico; Guadelupe.
tumidus, Pfr	×			Mexico; Texas; Florida.
riisii, Dkr			×	
refulgens, Dkr		×	×	
haldemani, C. B. Adams			×	
lucidus, Pfr			×	Guadelupe.
macnabianus, C. B. Adams			×	
circumlineatus, Shutt		×		St. Thomas.
albicans, Pfr	×			Do.
Ancylus obscurus, Hald			×	St. Thomas; United States.
Aplecta sowerbyana, d'Orb	×		×	St. Thomas; Guadelupe.
Potamopyrgus coronata, Pfr			×	Guadelupe; Martinique; Central America; Mexico.

It will be seen that so far as species are concerned the relationship between the land and fresh-water mollusks of Puerto Rico is much closer with the Greater than with the Lesser Antilles. It is, however, among the genera and minor groups that the break in the molluscan faunas of the two archipelagoes is most noticeable. Among the Helices the genus *Pleurodonte*,† which includes all the sections of the old and well known *Carocolus*, is distributed throughout the West Indies, northern South America, and Central America. The section *Carocolus*, consisting of lenticular toothless species, is confined to the Northern Archipelago, and is found in Cuba, Haiti, and Puerto Rico. The section

* *Helix nemoralina* is common to Haiti, St. Thomas, St. John, Tortola, and the Virgin Islands, but is not found in Puerto Rico.

† I follow essentially Pilsbry's arrangement of the West Indian Helices, in IX., series 2, pp. 54 and 84, and V., p. 5, Manual of Conchology.

Pleurodonte, better known as *Lucerna*, is limited to Jamaica, as is *Euryceratera*. The section *Polydontes* is Cuban; *Parthena* and *Luquillia* are confined to Haiti and Puerto Rico, while *Gonostomopsis*, with a single species, belongs in Martinique, and *Caprinus*, better known as *Dentellaria*, is a characteristic group of the Lesser Antilles, extending into South America, but is not found in the Greater Antilles. *Thelidomus* with a metropolis in the Greater Antilles has three species in the Lesser Antilles and South America. Not a species of the genus *Pleurodonte* is common to the two regions.

Another great genus found abundantly in all the islands of the Northwestern Archipelago, *Hemitrochus*, is absolutely wanting in the Windward Islands, as are also the smaller Cuban genus *Polymita*, the Jamaican genera *Sagda*, *Lucidella*, and *Neocyclotus*, and *Cepolis* of Haiti and Puerto Rico; though the latter genus has a single species in Central America, and another in Peru.

Macroceramus,* *Liguus*, *Cerion*,† *Vendreysia*, *Geomelania*, *Proserpina*, *Ctenopoma*, *Adamsiella*, *Megalomastoma*, *Colobostylus*, *Alcadia*, *Stoastoma*, and *Eutrochatella*, Greater Antillean genera, are entirely wanting in the Lesser group; while *Cylindrella*, *Glandina*, *Cistula*, *Choanopoma*, *Choudropoma*, and *Tudora*, all highly characteristic of the Northwestern Archipelago are but feebly represented by a few stragglers, mostly in the northern end of the chain. Three genera only are peculiar to the Windward Islands; two with a single species each; *Rhodonyx* in Martinique; *Amphibulima* in Dominica, Guadeloupe, and St. Kitts; and *Pellicula* with two species in Guadeloupe.

The fact of the rather recent formation of these northern volcanic islands, built upon an old submarine plateau, that of the comparative poverty of the species and genera of this archipelago, and of their slight relationship to those of the northwestern group, all go to indicate that the Anegada Channel has not in the lifetime of the present land-snail fauna been bridged. A few species, however, have passed, no doubt by way of the sea or other means, from one group to the other, more from the northern islands to the southern than the reverse, as might be expected from the comparatively richer fauna of the former. The current which flows from the Atlantic through this channel would not probably favor the drifting of species from either archipelago to the other, and this with the prevailing wind from the east-northeast would naturally carry most of the land snails washed into the sea out into the open water of the Caribbean, where they would perish.

I do not think that anyone who at all carefully studies the land and fresh-water molluscan fauna of the Lesser Antilles can doubt that it is

* One species *M. signatus* is found in Anguilla. This island and St. Bartholomew having each only a few species, though south of the Anegada Channel, have a somewhat mixed land-snail fauna, partaking of the characters of those of both the Greater and Lesser Antilles. That a few species might have drifted to these islands from the abundantly stocked Northern Archipelago is not strange. Bland groups the two with Puerto Rico.

†One species is found in Curaçoa, one of the Leeward Islands.

for the most part derived from South America. At Trinidad—which is merely a detached fragment of Venezuela—more than half the species are common to the mainland, and among them are one or more of the continental *Borus*, an *Ampullaria*, a *Marisa*, and an *Anodon*.*

Borus is found in St. Vincent, Barbados, Guadeloupe, St. Kitts, and Montserrat,† and *Bulimulus*, another most characteristic South American genus is abundant throughout the Lesser Antilles. The 500-fathom line will be found to divide the Lesser Antilles into three groups; the most northern embracing every island from Sombrero and the Saba bank south to and including Dominica. Between the latter and Martinique is a channel 575 fathoms in depth, and south of it is another of 548 fathoms. Beginning with St. Lucia, which is separated from St. Vincent by a depth of 486 fathoms, all the islands to the southward are united to the mainland by the 500-fathom line. Barbados is somewhat isolated, and is surrounded by comparatively deep water, being separated from the chain by 1,403 fathoms, while Trinidad, Tobago, Margarita, and Tortuga are all within the 100-fathom line. Several South American *Bulimus* typified by *B. auris-sileni* are found in the islands from St. Vincent southward, and Martinique, which is separated from the islands north and south of it by channels over 500 fathoms in depth, has no *Pineria*, *Chondropoma*, *Choanopoma*, or *Cistula*, which are Greater Antillean genera found in the Windward Islands north of it. As a proof of the comparative poverty of the Lesser Antilles it may be stated that the whole archipelago does not contain 300 species of terrestial and fluviatile mollusks; scarcely more than half the number belonging to Jamaica.

One group is found in nearly all the Windward Islands, *Caprinus* (better known as *Dentellaria*), a section of the genus *Pleurodonte*, which seems to bear about equal relationship to the sections found in the Greater Antilles, and to *Labyrinthus* of northern South America. There is another division of the genus, *Isomeria*, which is confined for the most part to the higher Andean regions of Peru, Equador, and Colombia, characterized by a lesser development of teeth in the aperture than *Labyrinthus*, and which may have sprung from the latter. The distribution of these groups is a little peculiar. We may suppose the Greater Antilles to be the site whereon *Pleurodonte* developed, from the fact that six out of the eleven of its sections are wholly confined to that region, as is another, *Thelidomus*, with the exception of a couple of species, while a majority of the species of the genus are also found there. It would seem strange that some ancestral form which had migrated to the Lesser

*The latter is a *Glabaris* no doubt. Ihering has shown (Archiv für Naturgeschichte Jahrg 59, 1 Bd., 1 Heft., p. 52), that all the South American *Anodons*, so called, are anatomically quite distinct from the Unionidæ, and that they belong to the Mutelidæ. This form, *A. leotandi*, Guppy, is no doubt derived from some of the continental species.

†Introduced into the more northern islands, probably on coffee trees.

Antilles should develop into the group *Caprinus*, not a species of which should be found north of this archipelago, and that not one of the six other Greater Antillean groups should be represented in the Windward Isles; that it should develop a few species on the mainland and pass into *Labyrinthus*, no species of which is found outside the continent.

It appears to me a not unreasonable solution of this rather curious phase of distribution, in view of the very slight relationship that otherwise exists between the land and fresh-water mollusks of the Greater and Lesser Antilles, and of the fact that many of the latter islands are of such recent date, that it is more probable that ancestral forms of *Pleurodonte* migrated from Jamaica across the old landway to Honduras; that the subsidence of some 400 miles of this ancient bridge destroyed the connecting links so that *Pleurodonte* restricted developed in the island and *Labyrinthus* on the continent; that the latter (extending now as far north as Central America) spread out over the lower regions of northern South America, and developed into *Isomeria* in the mountains; that from this stock descended *Caprinus*, which is now represented by a few species in Guiana, and probably in the adjacent territory, and which migrated northward among the Lesser Antilles to St. Kitts and Barbuda, its farthest limit.*

To briefly recapitulate, a considerable portion of the land snail fauna of the Greater Antilles seems to be ancient and to have developed on the islands where it is now found. There appears to be good evidence of a general elevation of the Greater Antillean region, probably some time during the Eocene, after most of the more important groups of snails had come into existence, at which time the larger islands were united, and there was land connection with Central America by way of Jamaica and possibly across the Yucatan Channel, and there was then a considerable exchange of species between the two regions. At some time during this elevation there was probably a landway from Cuba across the Bahama plateau to the Floridian area, over which certain groups of Antillean land mollusks crossed. At this time it is likely that the more northern isles of the Lesser Antilles, which seem to be volcanoes of later Tertiary and Post Pliocene date, were not yet elevated above the sea or if so they have probably been submerged since. After the period of elevation there followed one of general subsidence.†

* *Cistula*, which has its metropolis in the Greater Antilles, has a somewhat similar distribution. Several species are found in Mexico, Central and northern South America, with one species in Trinidad, but not north of that until we reach Antigua, near the upper end of the chain. *Neocyclotus*, with a great development in the more northern archipelago, is also abundant on the continent, and is found in the Lesser Antilles as far north as Martinique; and *Colobostylus*, with a similar distribution, extends northward only into Trinidad.

† Just how extensive this disturbed area was can not now be told. It is well known that along the north shore of Cuba, back of Matanzas and Havana, there are raised beaches, some 1,200 feet above the sea, which have been supposed to be recent, but Mr. R. T. Hill, of the U. S. Geological Survey, who has recently visited the island

During this the island of Jamaica—as the character of its land-snail fauna shows, as well as the depth of the channel between it and Haiti—was first to be isolated, then Cuba, and afterwards Haiti and Puerto Rico were separated. The connection between the Antilles and the mainland was broken, and the Bahama region, if it had been previously elevated above the sea, was submerged; the subsidence continuing until only the summits of the mountains of the four Greater Antillean islands remained above water. Then followed another period of elevation, which has lasted no doubt until the present time, and the large areas of limestone uncovered (of Miocene, Pliocene, and Post Pliocene age) in the Greater Antilles have furnished an admirable field for the development of the groups of land snails that survived on the summits of the islands. The Bahamas have appeared above the surface of the sea, either by elevation or growth, and have been peopled by forms drifted from Cuba and Haiti, and a number of land and fresh-water species have been recently colonized in South Florida, probably since the Glacial epoch. The Lesser Antilles have been peopled for the most part from South America, possibly receiving from that region the group *Caprinus*, so characteristic of the former region, as well as several genera of land operculates, while a few stragglers have been carried by sea no doubt from the Greater Antilles and colonized on the more northern of the Windward Islands.

DESCRIPTIONS OF NEW SPECIES OF RECENT AND FOSSIL LAND SHELLS FROM THE ISLAND OF JAMAICA.

I.—*Recent species.*

SAGDA MAXIMA, new species.

Plate XVI, figs. 7, 8.

Shell large, pyramidal in form, with nearly straight sides and obtuse summit, moderately striated, and covered with a thin, horn-colored epidermis; whorls, 8½ to 9, moderately convex; suture distinct and well impressed, sometimes slightly margined; last whorl wide, well rounded; aperture large; base rather flat, not deeply excavated at the umbilical region; the latter covered with a light, glazed callous, which joins the outer edge of the aperture. Interior entirely destitute of a lamella. Greater diameter 30; lesser 27 mm.; height 28 mm. Near Petersfield, Westmoreland, on a mountain, in heavy forest.

This species resembles *S. epistylioides* somewhat, but has a broader, less excavated base, and from one to one and a half less whorls, which are wider than those of the latter, and the shell has not so pointed a summit. Some 25 specimens (all dead) were obtained, varying from

has brought shells from these beaches and submitted them to Dr. Dall, who pronounces them to be Miocene, and probably of the same general age as the Bowden beds of Jamaica. It would seem most likely that the elevation and subsidence would extend to some extent through the Bahamas and into the South Floridian regions.

young to adults, and though several were broken open no vestige of a lamina was observed at any stage of growth.

PLEURODONTE (EURYCRATERA) JAMAICENSIS, Chemitz, var. CORNEA.

A variety of this species was found at Mandeville, Manchester, rather more delicate in structure than the type, and entirely destitute of color, the epidermis being horn-colored.

ADAMSIELLA GRAYANA, Pfeiffer, var. AUREOLABRA.

A large number of specimens of what may prove to be a new species were found at Rio Novo, in St. Mary. The aperture is smoother than that of the type, and is of a rich, reddish-orange color; the body of the shell is shining, and very finely decussated under a glass. The species is exceedingly variable, and this may be only a strongly marked variety.

LUCIDELLA AUREOLA, Ferussac, var. INTERRUPTA.

This variety is covered with interrupted and slightly wavy, revolving striæ, the liræ blotched with white. Duncan's, Trelawney.

II.—*Fossil species.*

NEOCYCLOTUS (PTYCHOCOCHLIS) BAKERI, new species.

Plate XVI, figs. 1, 2.

Shell large, depressed, with 5 well-rounded whorls; nuclear whorl wanting in the only specimen found; second, third, and fourth whorls covered with delicate, radiating, zigzag corrugations, which become very much coarser on the last three fourths of the body whorl; the periphery of the latter being almost smooth, the upper surface becoming very strongly and irregularly waved toward the aperture; the base and umbilical region having strong folds, which sweep forward obliquely toward the periphery; umbilicus rather wide, extending to the summit of the shell, and exhibiting the volutions; umbilical keel almost entirely wanting, there being two very slight revolving elevations, one at the outer edge of the umbilicus, the other farther out on the base, the area between them being flattened so that the shell seems to have two faint keels; aperture moderately large; operculum unknown. Greater diameter 25, lesser 21 mm., height 12 mm.

Locality and position: stratum of marl in the Miocene beds at Bowden, St. Thomas, Jamaica, associated with marine fossils.

I take pleasure in naming this fine species in honor of Capt. L. D. Baker, president of the Boston Fruit Company, who gave us permission to excavate in the beds, and furnished us men and every facility possible to make our work a success.

LUCIDELLA COSTATA, new species.

Plate XVI, fig. 6.

This is a small species, about one-half the diameter of the average *L. aureola*. There are 5 whorls which are moderately rounded; the

suture being shallow and somewhat canaliculate, with about 10 strong, revolving costæ on the body whorl and 5 on the penult whorl, and between these are smaller revolving liræ. The center of the base for about two-fifths of the diameter of the shell is perfectly smooth, and slightly hollowed in the umbilical region. The upper part of the aperture of the only specimen found is broken away, leaving only the basal tooth, which is slightly compressed parallel with the outer edge of the basal lip.

Diameter 3½, height nearly 3 mm.

Found with *Neocyclotus bakeri* and other fossil shells.

PLEURODONTE BOWDENIANA, new species.

Plate XVI, figs. 3, 4, 5.

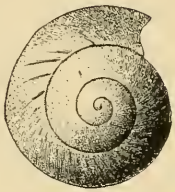
Two fragments of this shell were found, an apex with 3 whorls and about one-third of the base of a body whorl with the aperture in perfect condition. The fragment containing the nucleus shows the upper surface of the whorls perfectly plain, the suture being only marked by an elevated line; it has a wide umbilicus and a very sharp keel. The other fragment shows a rather sharply defined peripheral keel; the aperture is very oblique and rather compressed, with two strong teeth, which are somewhat like those of *P. lucerna*, but are set more obliquely with the aperture, the outer one being somewhat flattened on the upper extremity; the lip is thin, not reflected above, reflected and joined solidly to the base along its inner half, the outer basal half is free and well reflected. Back of the basal lip there is a deep, somewhat oblique, oval pit, corresponding exactly with the shape of the outer tooth, and extending within it to its summit. The large umbilicus of the young shell is completely closed by the flattened callous of the lower lip in the adult. The diameter of this shell if perfect would probably be about 40 mm., the height about 15 mm. It was found in company with the other fossils in the Bowden beds. The basal pit behind the aperture is a remarkable character, and I know of no other *Pleurodonte* which has it developed in such a manner.

The *Thysanophora* found with the above fossils is, I believe, new, but it is not in fit condition to describe or figure.

EXPLANATION OF PLATE XVI.

Fig. 1. *Neocyclotus (Ptychocochlis) bakeri*, new species; from above.
Fig. 2. *Neocyclotus (Ptychocochlis) bakeri*, new species; dorsal view.
Fig. 3. *Pleurodonte bowdeniana*, new species; aperture, front view.
Fig. 4. *Pleurodonte bowdeniana*, new species; base.
Fig. 5. *Pleurodonte bowdeniana*, new species; upper view, fragment.
Fig. 6. *Lucidella costata*, new species; front view; upper portion of outer lip broken.
Fig. 7. *Sayda maxima*, new species; front view.
Fig. 8. *Sayda maxima*, new species; basal view.

1



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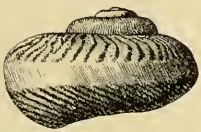

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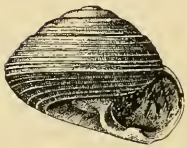

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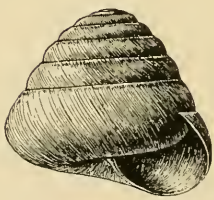

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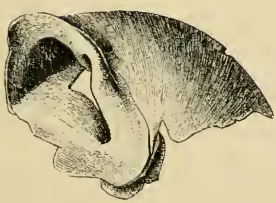

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8

NEW SPECIES OF MOLLUSKS FROM JAMAICA.

Figs. 1, 2. *Neocyclotus bakeri* (Fossil).
Figs 3-5. *Pleurodonte bowdeniana* (Fossil).
Fig. 6. *Lucidella costata* (Fossil).
Fig. 7, 8. *Sagda maxima* (Recent).