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LAND AND FRESHWATER MOLLUSCS OF THE DUTCH LEEWARD ISLANDS

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INTRODUCTION

In 1920, while on the University of Michigan-Williamson Expedition to Venezuela, a small collection of land shells was obtained from the Schaarlo, back of Willemstad, Curaçao.[1] In 1922, the University of Michigan Museum of Zoölogy sent me back to the Dutch Leeward Islands to collect molluscs, reptiles, amphibians and ants. With the assistance of an additional grant from the Zoölogical Laboratory of the University of Pennsylvania, for the collection of grasshopper testes as cytological material, I was able to spend the summer, from June 11th to September 17th, 1922, in a study of all five of the islands of the group. The reptiles collected have been listed already, in a paper by Dr. A. G. Ruthven.[2]

From June 11th to 28th, Overzijde (Otrabanda), Curaçao, was the base for collecting trips. From June 29th to July

[1] 1923; *Occ. Papers, Mus. Zool. Univ. Mich.*, no. 137; pp. 1–7, pl. I.

[2] 1923; *Occ. Papers, Mus. Zool. Univ. Mich.*, no. 143.

12th, I was guest of Mr. Richard Muskus at his Landhuis Knip, near the northern end of the same island. On July 19th, the schooner "Albertina" took me to Oranjestad (Plaja Aruba), from which town a study was made of the island of Aruba, until August 10th, when I sailed, on the packet schooner "Ligia," back to Willemstad (Punta), Curaçao, and then to Kralendijk (Plaja Bonaire), Bonaire. From August 13th to September 1st, collections were made on this island, with a visit to Klein-Bonaire (Bonaire Chikitoe) on August 24th. By arrangement, the sloop "America" put me ashore for two hours, on September 1st, at the island of Klein-Curaçao (Curaçao Chikitoe). September 2nd to 17th were spent at Overzijde, Curaçao, from where trips were made to Sint Willebrordus and New Port, on the same island.

A note in regard to the locality names may not be out of place. The language of the Dutch Leeward Islands is Papiamento, which seems to have started as a dialect of Portuguese, but which has acquired words from all of the languages spoken in the West Indies. Written Papiamento was invented by Dutch orthographers, with the result that the combinations of letters, used to express certain sounds, are very different from those in the Romance languages. The larger towns and the more conspicuous topographic features have Dutch names, but the official language is infrequently heard in the islands, and the Papiamento synonyms are much more commonly used. The former are preferred throughout this paper, but the latter are occasionally added in parentheses. The spellings used here are taken from the Dutch Government 1/20000 topographic maps, but, even in these, variations occur.

My thanks are due the Government officials of the islands, especially the Procureur-General and the Government secretaries of Curaçao and the Subgovernors of Aruba and Bonaire, and also to the United States Consul, Mr. B. S. Rairden, for assistance in many ways. In addition, I found all of the people of the islands extremely hospitable and always willing to direct me to favorable localities for study. In particular,

I wish to express my indebtedness to Mr. Richard Muskus, of Campo Knip, Curaçao, whose hospitality I enjoyed for two weeks, to Mr. Gravenhorst, of Kralendijk, Bonaire, who helped me to find quarters on that island, and to Mr. and Mrs. de Veer, of Oranjestad, Aruba. I also wish to thank the firm of S. E. L. Maduro and Sons for their many courtesies, and that of John Godden and Co., for permission to visit the Tafelberg of Santa Barbara.

I am deeply indebted to Ir. G. J. H. Molengraaff, M.I., for the meteorological data which are collated in Tables I, II and III, and to Dr. N. L. Britton, who, through the kind mediation of Mr. J. M. Fogg, identified some specimens of characteristic plants. The identification and comparison of the molluscs collected were made possible by the library and collections of the Academy of Natural Sciences of Philadelphia, where Dr. H. A. Pilsbry and Mr. E. G. Vanatta were, as always, very helpful. Drawings, photographs, and preparations of radulae, etc., were made at the Zoölogical Laboratory of the University of Pennsylvania.

Environment

The Dutch West Indies, or the Netherlands Colony of Curaçao, consist of islands in the northern Lesser Antilles, and the ones studied in the Leeward Group. The island of Curaçao, from which the entire colony takes its name, is the largest of the latter, and lies in the Caribbean Sea, 47 miles north on the 69th west meridian from the coast of Venezuela, and just north of 12° north latitude. The island of Aruba is about 60 miles to the northwest; it lies on the 70th west meridian, approximately 20 miles north of the Paraguana Peninsula, and around 12° 30′ north latitude. Bonaire and the closely associated island of Klein-Bonaire are about 30 miles east of Curaçao, just northwest of 12° north latitude and 68° west longitude. Klein-Curaçao is a small coral island about 8 miles southeast of the southeastern end of Curaçao, at 12° north latitude and 68° 39.5′ west longitude.

The ocean bottom has not been mapped thoroughly in all parts adjacent to the islands, but it seems quite certain that

738 fathoms of water lie between Curaçao and the mainland. Such a depth of water would mean that a constant negative movement of the strand line would connect the Lesser Antilles, and even the Greater Antilles, to the South American mainland, before the 40 mile strait between Curaçao and Venezuela would be drained. On the other hand, the passage between Aruba and the Paraguana Peninsula is less than 40 fathoms deep in the shallowest place. The United States Hydrographic Office chart, number 964, shows one sounding of 830 fathoms between Curaçao and Aruba, but the depths between Curaçao and Bonaire, and between the last island and the groups to the east, are not mapped. Nevertheless, it seems probable that the isolation of Curaçao, Klein-Curaçao, Bonaire and Klein-Bonaire is at least directly comparable to that of the northern Lesser Antilles. As will be discussed later, this geographic separation is intensified by the ecological differences between all of the Dutch Leeward Islands and most parts of the South American mainland.

Ir. G. J. H. Molengraaff, M.I., Chief of the Weather Bureau of Curaçao, very generously sent me the meteorological data which are compiled into the following tables. As will be seen from the first of these, the climate of the Dutch Leeward Islands is influenced by an almost constant, east trade wind of considerable strength. As will be discussed later, this produces a marked difference between the eastern and western slopes on the islands. All of the records given are from points on the western side of the islands, with the exception of those from Rincon, Bonaire, which is also partially protected from the east winds.

The usual ocean currents follow quite closely the direction of the trade winds, but are deflected somewhat to the northward by the South American coast line and those of the islands. For instance, the trip from Willemstad to Oranjestad was accomplished in about 12 hours, although the schooner's sails were flapping most of the time. On the other hand, the return trip, which was said to be a fast one, required 34 hours. However, this general trend is occasionally reversed. "South

Table I. Winds at Fort Amsterdam, Willemstad, Curaçao from August, 1910, to December, 1921, inclusive[3]

	Wind Direction in Percentages								Wind Velocity Beaufort Scale (0–12)		
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	8:00 A.M.	2:00 P.M.	6:00 P.M.
January	0.2	14.8	84.0	0.7	0.0	0.1	0.2	0.0	2	2	2
February	0.6	13.0	84.2	1.9	0.0	0.0	0.0	0.1	2	3	3
March	0.0	13.9	84.2	1.9	0.0	0.0	0.0	0.0	3	3	3
April	0.7	9.8	86.9	1.3	0.2	1.2	0.0	0.0	3	3	3
May	0.0	8.8	88.0	3.2	0.0	0.0	0.0	0.0	3	3	3
June	0.0	6.7	92.6	0.7	0.0	0.0	0.0	0.0	3	4	3
July	0.0	7.7	91.2	1.0	0.1	0.1	0.0	0.0	3	3	3
August	0.2	7.4	88.2	3.4	0.1	0.5	0.1	0.0	3	3	3
September	0.1	6.2	87.8	5.0	0.4	0.2	0.2	0.0	3	3	3
October	0.1	8.5	79.3	7.5	2.6	1.1	0.8	0.1	2	2	2
November	0.3	13.4	78.0	6.0	1.0	1.2	0.2	0.0	2	2	2
December	0.0	13.3	83.7	2.6	0.2	0.0	0.1	0.0	3	3	3
Mean Annual	0.2	10.3	85.7	2.9	0.4	0.4	0.1	0.0	3	3	3

of Curaçao the surface current is generally to the westward, but an easterly sub-current exists and this is of such volume that it is liable entirely to overcome the surface set.''[4]

The temperatures (Table II) are remarkably uniform, with a total extreme fluctuation of 23 degrees Fahrenheit, during the period measured. The mean annual temperature (81° F.) places the islands in Calvert's zone II.[5] It is also noteworthy that the mean daily variation (8° F.), although small, is twice as great as the fluctuation in the mean monthly temperature (4° F.).

The rainfall (Table III) is as variable as the temperature is uniform. The mean annual rainfall of the four localities measured (17 to 22 inches) immediately establishes the islands as tropical semi-deserts. It will be noted that a distinct rainy season occurs in the months October to January, although the

[3] Observations missing between Nov. 2nd and 7th, 1918. The table of wind directions is reduced from one containing intermediate points; most of the N.E. and S.E. winds listed were actually observed as E.N.E. and E.S.E. winds, respectively.

[4] United States Hydrographic Office chart, number 1290.

[5] 1908; *Proc. Acad. Nat. Sci. Philadelphia;* Plate xxvi.

Table II. Temperatures at Fort Amsterdam, Willemstad, Curaçao from January, 1903, to June, 1921, inclusive[6]

	Mean Monthly		Mean Daily Range		Extremes	
	Cent.	Fahr.	Centigrade	Fahr.	Centigrade	Fahr.
January	25.9	79	23.6–28.2	74–83	21.0–30.5	70–87
February	25.9	79	23.7–28.2	75–83	21.0–30.5	70–87
March	25.9	79	23.7–28.7	75–84	20.5–31.0	69–88
April	26.8	80	24.5–28.7	76–84	21.0–31.5	70–89
May	27.7	82	25.4–30.1	78–86	23.0–32.8	73–91
June	27.7	82	25.6–29.9	78–86	22.4–32.0	72–90
July	27.6	82	25.3–29.9	78–86	22.0–32.2	72–90
August	26.7	80	25.7–30.3	78–87	21.0–32.5	70–90
September	28.3	83	25.9–30.8	79–87	20.0–33.0	68–91
October	28.0	82	25.6–30.4	78–87	21.0–33.0	70–91
November	27.5	81	25.1–29.8	77–86	21.0–32.0	70–90
December	26.5	80	24.2–28.8	76–84	21.5–32.3	71–90
Annual	27.0	81	24.9–29.5	77–85	20.0–33.0	68–91

usual rainy period of the higher West Indian islands and the Venezuelan mainland comes between June and November. But extreme variation is the most conspicuous feature; less rain may fall in one of the wet months than the mean precipitation of the driest month. The rainfall of a single month may be much greater than that of an extremely dry year; in fact, it may be practically as great as the mean annual precipitation. In addition, my own experience, and conversation with the inhabitants, lead me to believe that the greater proportion of the downfall comes in a few torrential deluges. Attention also should be called to the fact that my study of the islands was made during the dry season, but that the preceding year and the one of my visit (1921 and 1922) were wet years (875 and 810 mm. rainfall, respectively, at Cas Chikitoe, near Willemstad, Curaçao).

All of the recorded data come from near the towns. From the vegetation, and the rainfall while I was on the islands, I suspect that the vicinity of the higher hills receives a considerably greater amount of precipitation, especially during the

[6] Not recorded from Feb. 11–17, 1905; Nov. 3–7, 1918; Sept. 1–23, 1904; Oct. 5–31, 1904; June and Sept., 1906; July and Sept. to Dec., 1919; Jan., 1920.

drier months. In fact, it seems probable that the differences between the stations recorded are quite largely due to such local factors as the height of the hills in their vicinity. However, none of the "seroes" is high or large enough to produce anything like a rain forest. Sint Christoffelberg (1,229 feet), on its western side near the summit, is the only place where bromeliads and other epiphytes are at all conspicuous.

Table III. Rainfall in Millimeters[7]

	Fort Amsterdam, Curaçao		Oranjestad, Aruba		Kralendijk, Bonaire		Rincon, Bonaire	
	Mean	Extremes	Mean	Extremes	Mean	Extremes	Mean	Extremes
January	54	9–115	50	0–151	50	3–111	63	0–167
February	30	1–102	14	0–64	32	0–95	32	1–79
March	25	1–81	15	0–56	24	0–74	18	Tr.–50
April	24	0–173	23	0–168	24	0–104	28	Tr.–185
May	11	0–54	8	0–51	13	0–48	21	Tr.–136
June	19	1–72	13	0–54	10	0–30	14	Tr.–53
July	30	2–89	21	2–45	27	4–62	27	Tr.–60
August	38	3–142	33	1–139	28	3–88	29	Tr.–98
September	27	4–89	24	2–59	15	1–38	23	0–70
October	99	1–472	74	6–252	100	Tr.–494	88	8–342
November	118	12–325	96	4–358	114	31–241	123	35–214
December	83	10–262	65	11–228	80	21–265	79	25–269
Annual	561		435	86–941	516	164–982	545	133–883

The data sent me by Ir. Molengraaff show a rather high and constant humidity, during the daytime, at Fort Amsterdam, Willemstad, Curaçao. The mean annual (August, 1910, to December, 1920) and the variations in the mean monthly relative humidity are: at 8 A. M., 74 and 73–75, respectively; at 2 P. M., 71 and 68–72; at 6 P. M., 73 and 71–74 per cent. Although I have no data to present, I believe that dew is a comparatively rare and inconspicuous phenomenon on the

[7] The records from Fort Amsterdam, Willemstad, Curaçao, cover a period of from 28 to 29 years, dependent on the month (Jan. and Feb., 1895–1923; Mar. to May, 1895–1922; June to Sept., 1894–1922; Oct. to Dec., 1894–1921). From Oranjestad, Aruba, they cover a period of 16 years (1901–1916). From the two localities on Bonaire, they cover a period of 12 years (1905–1916).

highlands and along the western sides of the islands, at least during the dry months. On the other hand, along the excessively arid eastern shores and northern and southern tips of the islands, a rather heavy dew formation seems to be the usual thing.

Land Habitats

Sometime after the Miocene,[8] the Dutch Leeward Islands must have been almost entirely submerged; so that they were largely covered with a thick coral formation. Three or four prominent beach-lines, around the hills (fig. iii–5), were formed at different stages of the emergence, and the limestone was eroded away from the central portions, so that the older rocks were extensively exposed. Recently, another period of partial submergence must have taken place, as the peculiar shape of such bays as the Schottegat (Plate I, 5–R) and Spaansch Water (2–E) on Curaçao, certainly indicate that these are sunken valleys. As the central dome was eroded away, the stream channels formed narrow outlets through the tilted limestone at the edges, and most of the present valleys have a similar shape to these submerged ones.

Fundamentally, on the basis of their igneous intrusions, the Dutch Leeward Islands have been considered a portion of a complex which includes the Goajira Peninsula and the Sierra Nevada de Santa Marta (perhaps also the Paraguana Peninsula) of the South American mainland.[9] Superficially, each island is a canoe-anticline, the long axis of which extends approximately northwest southeast. The central portion of each island is composed largely of highly metamorphosed and crumpled, Cretaceous conglomerate-schists, and of igneous

[8] Compare J. Lorié; 1887–9; *Samml. Geol. Reichsmus. Leiden,* 2 ser., Bd. I, pp. 111–149; and K. Martin; 1887, 1888; *Bericht über eine Reise nach Niederländisch West-Indien,* I and II. The latter contains a detailed discussion of the geology of the three main islands, with rather inelaborate maps of the formations.

[9] W. Sievers; 1896; *Petermanns Mitteilungen,* Vol. XLII, p. 129, and pl. X.

rocks, such as diabase, quartz-diorite (northern Aruba) and mica-porphyrite (northern Bonaire). These older rocks may resist erosion so as to form the highest hills in the islands (figs. iii–6, and vi–14), or they may be peneplainized (especially the diabase) to rolling plains (fig. vii–17), inside of the limestone ramparts (fig. iii–5) along the seashore. Most of the soil of the islands is derived from these more ancient rocks, but the rapid erosion prevents the retention of much residue, except on the more nearly level portions. As a result, almost all of the agricultural development (hofjes), except the aloe plantations, is in the valleys of these central basins.

The calcareous strata are markedly unconformable on the older rocks. The earlier limestone layers are very hard and are darker in color; the more recent ones (fig. iii–7) are simply exposed coral reefs and are quite soft and chalky in texture. Where exposed, the older limestone (fig. vi–14) erodes into characteristic jagged points, separated by irregularly rounded holes, which may be several feet in depth; thin slabs of this material ring like steel when struck. The central dome has been largely removed, but in the middle of Curaçao and on the southern ends of Aruba and Bonaire, the calcareous rocks still practically bridge each island, while capped monadnocks, such as the Tafelberg of Sint Hyronimus (Pl. I, Curaçao, 20–N) and Ronde Klip (12–P) on Curaçao, show its former extent and altitude. Usually the southwestern rim is more markedly tilted than the northeastern; the latter is often eroded almost to the shore (northern Curaçao and Aruba), or may remain as flat-topped ridges and mesas of the older limestone (for example, the coast of Hato, Curaçao; fig. v–13), while the former is carved by the canyon-like valley outlets into bold, angular hills (fig. iii–5).[10] Almost invariably, the northeastern escarpments of all of the older remnants form vertical, or even overhanging cliffs, which are commonly excavated into more or less extensive caves, and decorated with

[10] K. Martin, I, Plate IX, shows the inland side of the limestone rim from Seroe Domi to Seroe Salinja Abau, with the Tafelberg of Santa Barbara in the background.

stalactites, stalagmites and other seepage deposits (figs. iv–8, v–13). In addition, less prominent cliffs may occur above the fossil beaches on the leeward side of the hills, and the more recent coral layers quite commonly form lower ridges, which are separated from the more prominent monadnocks of older limestone by valleys parallel to the shore. The true mesas, like the Ronde Klip and the Tafelberg of Santa Barbara, are almost entirely surrounded by steep cliffs.

The flora of the islands is discussed in detail by Dr. I. Boldingh.[11] "The general impression of the vegetation of the islands Curaçao, Aruba and Bonaire is that of a dry country, where thorny shrubs and cactuses predominate . . . the vegetation has everywhere a rather uniform aspect. . . . Excepting a few less exposed parts and the higher tops of Curaçao and Bonaire, the whole vegetation may be said to have a more or less xerophile character; in many places where the soil is covered by hardly any humus, as on the numerous limestone table-lands, it becomes a poor vegetable cover . . . ; nearly everywhere the soil is clearly visible and not covered by a connected vegetation. . . . The type of vegetation might be generally described as a **Croton vegetation**, . . . determined by plants like Croton, Acacia, Lantana, Melochia, Opuntia, Melocactus. . . . *Capparis Breynia* is characteristic for the vegetation outside the lime and *Rhacoma crossopetalum* and *Antirrhoea acutata* for the lime." (Excerpts from pages 149 and 150.)

Commonly the omnipresent thorn trees are dwarfed and distorted by the dry trade winds; the foliage of the divi-divi (*Caesalpinia coriaria*) usually consists of a flat, matted fan, which only spreads out to the leeward of the trunk (fig. v–12). The giant organ-pipe cacti (Cereus) are among the most conspicuous features of the landscape; planted closely in rows, they form many of the fences (fig. vi–14), although the dead branches of *Acacia tortuosa* are as commonly used on Curaçao. The flat-jointed cacti (Opuntia) are almost everywhere, and

[11] 1914; The Flora of Curaçao, Aruba and Bonaire; Leiden.

may form quite impassable thickets, while the large "nigger-heads" of Melocactus and the spiked rosettes of Agave may be about the only vegetation near the summits of the larger monadnocks of older limestone.

Nowhere can the vegetation truly be called a forest, although, in protected places, especially on the leeward slopes of the higher hills, larger trees, such as various species of Bursera, *Casearia bonairensis, Bumelia obovata, Capparis jamaicensis, Machaonia Ottonis,* and *Guaiacum officinale,* do form small, or even quite extensive, open groves. However, the largest masses of natural foliage are furnished by the poisonous "manzalienja" (*Hippomane mancinella*), which forms quite dense and high tree-growths along the dry water-courses of the inland region, especially on Curaçao. Quite a few of the shrubs and trees, such as *Bursera semiruba,* shed their leaves during the dry periods, while others, like *Guaiacum officinale,* are evergreen.

The native species of molluscs are quite largely confined to the limestone outcrops, although certain of them extensively penetrate the more heavily wooded valleys of the higher hills, especially of those in the Cretaceous rocks (fig. vii–19). At the inner borders of the limestone rim (fig. vii-18), the soil of the inland region is impregnated with the reddish deposit that appears to be the principal residuum from the decomposition of coral rocks. Apparently enough calcareous material remains in some of these places to support the limestone-loving species.[12] However, the extensive grass and brush covered plains of the central region (fig. vii–17) are practically without molluscan life.

The limestone rim is broken by numerous "rooi's" and, more rarely, by deep salt water channels that connect with the broad, shallow lagoons behind the shore ramparts. Especially on the island of Curaçao, the molluscs of each of these limestone remnants form a quite isolated colony. The result of this separation is most noticeable among the forms of the

[12] Included in the "calcareous soil" of Boldingh's maps. For the vegetation of the non-calcareous soils, see page 158, *l. c.*

genus Tudora on the island of Curaçao, where the prominent breaks in the limestone rim are accompanied by changes in the shells themselves. On Curaçao, the main station numbers indicate those areas of the limestone which are most markedly isolated by such natural boundaries, but, on Aruba and Bonaire, sharp lines of demarcation can rarely be drawn.[13]

Curaçao

Although Curaçao (Plate I, fig. 1) is only about 35 miles long, it can readily be divided into three, quite distinct areas, on the basis of the distribution of land molluscs. The first of these centers about the Tafelberg of Santa Barbara (fig. 1, 2–B); the second includes the remainder of the southwestern shore between Spaansche Baai (2–E) and Boca Sint Marie (9–G), and the coast of Hato (10, 11, 12) on the northeastern side; while the third is composed of the western shore north of Bullen Baai (9–F) and the higher hills in the older rocks (20). As already discussed, the many breaks in the limestone rim of Curaçao quite markedly isolate the various stations. The more recent limestone is mainly limited to the shore region southeast of Piscadera Baai (5–W).

Station C1. Northwest of New Port (fig. I, 1–A; L68° 50.72′, 12° 3.52′).[14] New Port is the harbor of the phosphate company; it is situated on a rather broad shelf of recent limestone along Fuik Baai. As this locality is on the leeward side of the

[13] Throughout this paper, the stations are designated by letters and figures, as follows: C, A, B, and K stand for the islands of Curaçao, Aruba, Bonaire and Klein-Bonaire, respectively; these, followed by b, c, or d indicate (b) the localities on the older deposits, and (c) the freshwater and (d) marine habitats, as opposed to the stations on the limestone. The figures give the station numbers; these are followed by letters for the substations.

[14] After each station is given a reference to the map of the island concerned (plates I and II), followed by the west longitude and north latitude of the place mainly collected (indicated by the letter L). These are measured to 1/100 of a minute on the Netherlands Government 1/20000 topographic maps, and thus locate the type localities within approximately 20 meters.

Tafelberg, it is more heavily wooded than are most of the stations near the shore. The adjacent slope of the Tafelberg is not precipitous and probably similar conditions occur for some distance up this side. Near the top, on one of the fossil beach levels, occur the rich phosphate deposits that produce most of the export from Curaçao.

Station C2. Base of escarpments of the Tafelberg of Santa Barbara (2–B; L68° 50.78′, 12° 4.31′ and 68° 51.07′, 12° 4.35′ for substations C2a and C2b, respectively). This Tafelberg is the highest hill (193.8 meters) on the southern portion of Curaçao, and undoubtedly was a separate island at several of the ancient beach levels. The escarpments of the older limestone, below the summit of its northern and western sides, form almost vertical cliffs which are 200 feet high in places. As erosion appears to take place most rapidly at the uncomformity over the underlying, older rocks, these cliffs often overhang, and the limestone tends to break off in enormous, angular blocks, which slump down the steep slopes below the escarpments (compare fig. iv–8). Most of the shells occur in the talus from these cliffs; the Tudorae do not extend any great distance down the slopes, which are covered with a thin soil from the older rocks, but Cerion occurs to the base and some distance beyond. These slopes are held by thickets of brush, but the larger trees are usually near the base of the cliffs. Two localities were collected: the central portion of the northern side (C2a) and the base of the western escarpment (C2b).

Station Cb2. Manzalienja Rooi, Campo Santa Barbara (2–C; L68° 50.63′, 12° 4.94′). A few shells were collected near one of the dry water-courses (roois) of the diabasic central region. These are commonly bordered by luxuriant groves of large trees (*Hippomane mancinella*), but are usually devoid of molluscan life.

Station C3. Hill north of Fort Beekenberg (3–F; L68° 52.54′, 12° 4.55′).[15] This rather barren block of limestone

[15] For vegetation of nearby crest, see Boldingh, p. 155, "Kabrietenberg near Beekenberg."

(25.1 meters) just north of the old fort near the Quarantine Station, is the type locality of *Tudora megacheilos kabrietensis.*

Station C4. Seroe Mansinga (4–H; L68° 53.22′, 12° 4.81′). The older limestone remnants between Caracas Baai (3–G) and Lagoen Jan Tiel (4–I) reach an altitude of 49.2 meters. The brush on the hills themselves is rather dwarfed, but larger trees are quite numerous on the northern slopes, just inside of the limestone ramparts. In these places, *Drymaeus virgulatus* is especially numerous and occurs even on the lower crotons.

Station C5. The limestone rim between Lagoen Jan Tiel and Sint Anna Baai (5–P) is included in this station. The following substations represent the main localities collected.

C5a. Seroe Spanjo (5–K; L68° 54.21′, 12° 5.11′). Very similar to the preceding, but most of the collection comes from the more recent limestone.

C5b. Seroe Salinja Abau (5–L; L68° 55.38′, 12° 6.31′). Practically a continuation of the Schaarlo.

C5c. Schaarlo (5–M; L68° 56.55′ 12° 6.81′). Back of Willemstad (5–O) is a low ridge (41 meters) of recent limestone. It is rather barren, although quite densely covered with *Croton flavens,* etc. Along the northern side, acacias and other small thorn trees are more abundant (fig. iii–7). As Willemstad is the principal port of the islands, it is probable that most of the species described from Curaçao by the earlier writers came from its near vicinity; and I am regarding the Schaarlo as the type locality of all of them that occur there.

C5d. Fort Nassau (5–N; L68° 56.41′, 12° 7.03′). The old fort crowns the summit (68.3 meters) of a triangular monadnock of the older limestone, which is separated from the Schaarlo by a small valley. Most of the shells collected come from the base of the eastern end of the escarpment, where the vegetation is slightly more luxuriant than on the Schaarlo.

Station C6. This includes the limestone ramparts from Sint Anna Baai to Piscadera Baai (5–W). The two main peaks of the older limestone, Seroe Pretoe and Veerisberg, together with Jack Evertszberg, are known as the "Three Brothers" (fig. iii–5). Three substations are recognized.

C6a. Seroe Quinta (6–S; L68° 56.96′, 12° 6.97′). Behind Overzijde, which is the portion of Willemstad on the northwest side of the harbor channel, is a ridge (37.7 meters) very similar to the Schaarlo.

C6b. Seroe Domi (6–T; L68° 57.57′, 12° 7.32′). This monadnock (84.8 meters) of older limestone bears about the same relation to Seroe Quinta that Fort Nassau does to the Schaarlo.

C6c. Seroe Pretoe (6–U; L68° 58.33′, 12° 7.41′). Black Mountain, the first of the Three Brothers, is slightly higher (135.5 meters) than the second, Veerisberg (131.5 meters; 6–V). Most of the collection comes from the leeward slope of the former and from the ridge of recent limestone between both of them and the ocean. This locality, probably on account of the greater altitude of the two peaks, is considerably better wooded than the ridges around Willemstad. It is separated from Seroe Quinta by a valley in the diabase.

Station C7. This includes the limestone from Piscadera Baai to the Salinja van Sint Michiel (7–B). Two localities were collected.

C7a. Jack Evertszberg (7–Z; L68° 59.39′, 12° 7.92′). The lowest of the Three Brothers (115.3 meters) is quite heavily wooded along Piscadera Baai and at the base of the northern escarpment. Most of the shells obtained come from the ridge of recent limestone near the ocean; along this portion the sea-cliffs are quite high. I ascended this peak on the day after a heavy rain, which had cleared the atmosphere of its usual haze (fig. iii–5); from the summit, Bonaire seemed but a short distance away, while Aruba could be made out, and the higher coastal peaks of Venezuela, from Santa Ana on the Paraguana Peninsula to the Cumbres back of Puerto Cabello, were plainly visible.

C7b. Sint Michielsberg (Seroe Blandan; 7–A; L69° 0.09′, 12° 9.24′). This peak of the older limestone is quite barren, except at the base of the western escarpment, where the collections were made.

Station C8. Seroe Spreit (8–D; L69° 0.34′, 12° 9.34′). Although this peak of the older limestone, to the north of

Salinja van Sint Michiel, is considerably lower (51.2 meters) than Seroe Blandan across the lagoon, the western escarpment is more heavily wooded and has a richer molluscan fauna.

Station C9. Seroe Popchie (9–E; L69° 3.92′, 12° 12.44′). This hill of the older limestone (85.3 meters) on the eastern side of Boca Sint Marie (9–G) is quite barren, as regards both vegetation and molluscan population. The collection comes from the steep, western slope.

Station C10. Seroe Boca (10–H; L68° 49.19′, 12° 7.14′). This low ridge (40 meters) on the eastern side of Sint Joris Baai (10–I) is one of the most barren localities collected. The cap of older limestone is quite thin and the reddish residuum correspondingly prominent. The top of the mesa is quite devoid of vegetation, with the exception of two or three giant cacti (Cereus). The trade winds, although they come fresh from the ocean, are so dry that after a few hours sojourn (much of the time in the shade), my conjunctivae became so inflamed that I was hardly able to see for some time afterward. However, the deeper crevices of the rocks are green with grass, and dwarfed manzalienja trees, which require considerable moisture, are bunched on the leeward side of the escarpments and detached rocks. The effect of the trades is evident, for their tops are leveled off at the limit of protection, as if they had been trimmed artificially. The entire aspect of the locality gives the impression of a wind-swept mountain peak at and above timberline (compare fig. v–11). As already mentioned, I suspect that a portion of the moisture comes from the heavy dews; I am sure that these form in similar places on Aruba. Despite the vicissitudes of such a habitat, Tudora and Cerion are present in the cracks of the rocks and even upon the cacti. Peculiarly enough, the specimens of the former are larger than the average, although those of the latter are much dwarfed (*C. uva diablensis*). The specimens of Cerion from the base of the leeward escarpment, where they occur even under the manzalienjas, are larger than those from the summit of the ridge; the entire lot from this station gives a bimodal curve.

Station C11. This includes four localities along the ridge that skirts the coast of Hato. The cap of ancient limestone becomes progressively thinner and the vegetation more sparse towards the southeastern end, where the conditions approximate those of Seroe Boca (C10).

C11a. Seroe Markita (11–L; L68° 50.95′, 12° 9.06′). This lot is from the more barren end (50.1 meters) of the Hato ridge.

C11b. North of Ronde Klip (11–M; L68° 52.06′, 12° 9.38′). The southern slope of this portion of the ridge (59 meters) is more heavily wooded than C11a.

C11c. Seroe Papaja (11–N; L68° 57.20′, 12° 10.71′). The dwarfed vegetation on the top of this ridge (62.6 meters) is abundant, while the base of the low escarpment, and the areas between the large, detached blocks of limestone, are grown up with brush and trees and support a thriving molluscan population. Most of the collection comes from these more protected places.

C11d. Near Landhuis Hato (11–O; L68° 57.92′, 12° 10.95′). The high northern escarpment of Seroe Spelonk (70.4 meters) is excavated into spacious caves, with enormous stalactites pendant from their roofs (fig. v–13). At Landhuis Hato, one of the only permanent streams on the islands issues from a cave. The nearly level terrane near the base of these cliffs supports a luxuriant growth of brush, and the densest stands of Cereus that I have ever seen.

Station C12. Ronde Klip (12–P).[16] This mesa is separated from the nearby Hato ridge by a valley, in which the diabase comes to the surface. It is almost encircled by a high escarpment of the older limestone, which surmounts the steep, reddish slopes with diabase outcrops.

C12a. Base of western escarpment. (L68° 52.08′, 12° 9.00′). At the base of the limestone cliffs are thickets of brush and clumps of larger trees. This is one of the richest habitats in central Curaçao.

[16] See Boldingh, p. 156; "Ronde Klip."

C12b. Top of Ronde Klip (L68° 52.02′, 12° 8.98′). The plane summit (129 meters) of the mesa slopes slightly towards the north. The brush is dwarfed and much less luxuriant than in C12a.

Station Cb6a. Shore, Campo Marchena (6–X; L68° 57.73′, 12° 7.72′). An old fruit plantation on the east shore of the Schottegat (5–R) was searched, but *Succinea gyrata* was the only species obtained.

Station Cb6b. Hill with ruins, Campo Blenheim (6–Y; L68° 57.1′, 12° 7.94′). This small knob (20 meters) is formed by an outcrop of diabase, but the reddish color of the residual soil gives evidence of the former limestone cap (compare fig. vii–18). The type locality of *Cerion uva desculptum* is probably some similar hill in this vicinity, as it forms here a small proportion of the Cerion population. The shells occur only on the rather barren hill, although it is near fertile and wooded valleys.

Station Cb7. Near Landhuis Klein Piscadera (7–C; L68° 59.03′, 12° 8.64′). A few dead shells were collected among leaves at the edge of an irrigated fruit plantation near the highway. Diabase is the underlying rock.

Station Cb10. Near Seroe Mainsjie (10–K; L68° 49.21′, 12° 6.75′). This hill (30.7 meters) formed by an outcrop of diabase, is partially protected by the ridges nearer the shore. *Cerion uva desculptum* occurs here, along with the sculptured form.

Station C13. Seroe Largoe (13–R; L69° 4.18′, 12° 12.17′). The sloping top (73.2 meters) of this headland is covered with a rather thick growth of brush. At the base of the high northern and western escarpments of the older limestone, Bursera and other large trees are quite numerous. The molluscan population of this station is a mixture of the northern and central elements of the Curaçao fauna. *Tudora fossor djerimensis* occurs especially along the base of the escarpment, while *T. megacheilos spreitensis* and *T. muskusi bullenensis* share the mesa top itself. The cerions are representative of the southern subspecies, *C. uva uva.*

Station C14. Seroe Grandi (14–V; L69° 7.00′, 12° 14.60′). This quadrangular headland (80.2 meters) of the more ancient limestone is much more barren of vegetation than are the stations farther north, or even C13. The collection comes from the northwestern end, and from along the hills just south of Sint Jan Baai (14–W).

Station C15. Seroe di Boca (15–X; L69° 8.11′, 12° 16.13′).[17] This ridge (70.2 meters), just south of Sint Martha Baai (15–Y), is capped with a thin layer of the older limestone, and the unconformity with older rocks is very evident at the base of the northeastern escarpment, where the collection (accidentally mixed with one of the lots from C17a) was made. The vegetation in this locality is more or less intermediate between that of C14 and that of C16.

Station C16. Seroe Baha So (16–Z; L69° 9.51′, 12° 17.68′). This lot of specimens comes from the southern escarpment of the hill itself (118.2 meters) and from near the edge of the shore cliffs (11.4 meters) as far northwest as Sint Kruis Baai (16–A). As regards vegetation, this is perhaps the richest limestone habitat studied in northern Curaçao.

Station C17. This includes the rim of the older limestone formation, from Sint Kruis Baai to Plaja Abau. Three localities were collected.

Station C17a. Seroe Djerimi (17–C; L69° 9.77′, 12° 20.14′). This quadrangular limestone hill (70 meters) is almost entirely surrounded by escarpments, which are more precipitous at the eastern end (fig. iii–6). The collections come from the base of this escarpment (lot accidentally mixed with that from C15), and from the top.

C17b. Top of shore cliffs (17–D; L69° 10.02′, 12° 20.46′). This lot comes from the top of the high shore cliffs (about 10 meters) between Plaja Djerimi (17–F) and Knip Baai (17–D). It is a considerably more barren substation (fig. vi–14) than the nearby seroe.

C17c. Sides of Plaja Abau (17–E; L69° 9.83′, 12° 21.24′). Plaja Abau ends in a beach of dazzling white, coral sand.

[17] Compare "The lime hills near St. Martha," Boldingh, p. 155.

On either side, the overhanging shore cliffs (8.2 meters) extend for a short distance inland; the calcareous zone at their summits is very narrow. The valley mouth itself is choked with mangroves and brush.

Station C18. Limestone remnant (18–K; L69° 9.88′, 12° 21.41′). North of Plaja Abau, the older limestone formation is mainly limited to the short cliffs. A small isolated remnant (25 meters) about 400 meters north of Plaja Abau, was collected during a shower. The rapidity with which the cyclostomes, and even the cerions, are activated by the rain, is astonishing; copulation seems to be the first motive after release from aestivation. Peculiarly enough, the specimens of *Tudora fossor westpuntensis* from this station are very small, while those of *Cerion uva knipensis* are among the largest collected.

Station C19. Westpunt (19–M; L69° 10.52′, 12° 22.94′). The top (9.9 meters) of the shore cliffs at Westpunt, which is northwest of the hamlet of the same name, is bordered with a narrow strip of quite barren, older limestone, dirtied by abundant pockets of the characteristic reddish residue. Cacti form the major portion of the very sparse vegetation.

Station C20. Tafelberg of Sint Hyronimus (20–N; L69° 6.90′, 12° 19.32′).[18] This high, isolated mesa (229.9 meters), more commonly known as Sint Hyronimusberg, is one of the most conspicuous landmarks of Curaçao. The ancient limestone cap is thin, so that the encircling escarpments are low, but the reddish slopes of the underlying, diabasic rocks are also quite steep. The leeward side is well wooded, as is also a portion of the top, but the omnipresence of reddish residual dust appears to make this a rather barren habitat for land molluscs.

Station Cb16. Near Landhuis Sint Kruis (16–B; L69° 8.86′, 12° 18.49′). Southeast of the head of Sint Kruis Baai, an outcrop of Cretaceous rocks is crowded with a dense growth of organ-pipe cacti. Among these, a few land shells were collected.

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[18] See Boldingh, p. 157; "The limestone table-land on Hieronymusberg."

Stations Cb17 and 20.[19] Sint Christoffelberg (372.44 meters), the highest peak in the Dutch Leeward Islands, is the climax of a much dissected mass of sedimentary, Cretaceous rocks, which outcrop in a complex series of folded and twisted laminae. The leeward slopes of these hills, and especially the narrow valleys that open to the north and west, are the most heavily wooded places in the islands. Especially conspicuous are the large clumps of the yellowish-green *Bromelia lasiantha,* which holds water in its sheathing leaves, and may carpet areas several acres in extent. In the richer valleys, and especially near the top of the western side of Sint Christoffelberg, epiphytes (*Tillandsia utriculata,* etc.) and lianas (Ficus, etc.) increase the luxuriance of the foliage, until it presents an aspect very different from the usual arid lowlands of the islands. In the broader valleys (fig. iii–6), the divi-divi and acacias attain a larger size than elsewhere, and, with the organ-pipe cactus and Opuntia, often form quite impassable thickets; the larger trees are also more abundant on the hillsides. Peculiarly enough, the land molluscs, with the exception of *Drymaeus virgulatus,* bury themselves deeply in the rock talus, although the same or similar species may aestivate on the brush and trees in much less humid situations.

Cb17a. Valley between Seroe Bientoe and Seroe Palomba (17–C; L69° 9.47′, 12° 20.29′). This steep-sided, west-facing valley between Windy Mt. (224.8 meters) and Dove Mt. (163.1 meters) is almost choked with brush (fig. vii–19), but is more barren than the next.

Cb17b. Valley between Seroes Palomba and Baha Hoendoe (L69° 9.10′, 12° 20.34′). This north-facing canyon was collected during a rainstorm, when the molluscs were moving around on the surface; for this reason, the shells appeared much more abundant than in the other localities examined. However, this was the most heavily wooded valley visited. Most of the shells were obtained near its mouth, but *Drymaeus*

[19] Compare Boldingh, p. 157; "Christoffelberg"; and K. Martin, I, pl. X, XI and XII.

virgulatus was more numerous at its head, near the saddle between Seroes Palomba and Baha Hoendoe (211.9 meters).

Cb17c. Landhuis Knip (17–H; L69° 9.33′, 12° 20.77′). The country house of plantation Knip is on a spur (40.6 meters) of Knipberg. A few shells were picked up around the outhouses.

Cb17d. Irrigated valley (17–I; L69° 9.59′, 12° 21.11′). The hofje that ends in Plaja Abau is mainly planted with sorghum, but includes a few clumps of fruit trees and bananas.

Cb20. Sint Christoffelberg (20–P; L69° 8.24′, 12° 20.30′). Near the summit of the western side of this hill, the slope is very steep, with many small cliffs, but humus and leaves have collected on the ledges where trees and brush can gain a foothold.

Klein-Curaçao

This low, comma-shaped island (fig. 2) is less than 2 1/2 kilometers long. The surface is practically flat, and probably nowhere attains an altitude of much over 5 meters; I was told that the waves break over it during the heavier storms. It is very barren and arid, like the eastern shores of the larger islands, and the sparse vegetation is entirely composed of halophytes. Except for the phosphate deposits on the western shore, the bare limestone rocks are exposed everywhere, and form low sea-cliffs along the eastern side and at the ends of the island. No land molluscs were found.

Aruba

The island of Aruba is the smallest and most arid of the three main islands. The limestone is mainly restricted to the southwestern side and the southeastern end, where the more recent layers form quite extensive, rather featureless areas, which usually slope up quite gently from the low (1 to 2 meters) shore cliffs. As the older limestone is not so generally exposed, high escarpments are rarely formed, although those of Seroe Canashito are conspicuous exceptions, while the eastern escarpment near Boca Grandi (fig. I–3, C), and the sides

of the canyon-like roois around Savaneta (I), are also precipitous. The southwestern side of the island is protected by a series of coral reefs, which often form narrow islands, less than a kilometer off shore (fig. v–12).

In the diabasic portion of the central region,[20] Seroe Jamanota (J), the highest hill (188.37 meters) on the island, is considerably lower and much less wooded than are the higher hills in Curaçao and Bonaire. The northern half of Aruba has a core of quartz-diorite, which closely resembles the rocks of the Pikes Peak Region in Colorado, and also contains veins of gold. Enormous, rounded boulders of this material, which are often hollowed out on their leeward sides, and outwash fans of angular gravel are conspicuous features of the landscape in this portion.[21]

Although the molluscan fauna changes slightly at Spaansch Lagoen (M), Aruba is more nearly a unit than is the case with Curaçao.

Station A1. Culebra (A; L69° 52.99′, 12° 25.26′). Near the southern end of Aruba is a rolling plain of the older limestone, with many sink-holes, which contain the characteristic reddish residuum. Most of the shells were collected around the buildings of an abandoned mining camp, near the phosphate deposits. Subfossil *Cerion uva* is common in this locality, but no living specimens could be found. The eastern shore near Boca Grandi (C) is built up with sand dunes, partially held by clumps of "dreifi" trees (*Coccoloba uvifera*). Most of the region is very barren and resembles C10.

Station A2. This includes the higher plateaus and mesas of the ancient limestone, south of Spaansch Lagoen. Most of the specimens collected came from three localities.

A2a. Near Butucoe (D; L69° 55.44′, 12° 28.23′).[22] This lot comes from a small, wooded valley near the southern edge of Baranca Kasioenti. The higher portions of this plateau are about as heavily wooded as any portion of the limestone areas in the islands.

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[20] See Boldingh, p. 160; "Mirlamar."

[21] See K. Martin, II, p. 47, fig. 15.

[22] See Boldingh, p. 159, "The calcareous table-land near Fontein."

A2b. Spur of Seroe Pretoe (E; L69° 54.35′, 12° 26.74′). This plateau (altitude about 50 meters), between Roois Hundoe and Spoki, is southeast of the main summit of this limestone hill. The larger trees are especially common here; most of the shells come from around the bases of Guaiacum and Bursera trees.

A2c. Baranca Alto and Isla (F and G; L69° 57.77′, 12° 28.50′ and 69° 57.45′, 12° 28.28′, respectively).[23] The Isla is a rather high, limestone mesa (72.5 meters), which is almost completely surrounded by canyon-like roois. Baranca Alto (about 50 meters) is the crest at the inner edge of the coral formation, along Rooi Taki (K). Both of these localities have patches of brush and larger trees, but are considerably more barren than the southern substations.

Station A3. Rooi Frances (L; L69° 58.73′, 12° 29.09′). This lot was obtained from a ledge at the base of the escarpment of older limestone, on the western side of this rather barren canyon.

Station A4. Seroe Canashito (N). This quadrangular, limestone remnant (70 meters) is the only place, north of Rooi Frances, where the older limestone develops high, precipitous escarpments (fig. iv–8).

A4a. Base of northern escarpment (L70° 0.05′, 12° 30.50′). The inner edges of Seroe Canashito are broken off abruptly as high, vertical or overhanging cliffs, which surmount the steep slopes of the underlying, older rocks. These cliffs contain small caves which are decorated with aboriginal picture-writing. Most of the specimens come from the talus at the base of the northern escarpment.

A4b. Top of Seroe Canashito (L70° 0.07′, 12° 30.44′). The sloping top of this mesa is typically eroded into jagged points and honeycombed with irregular holes. Most of the vegetation is dwarfed and distorted by the wind.

Station A5.[24] The exposures of recent, chalky limestone

[23] Compare Boldingh, p. 159; "The calcareous table-lands near Belashi."

[24] Compare Boldingh, p. 159; "The country near Manshebo."

along the southwestern shore of Aruba, north of Spaansch Lagoen, form gently sloping plains, which are almost completely utilized as aloe plantations. However, a narrow strip along the top of the low shore cliffs (1 to 2 meters) is too jagged and broken by crevices to permit easy cultivation, and remains in quite primitive condition. A few distorted divi-divi trees and acacias break the monotony of Opuntia and dwarfed *Jatropha urens,* which does not hide the barren rocks (fig. v–12).

Subfossil shells of the recent species are quite common in the aloe fields, along with *Oxystyla maracaibensis imitator,* which was not found alive. Living shells are mainly limited to these uncultivated spots, although a few occur within the limits of the aloe plantings and even on the pungent, yucca-like leaves.

A5a. Near Perkietenboseh (O; L70° 0.54′ 12° 29.28′). Just north of Perkietenboseh, this shore strip is scattered with willow brush and small thorn trees.

A5b. Southeast of Oranjestad (P; L70° 2.04′, 12° 30.52′). The more barren portions along the top of the shore cliffs necessitate a great deal of work for the net results in shells collected. Only a few of the large, flat rocks have any shell population on their lower sides, and this mainly consists of pupillids.

Station A6. Limestone remnant, near Tanki Schipau (S; L70° 2.0′, 12° 31.88′). A few shells were collected around this little mass of the older limestone rocks, in the aloe fields near the inner edge of the limestone area.

Station A7.[25] This includes three localities near the northern end of the island, which is even more arid and barren than Seroe Boca (C10) on Curaçao.

A7a. Shore near Malmok (V; L70° 3.33′, 12° 35.93′). In this place, narrow strips of recent limestone alternate with low, brush-covered dunes.

A7b. Seroe Annaboei (W; L70° 2.64′, 12° 36.15′). The

[25] Compare Boldingh, p. 160; "The Hills in the N. W. part."

top of this small mesa of the older limestone (25 meters) is absolutely barren, but an impenetrable thicket of Opuntia and a few, dwarfed thorn trees grow in the shelter of the leeward end. A few living shells were collected under the rocks at the western end of the top.

A7c. Seroe Hudishibana (X; L70°, 3.45′ 12° 36.70′). This cap of extremely barren, ancient limestone (25 meters) is near the northern tip of Aruba. A few dead shells of *Tudora fossor canashitensis* were obtained at the base of the leeward escarpment near the lighthouse.

Station A8. Near Boedoei (Z; L69° 59.35′, 12° 32.89′).[26] Along the northern portion of the arid, northeast shore of Aruba, the limestone is mainly limited to the immediate vicinity of the shore cliffs. In a few places, narrow tongues of dirty limestone lie in the valleys. Near the gold mines of Boedoei, a small limestone remnant (26.2 meters) forms a little knob on the northern side of the valley. Although this locality is very barren, a few specimens were obtained.

Bonaire

Fundamentally, this island is very similar in structure to Curaçao and Aruba. However, apparently in quite recent times, low, almost flat wings have been added on either side of the main anticline, the long axis of which runs in the general direction of the line between Seroe Brandaris (Plate II–W) and the southern Seroe Grandi (I). The northeastern addition, which practically coincides with Campo Bolivia (O) is the higher (mostly less than 30 meters); while the southwestern one forms the low area (less than 10 meters' altitude) south of Kralendijk. Klein-Bonaire appears to be a continuation of this latter emergence. Also, the southwestern side of the main anticline still retains a large proportion of its cap of older limestone, so the entire island has a proportionately much greater exposure of the coral formations than either

[26] Boldingh, p. 160; "The Hills near Andikurie," describes the vegetation of the adjacent outcrops of quartz-diorite.

Curaçao or Aruba. On the whole, Bonaire is better wooded than are the other two main islands, but the northern hills do not attain the altitude or the richness of those on Curaçao. Like Aruba, this island has a more homogeneous molluscan fauna than is the case with Curaçao.

Station B1. South of Kralendijk (B; L68° 16.68′, 12° 8.08′).[27] The southern shore of Bonaire exposes extensive stretches of bare, recent limestone rock (fig. vi–15). Numerous sink-holes show the presence of fresh and brackish water a short distance below the surface; as a result, the vegetation is fresh and verdant, wherever it is sufficiently protected from the dry winds (fig. vi–16). Most of the shells come from along the highway near the western shore.

Station B2. Shore near Hato (F; L68° 17.51′, 12° 11.49′). As Kralendijk is the principal port of the island, the material from which the earlier species were described probably came from the near vicinity. Everything points to the fact that Hartert only collected near the town itself, as he obtained Potamopyrgus, which occurs in a well in the town, and the small species that live in the more arid situations, but missed those from the hills. *Neosubulina harterti* is the only one of his species that I did not find near town, and it doubtlessly occurs around some of the buildings. However, it seems peculiar that he should have missed *Cerion uva,* which is abundant everywhere. Either this station or the preceding one is quite representative of the conditions around Kralendijk. The present station, along the top of the low shore cliffs north of the town, is somewhat richer than B1.

Station B3. Eastern portion of Montagne. Seroe Largoe or Montagne (L) is the main portion of the limestone which covers the western side and summit (133.4 meters) of the southern portion of the principal anticline.

B3a. Southeastern escarpment (G; L68° 16.31′, 12° 11.76′). The southeastern edge of Seroe Largoe, south of Kibra di Montagne, forms a rather prominent escarpment of the older lime-

[27] Compare Boldingh, p. 161; "The country around Kralendijk."

stone. The locality collected is at the base of these cliffs, where the vegetation is as rich as in any portion of the windward side (fig. iv–10).

B3b. Kibrá di Montagne (H; L68° 16.29′, 12° 12.01′). A high saddle (about 100 meters) separates the main hill from a narrow limestone ridge that extends in an easterly direction. The pass itself is rather barren, although the vegetation is much richer in the valleys at either side (fig. iv–9).

Station B4. Western slope of Montagne (K; L68° 17.24′, 12° 11.86′).[28] The valleys on the leeward slopes of Seroe Largoe (Campo Santa Barbara) contain dense thickets of brush, interspersed with clumps of larger trees. The station is in one of the richer of these, and is perhaps the most heavily wooded locality collected on the limestone of any of the islands. The crotons attain a height of 2 meters, and form almost impassable thickets, except where the larger trees outshade them. Most of the shells come from around the Guaiacum and Bursera trees.

Station B5. Porta Spaño (M; L68° 16.68′, 12° 14.06′).[29] At the top of the low cliffs that form the northern border of the broad plain of Campo Bolivia (O), the larger trees form rather open groves, which are as extensive as any in the islands.

Station B6. Base of cliffs near Fontein (P; L68° 17.73′ 12° 14.66′). The northern escarpment of Seroe Grita Kabai (87 meters) is high and precipitous. At Fontein, a tiny rivulet, the only permanent stream on Bonaire, emerges from a cave in the older limestone. The locality collected is at the base of the cliffs just north of Fontein; the reddish residual deposit is especially prominent at this place.

Station B7. Punta Blanco (R; L68° 12.67′, 12° 10.25′). Near the southeastern end of the main anticline, the recent limestone, along the eastern shore of the island, is limited to a comparatively narrow border. At Punta Blanco (21.5 meters), the inland edge of this formation presents low escarp-

[28] Compare Boldingh, p. 162; "The lime table-land near Montagna."

[29] See Boldingh, p. 162; "On the calcareous soil near Bolivia."

ments. Near the shore, the surface is very barren (compare C10), but at the summit of the leeward cliffs, where this collection was made, scattered trees indicate a richer environment.

Station B8. Seroe Wassau (T; L68° 22.58′, 12° 14.18′). West of the Salinja Goto (U), the older limestone forms a rather high hill. The top (123.5 meters) and eastern slopes are considerably more barren than B3, 4, 5 and 6, but the base of the northern escarpment has developed quite rich vegetation. Collections were made in both portions.

Station B9. Seroe Grandi (V; L68° 21.33′, 12° 17.78′). At the northern end of Bonaire, the narrow shore zone of the older limestone is excessively barren and arid. In a few places, the inner edge rises into hills with steep, southern escarpments. The largest of these, Seroe Grandi, protects a sparse growth of acacias and organ-pipe cacti. The molluscs mainly occur at the base of the escarpment, around and on the cacti.

Station Bb3. Seroe Grandi (I; L68° 16.01′, 12° 11.07′). "Big Mountain" is a rather common name in the Dutch Leeward Islands. This one is a monadnock (115.3 meters) of Cretaceous rocks, near the southeastern end of the main axis of the island. The leeward slopes are quite well wooded. This is the type locality of *Anolis bonairensis* Ruthven.[30]

Station Bb5. Traai Montagne (N; L68° 16.35′, 12° 12.78′). Near the eastern slope of Seroe Largoe, the somewhat sparser vegetation in the region of Cretaceous rocks quite closely resembles the open groves of the limestone area near Porta Spaño (B5).

Station Bb7. Inland from Punta Blanco (S; L68° 13.17′, 12° 10.18′). Behind the protection of the eastern rim, the richer valleys of the central region develop thickets of brush interspersed with larger trees. Many localities show, by their reddish soil, that the erosion of the limestone cap has been comparatively recent.

Station Bb9. Base of Seroe Brandaris (W; L68° 23.97′,

[30] 1923; *Occ. Papers Mus. Zool. Univ. Mich.*, no. 143, pp. 4–5.

12° 17.13′).[31] Although extensive thickets of brush and clumps of larger trees are present, the northern hills of Bonaire are more arid and barren than those of Curaçao. The few shells collected come from the base of the leeward slopes of Seroe Brandaris, the highest peak (240.4 meters) on Bonaire. Here the thin soil overlies a substratum of mica-porphyrite.

Klein-Bonaire

Station K1. Klein-Bonaire (Y; L68° 18.02′, 12° 9.51′). This island is a low, almost flat mass of recent limestone (6.4 meters at the highest point), separated from Bonaire by a narrow, but rather deep (34 fathoms) channel, which forms the harbor of Kralendijk. The general aspect of the surface is very similar to that of the region south of Kralendijk (figs. vi–15, 16), but the vegetation is somewhat richer, especially near the center of the island, where most of the collection was made. The smaller shells are most numerous under slabs of limestone around the bases of the larger trees.

Freshwater Habitat

The permanent bodies of freshwater on the Dutch Leeward Islands, fall into three classes: (1) springs and pools in the central portion, (2) sink-holes in the recent limestone, and (3) the rivulets. As already discussed, the sparse precipitation tends to fall in rather heavy storms. During these, and for some time afterward, numerous streams pour down the roois, and form shallow sheets of water on the flats. In the central region of older rocks, extensive systems of artificial dikes hold some of this water, and a few of these pools may even outlast the dry periods (stations Cc11, 13, 17). The porous rocks also retain fresh to brackish water just above the level of the salt water; this is reached by artificial wells in the older rocks (Cc2), and by natural sink-holes in the recent limestone (Bc1, Kc1). All of the permanent streams emerge from caves in the

[31] See Boldingh, p. 163; "Brandaris."

older limestone escarpments near the northeastern shores. At Fontein van Bonaire, and at Hato van Curaçao, these tiny rivulets are piped into cement tanks, but at Fontein van Aruba (Ac2) a little stream escapes from the roughly dammed reservoir at its source. All of this water is heavily charged with mineral matter in solution, and a large proportion of the stagnant pools are so brackish as to be undrinkable.

Station Cc2. Reservoir, Campo Wilhelmina (fig. I–1, 2–D; L68° 50.57′, 12° 5.38′). In front of Landhuis Wilhelmina a small tank is supplied by a windmill. The water is drinkable.

Station Cc11. Pond, Seroe Papaja (11–N; L68° 57.31′, 12° 10.63′). In a rooi at the western end of Seroe Papaja, a clay dike retains a small, but apparently permanent pool of foul, bitter water. Only dead shells were found.

Station Cc13. Sint Marie Spring (13–S; L69° 4.53′, 12° 11.86′). Near the western end of Seroe Largoe (13–R), and not far from the shore of Salinja Sint Marie (9–G), seepage forms a small, but permanent pool of quite fresh water. The shells were collected on dead leaves and in the algae.

Station Cc17. Pond, Campo Lagoen (17–L; L69° 9.70′ 12° 19.83′). The rooi that issues from the valley of Newtown has been excavated and walled with stone so that a permanent pool is retained. The water is utilized for stock animals.

Station Ac2. Fontein van Aruba (fig. I–3, H; L69° 54.74′, 12° 29.54′). On the extremely barren northeastern side of Aruba, shoreward from the principal escarpment of the older limestone, is an oppressively arid zone of limestone or older rock, which, in places, is buried under rather extensive sand-dunes. Approach to Fontein from the south reveals what appears to be a bank, covered with dead brush, which extends from near the escarpment almost to the shore (fig. v–11). Penetration between this and the cliffs discloses that it is a windbreak of living thorn trees, which protects a garden of fruits and bananas. The cause of this abrupt change is the Fontein, which is roughly dammed at its source under the cliffs, but escapes as a small stream, about a foot wide by the same deep,

to irrigate the strip of plantation. The shells are very numerous on the rocks, in both the reservoir and the brook. The water is truly potable.

Station Bc1. Pos Baca (pl. II, C; L68° 16.32′, 12° 8.44′). South of Kralendijk, the low plains of recent limestone contain numerous sink-holes, which may form small caves; if these reach the level of the ground water, they become natural wells. The different cavities have a wide range in the saline content of the water; in some it is quite fresh, in others distinctly brackish, while the salt pans contain highly concentrated sea water. That of Pos Baca (fig. vi–15) is slightly brackish, but is used for stock animals, while that of Pos Frances, which contains small fishes, is potable.

Station Kc1. Pos di Cas (Z; L68° 17.56′, 12° 9.70′). Klein-Bonaire is very similar in structure to the southern portion of Bonaire, and contains several sink-holes which make natural wells. One of these forms a small cave near the only habitation on the island; the water is slightly brackish, but drinkable. Analagous cavities are also present on Klein-Curaçao; the water in one of these is drunk by goats, but no freshwater shells were found.

Native Species

NERITIDAE

Neritina zebra (Bruguière)

N. zebra Martens (1879; Chemn., II, 118); collected by Deplanche.
Type locality: Cayenne, Guiana.

Distribution: Brazil to eastern Venezuela; Panama? Curaçao. I did not obtain this species. Possibly it has been exterminated by the conversion of many "salinjas" into salt pans.

Theodoxus meleagris (Lamarck)

Type locality: Rivers of Santo Domingo.

Distribution: South Carolina, Bermudas and Mexico, to Brazil. Curaçao: five dead and one living juvenile specimen from the inner end of Sint Kruis Baai (Cd16).

The radula of the living specimen agrees with this species, although it is so juvenile that only 8 points occur on the D-lateral. No Neritidae were found in the truly fresh water habitats, and these were the only specimens (outside of the genus Nerita) obtained from salt or brackish water, although a number of promising localities were examined.

HELICINIDAE

Stoastomops walkeri H. Burrington Baker
(1924; Naut. XXXVII, 89)

Type locality: (B4) valley on western slope of Montagne, Bonaire.

Distribution: Bonaire, limestone hills (B3–8); Klein-Bonaire, central portion (K1). On the underside of surface rocks, usually cemented so firmly into cavities and crevices that it is very difficult to remove specimens entire.

Shell (fig. viii–20): depressed turbinate, subacuminate; thin and fragile. Color: golden brown to distinctly reddish. Whorls: 4½, markedly convex; suture well marked. Later whorls: growth wrinkles pronounced but rather irregular; spiral thread-riblets fine and numerous (about 30 on last whorl), but irregularly spaced, more obscure on base of shell. Embryonic shell: ¾ whorls; white; practically smooth but with irregular growth-wrinkles and punctations present. Umbilicus: narrowly rimate. Aperture: subbasal, reniform, internally deep orange. Peristome: simple, sharp, incomplete; columellar wall deflected and thickened by whitish callus, which spreads out extensively on base of penultimate whorl but terminates abruptly, at its distal end, so as to form a slight, but distinct emargination just above the basal angle.

Operculum (fig. viii–21): horny plate whitish and very thin, but slightly larger than the yellowish, calcareous one; the outer surface of the latter very slightly concave, with minute, raised punctations; inner surface with eccentric growth-lines and with subspiral nucleus at apex of rather broad, parietal triangle.

Radula (fig. ix–25): B; A/2–3, B/2–3, C/3, D/3, E; M 5–6/1, 2–3/2, 1/3, (13–15/3 +) = 23–25; total 57–61. Rhachidian central: broadly shield-shaped with raised, anterior margin. A–central: somewhat similar to that of Stoastoma,[32] but with two, stout, aculeate cusps and sometimes a minute accessory one. B–central: similar to A–central but with more ovoid base. C–central: elliptical with two, stout, aculeate cusps on the reflected, anterior end, and usually a small, outer one. D–lateral: similar to Stoastoma but with only two very heavy cusps and a third, vestigial one either outside or inside of these. E–lateral: similar to Stoastoma but stouter and heavier. Marginals: 23 to 25, of which the 5 or 6 inner are unicuspid, 2 or 3 are bicuspid, 1 is tricuspid, and the others of the series increase the number of cusps rapidly; the outermost uncini are broad and multicuspid plates as is characteristic in the Helicinidae.

What I take to be the males are smaller and more depressed than the dimensions given below.

Dimensions[33]

Shell		Aperture		Calcareous Operculum	
altitude	major diam.	altitude	diameter	length	width
2.14	109 (2.34)	42 (.91)	143 (1.31)	44 (.94)	79 (.74)

This monotypic genus combines, to a remarkable degree, the shell and operculum of Eutrochatella, subgenus Pyrgodomus, with the radula of Stoastoma. In general appearance, the shell most closely resembles the Cuban species, *E. continua*

[32] 1922; *Proc. Acad. Nat. Sci. Philadelphia,* LXXIV, p. 58, fig. vi–26.

[33] Throughout this paper, the altitude of the shell is given in millimeters, but the other dimensions are expressed as indices, followed by the actual measurement (in parentheses). The index of the major or minor shell diameters, the altitude of the aperture, or the length of the operculum, is the percentage obtained on division by the altitude of the shell. The index for the diameter of the aperture is similarly taken in terms of its altitude, while that of the operculum is in terms of its length. Unless otherwise stated, all dimensions are outside measurements. Altitudes are scaled parallel to the central axis of the shell, while the major and minor diameters are at right angles to this and to each other. Lengths are major dimensions, and widths are measured at right angles to them.

("Gundlach" Poey) and *E. pfeifferiana* ("Arango" Pfr.). It differs from all of the species of Pyrgodomus in its narrowly rimate umbilicus and the slight but definite notch on the columellar wall of the peristome. The incomplete, adnate peristome and the Pyrgodomus-like operculum separate Stoastomops from Stoastoma, with which genus the radula most closely allies it. I believe it should be placed in the subfamily Helicininae.

POMATIASIDAE

Members of this family form the most diversified elements of the molluscan fauna of the Dutch Leeward Islands. Most of the species are very local in their distribution; the genus Cistulops is, as far as is known, entirely confined to these islands, while the genus Tudora just reaches the adjacent mainland.

As large numbers of specimens of most of the species and subspecies were obtained, an attempt was made to study statistically their size and shape. For each subspecies, a set of shells, if possible from the type locality, was measured for altitude and minor diameter. The latter was chosen as less variable and more easily measured than the major diameter. As the shells were almost universally decollated, it was also necessary to count the whorls retained; quarter-whorls were taken as unit differences. From these dimensions, the minor diameter index was obtained. As the sexes of all of the specimens had not been noted during removal of the animal, a curve was made by counting the individuals of each minor diameter (in tenths of millimeters). In all cases where the specimens had come from a single locality, this curve was bimodal; and the lowest internodal point was taken as the dividing line between the two sexes. The obvious error, introduced by this approximation, was checked by reference to the modes and by comparison with the curves of species of Tudorata, in which the sexes do not intergrade in size; I believe it to be practically negligible in most cases, but it increases in the smaller species. Using this line of separation,

the shells were arranged in columns, according to sex and number of whorls, and the means for altitude, minor diameter and index were computed for each class, and for the total population of each sex.

In the tables of dimensions (tables IV–VII) are presented the data for the entire population and for some one of the whorl classes. As might be expected, the mean altitude increases and the mean minor diameter index decreases with the number of whorls retained. The males retain a smaller number of whorls than do the females; this appears to be a matter of sex and not of comparative size, as the mean diameter is usually quite constant in those whorl-classes near the mean, although very small shells often retain a smaller number of whorls than do the very large ones of the same sex. In *Cistulops raveni arubana,* complete individuals of both sexes were obtained, and the females appeared to develop a greater number of whorls than did the males. In the larger species studied, the males are slightly more slender than the females with the same number of retained whorls; this also may mean that the males tend to develop a lesser number of whorls. Complete males were obtained of *Cistulops raveni raveni, Tudora maculata, Tudora fossor fossor,* and *Tudora fossor canashitensis*; the data for these are given. In the other subspecies, the number of whorls is that estimated by the comparison of young shells and modal, decollated females; I suspect that the male would average ½ to 1 whorl less. The rather large variation in all dimensions is probably due, in large part, to variation in the number of whorls, which appears to be rather characteristic of these desert shells (compare *Cerion uva*). The apparent variation is also partially caused by the rather large whorl-classes chosen; data from a single whorl-class thus give a markedly flat-topped curve. For these reasons, apparent intergradation, in the indices of two species, does not necessarily indicate actual intergradation in shell form.

CISTULOPSINAE[34]

Cistulops raveni raveni (Crosse)

Cistula raveni Crosse (1872; J. de C., XX, 159); Crosse and Bland (1873; J. de C., XXI, fig. I–5). *Chondropoma* (s. s.) *raveni* Henderson and Bartsch (1920; P. U. S. Nat. Museum, LVIII, 62).

Type locality: "Curaçao"; probably the Schaarlo (C5c), back of Willemstad; collected by Raven.

Distribution of species: Curaçao; north of Seroe Salinja Abau and Ronde Klip; Aruba, south of Rooi Frances. 764 specimens collected.

Distribution of subspecies: Curaçao; Seroe Salinja Abau and Ronde Klip, north of Plaja Abau (C5, 6, 11, 12, 15, 17, 20). Rare to quite common; buried rather deeply under rocks and in crevices in talus, on the more humid, wooded portions of the limestone mesas and escarpments. A purely terrestrial species. 343 specimens collected.

Shell: small, slender obovate, thin. Color: cream to brownish, with 7 or 8, chocolate-colored spiral bands, usually broken into rows of flammulations except on the last ¼ whorl. Whorls: 7 and 8½ in two complete males; about 4¼ retained; not markedly convex, and with quite shallow sutures, at least on the middle whorls; last ½ whorl markedly descends, decreases in diameter and is solute and angulate above. Last whorl: growth sculpture of microscopic, undulating, incomplete and anastomosing wrinkles, and high, compressed, widely-spaced riblets, which are crested at the upper angle or form prominent buttresses at the suture; riblets much more closely spaced near peristome; spiral sculpture of numerous (15–18 counted), low, rounded cords, which are higher and more prominent in the umbilical region, where the growth riblets form cusp-like crests over them. Earlier whorls: similar, but spiral sculpture less prominent, and microscopic growth-wrinkles slightly more regular. Embryonic whorls:[35] 1¾; practically smooth, but very slightly and irregularly

[34] See 1924; *Naut.*, XXXVII, 89–92.

[35] 1923; *Occ. Papers Mus. Zool. Univ. Mich.*, no. 137, fig. I–6.

wrinkled; next whorl with microscopic growth-wrinkles and numerous, low growth-ridges; spiral sculpture and definite growth riblets begin on 3rd whorl; all apical whorls convexly rounded and with well-impressed sutures. Umbilicus: small, tubular; hidden by last whorl. Aperture: broadly obovate, almost circular, and with long axis at about 45° to that of the shell; internally light-colored with prominent, spiral bands. Peristome: duplex; outer portion abruptly deflected; parietal angle with prominent, lanceolate auriculation, which is concave externally and is slightly twisted backwards at its inner edge; lower palatal, basal and lower columellar walls with (almost invariably) 5 elliptical reflections, separated by 6 deep sinuses which correspond to the positions of the more prominent color bands; upper columellar region broadly reflected; parietal wall narrowly reflected; inner portion of peristome continuous but without internal callus.

Operculum (fig. xi–42): 4 to 4¼ whorls; almost circular; nucleus subcentral but slightly nearer basal angle; chondroid plate heavy, almost flat but with rim of each whorl slightly raised; calcareous portion represented only by irregular punctations.

Radula (fig. ix–26): C/3; L1/6–8 + 1/4; M/28–32. Rhachidia central: cowl-shaped, with large cusp curved over the anterior end and a minor one on each side; thickened portion of base ovoid, but thinner wings make the entire tooth a truncated isosceles triangle. Inner lateral: shape similar to central but asymmetrical, with the thickened, inner edge longer than the thin, outer one; the three principal cusps are similar in arrangement to those of the central, but the middle one almost always bears two serrations on either side near its base; on a few teeth only one of these last could be seen on the inner side while in a few others three were counted on the outer side (the refraction of the edge of the main cusp makes the definition of these small points very poor). Outer lateral: with a curved, rectangular base which bears 4 stout, aculeate cusps at its outer end. All of the three inner teeth are thickened transversely just below the cusped tips; when the second

lateral is viewed in profile (view labeled 2 in figure), this shows as a blunt, rounded projection. Marginal: with a series of recurved, lanceolate cusps, which decrease in size towards the outer edge; the edges of the outer ones pectinate

	Measurements					
	Shell		Peristome		Aperture	Whorls
	alt.	maj. diam.	min. diam.	alt.	diam.	inside	
Crosse and Bland; type, from figure	7.0	47(3.3)		34(2.4)	103(2.4)	22(1.5)	4
C12, male; complete	8.8	40(3.5)	31(2.7)	30(2.6)	96(2.5)	17(1.5)	8½
C15, male; complete	7.2	44(3.2)	35(2.5)	32(2.3)	96(2.2)	19(1.4)	7

C5. Living specimens rare (19 collected).
C6. Very infrequent (12 specimens).
C11cd. Frequent (84 specimens).
C12. Frequent (42 specimens).
C15. Quite common (82 specimens). One albino female.
C17. Quite common (94 specimens).
C20. Quite infrequent (10 specimens).

Table IV. Dimensions of Cistulops raveni and Tudora maculata

Subspecies		*raveni*	*arubana*	*maculata*
Locality		C11	A2c	B5
Number of individuals;	males	41	98	30
	females	38	40	21
Mean and extremes of whorls retained;	males	4.2(4.0–5.0)	4.1(3.8–4.5)	3.8(3.3–4.3)
	females	4.3(3.8–5.0)	4.2(3.8–5.0)	3.9(3.5–4.3)
Mean altitude;	males	6.7	7.2	7.0
	females	7.7	8.4	7.8
Mean index (minor diameter);	males	40	40	43
	females	38	39	42
Mean and extremes of minor diameter;	males	2.7(2.5–2.8)	2.9(2.5–3.1)	3.0(2.9–3.1)
	females	2.9(2.8–3.1)	3.2(3.1–3.5)	3.3(3.2–3.5)
Mean and extremes of altitude (4 whorls);	males	6.6(6.1–7.0)	7.2(6.5–7.7)	7.1(6.7–7.6)
	females	7.4(7.1–7.7)	8.0(7.7–8.7)	7.8(7.6–8.0)
Mean and extremes of index (4 whorls);	males	40 (39–42)	40 (38–42)	42 (41–45)
	females	40 (38–41)	39 (38–41)	41 (40–43)

the distal edge of the tooth to almost 1/3 of its depth; laterad to the cusps, fully half of the distal edge of the entire tooth is undivided, slightly thickened and recurved.

Animal: very dark in color, almost black; foot very short, almost circular; snout long; tentacles stout, clavate.

Cistulops raveni arubana, new subspecies

Type locality: (A2b) spur of Seroe Pretoe, between Roois Spoki and Hundoe, Aruba.

Distribution: Aruba, Rooi Frances, south to Seroe Pretoe and east of Fontein (A2, 3). Infrequent to common; habitat similar to *raveni*. 421 specimens collected.

Shell: males about as large as females of *raveni*. Color: typically albino, but more commonly as in *raveni*. Whorls: 7½ in an entire male; 8¾ and 9 in two entire females. Last whorl: growth riblets commonly thinner and more widely spaced than in *raveni*. Other characters as in *raveni*.

Operculum: similar to *raveni*.

Radula (fig. ix–26, no. 2): very similar to *raveni*, but the minor serrations of the central cusp of the inner lateral appear somewhat heavier.

Measurements

	Shell			Peristome		Aperture	Whorls
	alt.	maj. diam.	min. diam.	alt.	diam.	inside	
A2, male; complete	8.2	39(3.2)	33(2.7)	32(2.6)	100(2.6)	18(1.5)	7½
female; entire	10.5	35(3.7)	31(3.2)	28(2.9)	104(3.0)	17(1.8)	8¾
female (type)	11.1	33(3.7)	31(3.4)	26(2.9)	107(3.1)	16(1.8)	9

A2. Quite common (407 specimens collected). 28 specimens are quite unicolor, white to cream. The shells from the southern stations (A2a, b) average even larger than the lot from A2c.

A3c. Infrequent (14 specimens).

Although all of the lots of typical *raveni* average noticeably smaller than those of *arubana*, the two forms intergrade extensively. The much larger percentage of albinos (the typical form) on Aruba also seems evidence of racial differentiation.

CHONDROPOMINAE

Genus Tudora

Tudora Gray (1850; Brit. Mus. Cat. Cycloph., 48); monotype *Cyclostoma simile* "Gray" Sowerby.

Shell: ovate conic to elongate ovate. Sculpture: exceedingly variable, but the growth ribs are not tufted at the suture nor is the latter channeled. Embryonic whorls: 1½, not distinctly limited; cream to dark horn-colored, commonly darker below; practically smooth, but irregularly and very minutely wrinkled. Peristome: simplex, sharp; incomplete or continuous; not abruptly reflected.

Operculum: perimeter channeled; chondroid plate relatively thin; calcareous portion consists of vertical growth-lamellae, which are often cemented together by interstitial material, and which coalesce at their distal edges to form a calcareous plate; the last is almost parallel to the chondroid one, and is marked externally by rather weak growth-wrinkles.

Radula: central and inner lateral with heavy, triangular bases, each with a single, heavy cusp; outer lateral with rectangular base and markedly reflected tip, which bears about five aculeate to spatulate cusps; marginal with numerous, recurved, lanceolate cusps, which fill more than half of the entire distal edge, outer uncusped portion abruptly sloping down to relatively narrow base.

Although the radulae of the Chondropominae are simple and rather uniform in structure throughout the subfamily, they do show characters of considerable systematic value, which I hope to present in a future paper. Amongst many others, I have examined the radulae of several of the species that belong to the Jamaican, Mexican and Central American group, usually known as Colobostylus, and believe it to be quite distinct from Tudora. In addition, the simplex, slightly expanded peristome of the latter genus is quite different from the duplex, thickened condition in the northern group, and was utilized for their separation by most of the earlier writers. I have not been able to examine the radula of any of the Cuban and Haitian species, which include typical Licina, but

which were placed in Tudora s. s. by Henderson and Bartsch (1920, p. 77). However, the peristome of these species appears to be more like that of Colobostylus, and it seems probable that they will be found to be more closely related to some of the other groups of the Greater Antilles. In this connection, attention is called to the fact that Licina "Browne" Gray (1847; P. Z. S., XV, 81), monotype *"Turbo labea,"* is three years prior to Tudora Gray (1850). In the present paper, the genus Tudora is considered to include only the species listed below under the three minor groups, Bonairea, Tudorata and Tudora s.s. Regardless of the question of generic inclusion, these three groups are certainly quite distinct from any of the other groups of American Pomatiasidae, although Tudorata possesses certain characters in common with a mainland group, which includes *Adamsiella aripensis* Guppy, from Trinidad, *Cyclostoma aspratilis* Morelet, from Ecuador, *Cyclostoma rigidula* Morelet, from Guatemala, and my *"Tudora" williamsoni,* from Venezuela.

Subgenus **Bonairea,** new

This subgenus is characterized by the small size, the solute last whorl, the simple, continuous, unreflected peristome, the convex operculum (quite similar to Ramsdenia), and the stout, aculeate cusps of the outer lateral tooth of the radula. The chondroid plate of the operculum is smaller than the interior of the aperture, but the calcareous plate is larger; the entire structure fits the peristome like a flanged cover and the animal is usually unable to draw it inside. In all of the other species of Tudora, as in most of the Chondropominae, the operculum is readily withdrawn into the aperture. The radula of Bonairea is quite different from that of Ramsdenia, which is closely related to other Greater Antillean groups (Annularella, Rolleia, and Blaesospira). Monotype: *Tudora maculata.*

Tudora maculata "Bland" H. Burrington Baker (1924; Naut. XXXVII, 92)

Type locality: (B3a) base of east-facing escarpment, about ½ kilometer south of Kibrá di Montagne, Bonaire.

Distribution: Bonaire; the higher limestone hills, from Montagne and Seroe Largoe north to Fontein and east (at least) to Seroe Wassau (B3, 4, 5, 6, 8). In the more humid, wooded places; buried rather deeply under rocks and in the crevices of the talus. 175 adults collected.

Shell (fig. viii–22): small, elongate-conic, thin. Color: light to dark brown, with about 8, chocolate-colored, spiral bands, usually broken into rows of flammulations. Whorls: 6½ (in a complete male), of which a little less than 4 are usually retained; cylindrical, with very deeply impressed sutures; last ½ whorl descending, slightly tangential, gradually constricted, and solute. Last whorl: growth sculpture of crowded, regular, low, rounded threads, interspersed with more prominent riblets, at intervals which appear to correspond to resting periods as they are crowded closely together near the peristome; spiral sculpture only visible under lens, not especially prominent in umbilical region, consisting of widely-spaced, fine threadlets, which sometimes crenulate the growth threads, but are more commonly obscured by them. Earlier whorls: sculpture somewhat more prominent. Umbilicus: small, tubular. Aperture: circular; internally light colored. Peristome: simple, continuous; scarcely, if at all, thickened.

Operculum (figs. viii–23, 24): 4¼ whorls; almost circular; nucleus subcentral, but slightly nearer the basal angle; chondroid plate inconspicuous, markedly concave internally; calcareous portion thick, solid, and with channeled perimeter; external surface (calcareous plate) distinctly convex, larger than the chondroid plate, and marked by fairly prominent growth-wrinkles.

Radula (fig. xi–40): C/1: L1/1 + 1/5; M/40–41. Central: base very heavy, forming a truncated, isosceles triangle; single cusp heavy but slender, almost aculeate. Inner lateral: similar to central but asymmetrical, with inner side longer than outer. Outer lateral: with long, rectangular base; anterior reflection with 5 stout, aculeate cusps; the transverse thickening under the reflection is very heavy, so that it produces a marked angulation of the sides of the base (as viewed in profile). Marginal: relatively heavier than in Tudora s. s.

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	7.4	53(3.9)	42(3.1)	27(2.0)	95(1.9)	27(2.0)	90(1.8)	4
female (type)	8.8	51(4.5)	41(3.6)	27(2.4)	96(2.3)	26(2.3)	91(2.1)	4

B3. Infrequent (9 specimens collected). The type locality.
B4. Quite common (84 adults). Shells larger than those from B5.
B5. Frequent (51 adults). Lot measured (see Table IV).
B6. Quite infrequent (15 adults). Large, light colored.
B8. Quite infrequent (16 adults). Like B5 in size.

Subgenus Tudora s. s.

Shell: larger and heavier than in Bonairea. Post-embryonic whorl: horn-colored, with fine, regular and quite closely-spaced growth-riblets; all apical whorls high, convexly rounded and with well-impressed sutures. Aperture: ovoid. Peristome: incomplete to almost continuous; sharp; simply thickened or expanded.

Operculum: ovoid; nucleus markedly eccentric; external surface of calcareous plate almost flat to concave.

Radula: cusps of outer lateral are simply spatulate lobes of reflected portion.

Section **Tudorata**, new

Shell: elongate-conic. Males markedly smaller than the females; the two sexes scarcely intergrade in size. Sculpture: very variable, but always with a marked tendency to accentuate the spiral cords in the umbilical region. Post-embryonic whorls: color bands and spiral sculpture begin at about the fourth whorl. Peristome: sharp; simple, or gradually expanded in the palatal and basal regions but abruptly narrowed in the columellar.

Operculum: chondroid plate slightly concave internally; calcareous plate rather thin, much smaller than the horny base; supporting lamellae not greatly thickened and usually incomplete, so as to leave a considerable sulcus around the outer edge of the calcareous portion.

Type species: *Tudora muskusi.* Besides the three species on Curaçao and Bonaire, this group apparently includes *Tudora costata* ("Menke" Pfr.), habitat unknown, and *Tudora plicatula* (Pfr.), from Puerto Cabello, Venezuela.[36] All of the species are more or less arboreal.

Tudora aurantia aurantia (Wood)

Turbo aurantius Wood (1828; Index Suppl., fig. vi–23); compare Smith (1898; Proc. Mal. Soc., III, 116). *Cyclostoma aurantiacum* Sowerby (1843; Thes., fig. xxiv–46, 47), not Deshayes (1834; Bélanger voy. Zool., 146). *C. versicolor* Pfr. (1846; Zeit. Mal., 33; and 1847; Chemn., II, fig. ix–13, 14); substituted for preceding on account of *Annularia aurantiaca* Schumacher (1817). *C. carneum* "Menke" Pfr. (1847; Chemn., II, p. 65, fig. ix–11, 12); more cancellate form. *Tudora versicolor* Bland (1868; Amer. J. C., IV, 192); the first Bonaire record.

Type locality: unknown; probably in the vicinity of Kralendijk, Bonaire (B2).

Distribution of species: Bonaire and Klein-Bonaire; everywhere on limestone outcrops, on trees and brush and under rocks; also occurs in the more heavily wooded localities, in the region of the older rocks. 1,378 specimens collected.

Distribution of subspecies: Bonaire; southern portion, north to Porta Spaño and Seroe Montagne (B1–5; Bb3, 7). 781 specimens collected.

Shell (figs. xii–A): solid. Ground color: cream to pink; spiral bands present or absent, orange to chocolate, broken or entire; eroded apex and apical plug scarlet and orange to deep indigo, almost black. Whorls: about 9½, of which 4¾ are usually retained; not markedly convex and with suture shallow but distinctly marked; gradually increasing in diameter from first to last. Sculpture of last whorl: growth-cords quite regular, low, broadly rounded and usually closely spaced; spiral sculpture obscure (*aurantia*) except in umbilical region, to almost as prominent as growth-sculpture (*carnea*). Earlier whorls: growth sculpture more delicate, so that

[36] 1923; *Occ. Papers Mus. Zool. Univ. Mich.*, no. 137; pp. 23–26, fig. II–9.

the spiral sculpture is conspicuous. Third and fourth whorls (young shells): with delicate but high, slightly undulate, widely-spaced, growth costulation, which forms sutural buttresses distinctly reminiscent of *T. plicatula*; spiral sculpture indistinct. Umbilicus: subrimate, more open than in *rupis* or *muskusi*. Aperture: ovoid, with long axis almost parallel to that of the shell; internally light buff to deep orange, bordered with white callus. Peristome: simple, sharp, almost or quite entire; very slightly produced into parietal angle, where it is commonly double; thickened internally by white, rounded callus, which is always continuous in adult shells.

Operculum: 3¼ whorls: calcareous plate heavy (for the section) and distant from the horny base; outer surface concave at the nucleus, but with the last whorl quite markedly convex along a line parallel to the palatal edge.

Radula: quite similar to *muskusi*.

	Measurements				
	Shell		Aperture		Whorls
	alt.	maj. diam.	alt.	diam.	
aurantius Wood					
from legend (1828)	12.7–19.0				
from figure (1828)	14.9	53(7.9)	37(5.5)	80(4.4)	5¼
aurantiacum Sowerby					
from figure (1843)	18.1	49(8.8)	37(6.6)	77(5.1)	5½
versicolor Pfr.					
from figure (1846–9)	17.1	57(9.8)	38(6.5)	83(5.4)	4¾
carneum Pfr.					
from figure (1846–9)	16.7	66(11.0)	43(7.2)	78(5.6)	4¾

B2. Quite abundant (195 specimens collected). As it is very probable that the vicinity of Kralendijk is the type locality of this species, these specimens, from near the shore just north of town, are taken as topotypical material (see Table V).

B1. Common (134 specimens). Very similar to the preceding lot, but with the sculpture of the last whorl even more reduced. In some specimens, the growth threads are so broad and low as to coalesce and render the surface of the last whorl almost smooth.

B3a. Abundant (105 specimens). Very similar to B2, but attain a somewhat greater size.

B4. Abundant (32 specimens). Very similar to B3a.

B5. Very common (19 specimens). Very similar to B1.

B7. Common along the western escarpment (203 specimens). Similar to B1, but considerably heavier; the peristomal callus is especially well developed. Usually more bleached than the other lots, but one specimen is solid orange and another dark purplish-brown.

Bb3. Frequent (55 specimens). Darker and more strikingly colored. Growth threads finer, and practically all of the shells markedly cancellate.

Bb7. Quite infrequent, even in the richest portions (38 specimens). Similar to B1; some specimens are so smooth as to show a polish.

Table V. Dimensions of Tudora aurantia, T. rupis and T. muskusi[37]

Subspecies	*wassau-ensis*	*aurantia*	*newport-ensis*	*rupis*	*bullen-ensis*	*grandi-ensis*	*muskusi*
Locality	B8	B2	C1	C2	C13	C14	C17bc
Number of individuals	115	90	105	48	26	146	74
	140	105	95	47	28	164	91
Mean whorls retained	4.5	4.6	4.8	4.6	5.3	4.7	4.8
	4.8	4.8	4.9	4.7	5.7	5.2	5.3
Extremes, ditto	4.0–5.3	4.3–6.0	4.3–6.3	4.0–6.3	5.0–6.0	4.3–6.0	4.3–6.0
	4.3–5.5	4.3–5.5	4.3–5.5	4.3–5.3	4.3–6.5	4.5–6.5	4.3–5.8
Mean alt.	12.8	12.7	13.2	11.3	12.1	11.0	11.9
	17.0	16.4	15.7	13.2	16.1	14.9	15.9
Mean minor diam. index	46	48	47	47	44	46	47
	47	49	47	48	45	47	48
Mean minor diameter	6.0	6.1	6.2	5.3	5.3	5.2	5.6
	8.1	7.9	7.4	6.3	7.2	7.0	7.6
Extremes, ditto	5.2–6.9	5.4–6.8	5.3–6.7	4.6–5.7	4.7–6.1	4.6–5.8	5.0–6.3
	7.2–9.1	7.4–9.0	6.9–8.0	5.8–7.9	6.7–7.9	6.4–7.7	7.0–8.3
Mean alt., 5 whorls	13.6	13.1	13.3	11.8	11.6	11.6	12.2
	17.4	17.0	15.9	13.7	14.7	14.5	15.6
Extremes, ditto	12.2–14.9	12.2–13.5	11.5–14.1	10.2–11.9	10.8–12.1	10.7–12.3	11.3–12.8
	15.6–18.8	15.3–18.2	14.7–17.2	12.8–14.9	14.7	13.4–15.4	14.7–16.2
Mean index, 5 whorls	45	47	46	46	45	45	47
	47	47	47	48	47	48	49
Extremes, ditto	42–47	46–49	43–50	45–48	44–48	42–47	45–49
	44–49	44–50	45–49	46–50	47	46–51	47–52

[37] Males in upper horizontal row under each heading; females in lower.

Tudora aurantia wassauensis, new subspecies

Type locality: (B8) Seroe Wassau, just west of entrance to the Goto, Bonaire.

Distribution: Bonaire; northern portion, south to the Goto (at least) and east to the cliffs near Fontein (B6, 8, 9; Bb9). Klein-Bonaire: (K1). Quite abundant in similar habitats to *aurantia,* also in favorable valleys in the higher hills of the older rocks (Bb9). 597 specimens collected.

Shell (fig. xii–B): heavier and slightly larger and more slender than *aurantia.* Growth sculpture (fig. x–28): considerably heavier, higher, and more widely spaced, so as to expose the distinctly marked spiral sculpture. Peristomal callus: heavier. Other characters as in *aurantia.*

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	13.5	56(7.5)	45(6.1)	40(5.4)	78(4.2)	31(4.2)	78(3.3)	5
female	18.8	56(10.5)	47(8.8)	39(7.4)	80(5.9)	28(5.3)	85(4.5)	5¼
female (type)	18.2	57(10.4)	46(8.4)	40(7.2)	83(6.0)	29(5.3)	85(4.5)	5¼

B8. Quite abundant (155 specimens collected). Typical lot (see Table V).

B6. Very common (13 specimens). Somewhat smaller.

B9. Very infrequent; mainly on Cereus and under rocks at the base of these cacti. Bb9. Rare (141 specimens altogether). Somewhat smaller. The specimens from Seroe Grandi (B9) are bleached, and quite commonly stained with a rusty deposit, as appears characteristic of specimens of Tudora from these wind-swept, excessively arid places. Growth sculpture widely spaced but lower; scarcely more prominent than the spiral; the entire shell distinctly cancellate.

K1. Very common (288 specimens). Large and heavy; somewhat bleached. Altogether more or less intermediate between *wassauensis* and *aurantia,* this lot from Klein-Bonaire is considerably closer to the former; this is especially peculiar as the conditions are similar to those in the type locality of *aurantia,* just across the harbor.

Although this subspecies intergrades with typical *aurantia,* large lots give an impression of a markedly more costate shell. In the typical lot of *wassauensis,* the growth sculpture is rela-

tively much more prominent than the spiral sculpture, although the latter is usually more evident than in *aurantia*.

Tudora rupis rupis H. Burrington Baker
(1924; Naut. XXXVII, 93)

Type locality: (C2a) at base of northern cliffs of Tafelberg, of Santa Barbara, southern Curaçao.

Distribution of species: Curaçao; limestone of western side, south of Spaansche Baai. 290 specimens collected.

Distribution of subspecies: Curaçao; only found near the base of the cliffs on the northern and western sides of the Tafelberg (C2). Quite common; on trees and brush, also found under limestone rocks. 95 specimens collected.

Shell (fig. xii–E): somewhat less solid than *aurantia*. Ground color: white to buff or pink; spiral bands present or absent, pink to very dark chocolate with purplish tinge, rarely solid and then usually coalescent, normally broken and commonly with blotches connected so as to form irregular varices parallel to the growth-sculpture; eroded apex and apical plug, orange to purplish black. Whorls: about 9, of which about 4½, are usually retained; not markedly convex and with suture even shallower than in *aurantia*. Last whorl (fig. x–29): growth-cords quite regular but usually obscure, low and rounded; spiral sculpture of about 8, prominent, rounded ridges, which (typically) are scarcely surmounted and not broken by the growth sculpture. Earlier whorls: growth sculpture relatively more prominent; either cancellate or with spiral sculpture surmounted by cusp-like thickenings of the growth sculpture. Third and fourth whorls (young shells): with more widely spaced and stouter growth-riblets than in *aurantia*; these show less tendency to form buttresses at the sutures. Umbilicus: rimate. Aperture: ovoid, with long axis quite oblique to that of shell; internally buff to chocolate-brown, and sometimes showing the spiral bands; with white, peristomal callus. Peristome: sharp, always interrupted for a short distance on the parietal wall; well and rather abruptly expanded along the palatal and basal walls,

lobate at parietal angle and quite markedly auriculate at basal angle; but very slightly expanded in columellar region; thickened internally by continuous callus, which, however, is thin in the parietal and very narrow in the columellar region.

Operculum: 3¼ whorls; similar to that of *T. aurantia,* but with calcareous portion much thinner; calcareous plate closely applied to horny base; externally the nuclear concavity and the linear convexity are much less prominent than in *aurantia.*

Radula: similar to *muskusi.*

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	10.5	60(6.3)	47(4.9)	45(4.7)	92(4.3)	35(3.7)	73(2.7)	4¾
female (type)	14.0	54(7.6)	44(6.2)	44(6.2).	84(5.2)	34(4.7)	77(3.6)	5¼

Tudora rupis newportensis, new subspecies

Type locality: (C1) along road, just north of New Port, Curaçao.

Distribution: Curaçao; probably occurs on the more recent limestone all along the west shore, south of Spaansche Baai. Very common; on trees and brush and under rocks. 195 specimens collected.

Shell (fig. xii–D): considerably larger but relatively thinner than *rupis.* Color: like *rupis,* but spiral bands, although sometimes absent, usually are more distinct and more commonly continuous; almost always with at least one continuous band surrounding the umbilicus from just below the parietal angle of the aperture. Whorls: usually more than 4¾ retained. Last whorl (fig. x–30): growth-threads regular, closely-spaced, low and rounded, often so broad and coalescent as to render the surface practically smooth; spiral sculpture typically obsolescent except in umbilical region, where it develops low, rounded ridges, always surmounted by the growth sculpture. Earlier whorls: growth sculpture closely resembling that of *aurantia*; spiral sculpture very obscure. Peristomal callus: thinner than in *rupis.* Operculum: 3½ whorls. Other characters as in *rupis.*

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male								
(type)	14.0	51(7.2)	44(6.1)	41(5.7)	88(5.0)	31(4.4)	80(3.5)	5
female	15.8	58(9.2)	46(7.3)	43(6.8)	94(6.4)	34(5.3)	79(4.2)	5
female	17.2	57(9.8)	45(7.8)	43(7.4)	87(6.4)	32(5.5)	80(4.4)	5

Tudora muskusi muskusi H. Burrington Baker

(1924; Naut., XXXVII, 93)

?*T. costata* Vernhout (1914; Notes Leyden Mus., 180).

Type locality: (C17b) top of shore cliffs near Knip Baai, northern Curaçao.

Distribution of species: Curaçao; along western side, from north side of Plaja Abau to west side of entrance to Salinja Sint Marie. 1,252 specimens collected.

Distribution of subspecies: Curaçao; along western side, from both sides of Plaja Abau to Sint Jan Baai (C17, 16, 15), south of which subspecies *grandiensis* predominates. Quite abundant on trees and brush and under rocks; only found on or very near limestone. 881 specimens collected.

Shell (fig. xii–C): heavier, but slightly smaller, than *aurantia*. Ground color: flesh-color to opaque whitish; spiral bands usually absent although single chocolate band not infrequently circles the umbilicus from the parietal angle of the aperture; eroded apex and apical plug white to bluish drab, usually very dark. Whorls: about 8½, of which 5 are usually retained; not markedly convex, and with undulating suture rather well impressed. Last whorl (fig. x–31): growth costae quite regular but widely spaced, very prominent, heavy and angular, with a few, irregular, obsolescent cords between them; spiral sculpture of obsolescent, rounded thickenings, which are usually evident only as undulating buttresses along the sides of the growth costae; towards the umbilicus the spirals become much more prominent, and surmount and break the growth sculpture into heavy bosses. Earlier whorls: growth sculpture lighter and broken by the prominent spiral sculpture into

bosses; similar to that of the last whorl of *grandiensis*. Subapical whorls (young shells): similar to those of *rupis* but with heavier growth-costae. Umbilicus: rimate, even smaller than in *rupis*. Aperture: small, almost circular; with long axis inclined at about 45° to that of shell; internally light orange to chocolate-brown, with white, peristomal callus. Peristome: sharp, interrupted on parietal wall; not expanded at parietal angle, and with palatal wall slightly emarginate immediately below it; slight expansion of lower palatal and basal regions terminated abruptly just beyond slightly auriculate basal angle; columellar wall scarcely expanded; thickened internally by continuous, rounded callus, which is very narrow in the columellar region.

Operculum (fig. xi–43): 3¼ whorls; very similar to that of *T. rupis*.

Radula (fig. xi–41): C/1; L1/1 + 1/5–6; M/45–47. Inner lateral slightly more attenuate distad and spatulate cusps of outer lateral less variable than in *T. megacheilos*; other characters very similar.

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	12.4	56(7.0)	46(5.7)	40(5.0)	90(4.5)	30(3.7)	81(3.0)	5
female (type)	15.8	56(8.9)	48(7.6)	40(6.3)	89(5.6)	34(5.3)	79(4.2)	5
female	16.4	55(9.0)	48(7.9)	38(6.2)	97(6.0)	31(5.1)	78(4.0)	5½
female	17.0	53(9.0)	43(7.2)	37(6.3)	89(5.6)	31(5.3)	79(4.2)	6
T. costata; fig.(1846–1849)	15.7	52(8.2)		44(6.9)	78(5.4)			6

C17bc. Quite common on both escarpments of Plaja Abau; very common near Seroe Djerimi, between Knip Baai and Plaja Djerimi (165 specimens collected). Type lot (see Table V).

C17a. Quite abundant; this lot is from the top of Seroe Djerimi (128 specimens). Somewhat smaller, and with a slightly more noticeable tendency for the spiral sculpture of the last whorl to crenulate the growth costae.

C16. Quite abundant (157 specimens). Color and shape similar to typical lot, but would average a trifle larger. Growth costae noticeably

lower, sharper and more compressed, but widely spaced. Spiral sculpture as weak as in typical lot.

C15. Quite abundant; this lot was accidentally mixed with that from the eastern escarpment of Seroe Djerimi (C17a and C15; 431 specimens). By comparison of this mixed set with the other lot from Seroe Djerimi, it is very evident that the shells from C15 are similar to those from C16, but show still finer and more closely-spaced growth-costae. In addition, the spiral sculpture tends to approach that of the next subspecies.

This species appears to be quite similar to *T. costata* ("Menke" Pfr.) (1846; Zeit. Mal., 47) in color and sculpture; the habitat of the latter is unknown. However, if the figure (1846–9; Chemn., II, fig. ix–9, 10) is even approximate, the much larger aperture of that species has its long axis almost parallel to that of the shell, and the parietal angle is even more markedly lobate than in *T. rupis*. I do not believe that *T. costata* occurs in the Dutch Leeward Islands, as none of the thousands of specimens examined by me shows any tendency to approach this striking aperture. Probably the specimens quoted by Vernhout (1914) belong to one of the subspecies of *T. muskusi*.

Tudora muskusi grandiensis, new subspecies

Type locality: (C14) northern half of Seroe Grandi, south of Sint Jan Baai, northern Curaçao.

Distribution: Curaçao; along western side, from Seroe Baha So (4 specimens), to (at least) Seroe Grandi (C15, 14); southern limits undetermined. 317 specimens collected.

Shell (fig. xii–F): smaller and slightly thinner and more slender than *muskusi*. Color: spiral bands absent or present, rarely several continuous bands, frequently broken spirals, but most commonly with blotches of color connected to form undulating bands parallel to the growth lines; eroded apex and apical plug usually whitish or light yellow, and rarely as dark as normal *muskusi*. Sculpture of last whorl (fig. x–32): growth-costae much lower, and more closely-spaced (apparently due to the development of the interstitial cords) than in *muskusi*; spiral sculpture typically almost as prominent on the

sides as around the umbilicus; it breaks the growth sculpture into elliptical bosses, or even produces a cancellate appearance. Earlier whorls: markedly cancellate, with cusp-like bosses at the intersections. Umbilicus: a trifle larger than in *muskusi*. Peristomal callus: thinner than in *muskusi*. Other characters as in *muskusi*.

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	11.0	56(6.1)	46(5.1)	41(4.5)	89(4.0)	31(3.4)	79(2.7)	4¾
male	11.6	54(6.2)	43(5.0)	39(4.5)	85(3.8)	33(3.8)	74(2.8)	5¼
female	14.0	57(8.0)	48(6.7)	39(5.5)	91(5.0)	34(4.8)	75(3.6)	5
female (type)	14.9	57(8.5)	48(7.1)	40(6.0)	88(5.3)	34(5.0)	72(3.6)	5¼

C14. Very common (311 specimens collected). Typical lot (see Table V); includes many specimens with fine, rather closely-spaced growth-costae, cut by poorly-developed spiral sculpture.

C15. Very rare. Amongst the large numbers of shells examined in the field, 6 beautifully cancellate specimens were separated as quite characteristic of *grandiensis*. One other shell gives the appearance of a hybrid between *T. fossor djerimensis* and *T. muskusi*; a similar specimen comes from C17a (fig. xii–H).

This subspecies intergrades with the more southern forms of *muskusi*, but not with the typical form.

Tudora muskusi bullenensis, new subspecies

Type locality: (C13) top of Seroe Largoe, just southwest of entrance to Salinja Sint Marie, near Sint Willebrordus, northern Curaçao.

Distribution: only collected from the top of this hill; it was not found at the base of the escarpments, or on the hill east of the entrance to the salinja. Infrequent, on trees and brush and under rocks. 54 specimens collected.

Shell (fig. xii–G): thinner and more slender than *grandiensis*. Ground color: bleached; whitish to pinkish; spiral bands absent, except for a very faint umbilical band in a few specimens; eroded apex and apical plug yellowish, pinkish or purplish-drab; dilute varices of these last colors also common.

Whorls: about 5½ retained. Sculpture (fig. x–33): low and weak; closest to *grandiensis* but much more obscure; sides of last whorl cancellate or malleate; even the umbilical sculpture low and rounded. Earlier whorls: rather weakly cancellate. Other characters similar to *grandiensis.*

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	12.2	54(6.6)	44(5.4)	39(4.7)	87(4.1)	30(3.7)	70(2.6)	5½
male	13.0	52(6.7)	42(5.4)	38(4.9)	94(4.6)	32(4.1)	76(3.1)	5¾
female (type)	16.4	50(8.2)	44(7.1)	37(6.0)	85(5.1)	28(4.6)	75(3.5)	6
female	17.7	51(9.0)	42(7.5)	36(6.4)	88(5.6)	29(5.2)	79(4.1)	6¼

Section Tudora s. s.

Shell: elongate to obovate conic; males average smaller than females, but the two sexes markedly intergrade in size. Sculpture: very variable; no definite tendency to accentuate the spiral ridges of the umbilical region. Post-embryonic whorls: color bands and spiral sculpture begin on 3rd whorl. Peristome: sharp, interrupted on parietal wall; more expanded in columellar than in palatal and basal regions; parietal angle produced and adjacent upper palatal wall emarginate. Operculum: calcareous plate well developed, practically equal in area to horny base; supporting lamellae high, thickened, and usually confluent; outer edge of calcareous portion only shallowly sulcate. Radula: see *megacheilos.*

Monotype: *Cyclostoma simile* "Gray" Sowerby. This section appears to be restricted to the islands of Aruba and Curaçao.

Tudora megacheilos megacheilos (Potiez and Michaud)

Cyclostoma megacheilos Potiez and Michaud (1838; Gal. Douai, I, p. 237, fig. xxiv–9, 10). *C. simile* "Gray" Sowerby (1843; Thes., fig. xxiv–48, 49). *C. megacheilum* Pfeiffer (1846, Zeit. Mal., 33); first Curaçao record. *C. megachilum* and *megacheilus* Pfr. (1847; Chemn., II, p. 66, fig. ix–18, 19). *Tudora similis* Gray (1850; Cat. Cycloph., 48); monotype of Tudora. *Cyclostoma roridum* "Parr." Pfr. (1852; Mon. Pneum. Viv.,

244); in synonymy. *C. proteus* "Beck" Pfr. (*l. c.*); in synonymy. *C. cancellatum* "Menke" Pfr. (*l. c.*); very large, light-colored female (*cf.* 1847; Chemn., II, fig. ix–15, 16, 17).

Type locality: unknown; probably the Schaarlo, back of Willemstad, Curaçao (C5c).

Distribution of species: Curaçao; western side, from Spaansche Baai to Kaap Sint Marie; eastern side from south of Sint Joris Baai to north of Landhuis Hato (at least); narrowly invades central region of older rocks. 1,911 specimens collected.

Distribution of subspecies: Curaçao; western side from Sint Anna Baai to Caracas Baai (C4, 5); intergrades with other subspecies to north and south. Under limestone rocks and on trees and brush; subarboreal, but not so much so as the species of Tudorata; does not penetrate the region of the older rocks to any great extent. 714 specimens collected.

Shell (fig. xiii–A): subacuminate (with concave lateral outlines); obovoid-conic; quite solid. Ground color: whitish to pinkish and dull amber; spiral bands present or absent, continuous or broken; blotches rarely unite to form irregular bands parallel to growth lines; eroded apex and apical plug from almost white to orange-red and purplish black.[38] Whorls: about 7½, of which 4 are usually retained; quite convexly rounded and with well marked suture; last whorls increase more rapidly in diameter than the earlier ones. Sculpture of last whorl: growth threads regular, closely spaced to continuous, low and rounded; spiral sculpture present (typical *megacheilos*) to absent (form **desculpta** new; fig. xiii–B; x–34); when present it consists of few to numerous, low, rounded thickenings. Earlier whorls: similar to last whorl. Subapical whorls (young shells): almost as slender as in *T. aurantia* (*i.e.*, with similar apical angle); with well-developed, widely-spaced, growth lamellae and low, angular, spiral ridges. Umbilicus: of medium size, but almost hidden by peristome. Aperture: large, ovoid, with long axis at about

[38] 1923; *Occ. Papers Mus. Zool. Univ. Mich.*, no. 137, p. 3.

30° to that of shell; noticeably flattened on parietal wall; internally light buff to dark chocolate, usually showing the spiral bands when these are present; white peristomal callus often bordered internally by a dark band. Peristome: gradually but deeply expanded in palatal and basal portions, and broadly reflected, almost auriculate, in columellar region; parietal angle markedly produced; palatal emargination slight; internal callus quite thin, but continuous.

Operculum:[39] about 4 whorls; calcareous plate not extensively eroded over nucleus, elsewhere heavy, complete and distant from the horny base; inner surface (horny plate) almost flat; outer surface (calcareous plate) concave at nucleus and with rim of each whorl slightly raised.

Radula (fig. ix–27); C/1; L1/1 + 1/5–8; M/56–58. Central: shaped like a truncated, isosceles triangle; with very heavy base; single cusp stout and heavy; transverse thickening a short distance below cusp. Inner lateral: similar to central but asymmetrical, with inner side longer and heavier than the outer; cusp longer and somewhat more slender. Outer lateral: long, rectangular base, with strong distal reflection, which is pectinated into 5, spatulate, rather indefinite cusps (although 5 is the usual number, interstitial lobes or points may raise the number as high as 8); transverse thickening prominent, so as to produce a marked angulation on the sides of the base (as seen in profile). Marginal: with numerous, recurved, sharp cusps, which decrease in size towards the outer edge; the edges of the outer ones pectinate the distal edge of the tooth to fully 1/3 its depth; the undivided, slightly thickened, recurved, outer portion slopes down abruptly to the comparatively narrow base.

Measurements

	Shell		Aperture		Operculum		Whorls
	alt.	min. diam.	alt.	diam.	long	wide	
megacheilos P. and M. from text (1838)	15–18	67 (10–12)					

[39] *L. c.*, fig. ii–10.

Measurements (continued)

	Shell		Aperture		Operculum		Whorls
	alt.	min. diam.	alt.	diam.	long	wide	
from figures							
(1838)	16.3	57(9.3)	53(8.6)	90(7.7)			5
simile Sowerby							
from figures							
(1843)	14.7	68(10.0)	48(7.0)	91(6.4)			4¼
	19.0	66(12.5)	50(9.5)	85(8.1)			4¼
cancellatum Pfr.							
from figures							
(1847)	20.3	69(14.0)	52(10.6)	80(8.5)	36(7.4)	68(5.0)	4½
form *desculpta*, new							
male (C5cd)	13.1	69(9.0)	55(7.2)	90(6.5)	37(4.9)	78(3.8)	3¾
female							
(type, C5cd)	16.8	69(11.5)	52(8.8)	89(7.8)	37(6.2)	82(5.1)	4¼

C5cd. Quite abundant (359 specimens collected). The Schaarlo (C5c) back of Willemstad is probably the type locality of this species, and this lot is that described above (see Table VI). It contains a large proportion of shells with vestigial spiral sculpture (form *desculpta*).

C5ab. Quite abundant (186 specimens). Very similar to typical lot, but with considerably less tendency to approach form *desculpta*.

C4. Quite abundant (169 specimens). Sculpture heavy, and with a tendency for the growth threads to coalesce. A few specimens are somewhat cancellate, and thus show a slight tendency to approach *kabrietensis*. Form *desculpta* appears to be absent.

Tudora megacheilos spreitensis, new subspecies

Type locality: (C8) at base of northern escarpment of Seroe Spreit, Curaçao.

Distribution: Curaçao; western side, from Kaap Sint Marie to Seroe Quinta, west to Sint Anna Baai, where it intergrades with typical *megacheilos* and form *desculpta*; invades the region of the older rocks at Campo Bleinheim, and probably intergrades with *rondeklipensis* east of Bullen Baai (C6, 7, 8, 9, 13, Cb6b). 543 specimens collected.

Shell (fig. xiii–C): considerably heavier and larger than typical *megacheilos*. Color: similar in pattern to *megacheilos*, but usually more vividly colored and more distinctly banded. Sculpture of last whorl (fig. x–35): growth-cords heavier, more prominent, and more widely spaced than in *megacheilos*;

spiral sculpture always present; higher but more compressed than in *megacheilos*; surmounted by growth sculpture which is developed into heavy, elliptical bosses; the last give the shell a granulate appearance. Earlier whorls: distinctly cancellate, but without definite bosses or cusps at the intersections. Peristomal callus: heavier than in *megacheilos*. Other characters as in *megacheilos*.

Table VI. Dimensions of Tudor megacheilos and T. pilsbryi

Subspecies	*spreitensis*	*spreitensis*	*rondeklipensis*	*megacheilos*	*kabrietensis*	*pilsbryi*
Locality	C13	C8	C12a	C5cd	C3	C2ab
Number of individuals	16	65	32	77	21	63
	27	98	83	158	23	132
Mean number of whorls remaining	3.9	4.0	3.9	3.9	4.0	3.5
	4.1	4.3	4.1	4.1	4.3	3.6
Extremes, ditto	3.3–4.0	3.5–4.5	3.5–4.3	3.5–4.5	3.5–4.5	3.0–4.0
	4.0–5.0	3.8–4.8	3.5–4.5	3.5–6.5	3.8–4.8	3.0–4.3
Mean altitude	14.8	14.0	13.7	13.2	13.9	13.0
	17.1	16.4	16.5	15.5	15.8	14.7
Mean index (1d/a)	56	54	53	54	54	64
	55	53	53	54	53	64
Mean lesser diameter	8.2	7.5	7.3	7.1	7.4	8.4
	9.4	8.7	8.7	8.4	8.4	9.3
Extremes, ditto	7.6– 8.6	6.7–8.0	6.5– 7.7	6.3– 7.5	7.0–7.8	7.7– 8.7
	8.7–10.1	8.1–9.6	7.8–10.4	7.6–10.6	8.0–9.1	8.8–10.5
Mean altitude; 4 whorls	15.0	13.9	13.9	13.3	14.0	13.8
	17.0	15.7	16.0	15.3	15.6	15.3
Extremes, ditto; 4 whorls	14.0–15.6	11.5–15.2	12.7–14.8	12.2–14.3	13.1–14.7	12.2–15.8
	16.1–17.8	14.2–17.4	14.2–19.0	13.4–18.7	15.1–16.3	13.5–17.6
Mean index; 4 whorls	54	54	53	54	54	61
	55	55	53	55	56	62
Extremes, ditto; 4 whorls	53–56	51–58	51–55	51–56	53–55	54–65
	54–57	52–58	50–59	51–61	54–56	54–67

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	14.9	67(9.9)	54(8.0)	51(7.6)	96(7.3)	37(5.5)	80(4.4)	4
female (type)	18.3	67(12.3)	53(9.6)	50(9.2)	100(9.2)	34(6.3)	78(4.9)	4¾

C8. Quite abundant (163 specimens collected). Type lot (see Table VI).

C13. Common (43 specimens). Heavier; a larger proportion of cancellate specimens. Although *Tudora fossor djerimensis* also occurs in this locality, the two forms show no tendency to intergrade; in fact, the distinguishing characteristics appear to be actually accentuated (see tables VI and VII).

C9. Infrequent (4 specimens).

C7ab. Quite abundant (144 specimens). Very typical *spreitensis*.

C6a. Very common (110 specimens). Bleached, more depressed and with sculpture weaker. Quite a number of specimens approach form *desculpta*.

Cb6b. Frequent (79 specimens). Similar to C6a, but even more bleached.

Tudora megacheilos rondeklipensis, new subspecies

Type locality: (C12a) base of northwestern escarpment of Ronde Klip, eastern Curaçao.

Distribution: Curaçao; typical form only from the top and sides of Ronde Klip (C12); but the shells along the eastern limestone rim, from south of Sint Joris Baai to north of Campo Hato (C10, 11), are closer to this subspecies than to the others, although numerous specimens approach form *desculpta*; narrowly invades the region of the older rocks (Cb10). Habitat similar to *megacheilos*. 585 specimens collected.

Shell (fig. xiii–D): slightly larger and heavier than *megacheilos*. Color: similar in pattern to *megacheilos*, but the ground color is brighter and more pronounced, and the bands are usually obscure. Sculpture of last whorl (fig. x–36): growth cords similar to *spreitensis* but finer and more compressed; spiral sculpture of numerous, prominent and subangulate ridges, which are scarcely surmounted by the growth sculpture and without bosses or distinct cusps at the intersections. Earlier whorls: somewhat cancellate, but with the spirals much heavier than the growth sculpture. Umbilicus: more open than in *megacheilos*. Peristome: similar to, but more extensively expanded than that of *megacheilos*; inner callus heavier. Other characters as in *megacheilos*.

Measurements

	Shell		Aperture		Operculum		Whorls
	alt.	maj.diam. min.diam.	alt.	diam.	long	wide	
male	14.6	68(9.9) 53(7.7)	51(7.4)	95(7.0)	32(4.7)	83(3.9)	4¼
female (type)	19.0	68(13.0) 53(10.1)	52(9.9)	96(9.5)	33(6.2)	79(4.9)	4¼

C12a. Very common (115 specimens collected). Typical lot (see Table VI); on account of the great expansion of the peristome, the dimensions give the impression of a more elongate shell than is actually the case.

C12b. Common (89 specimens). Typical *rondeklipensis,* but more bleached in color.

C11ab. Very common (11b) to frequent (11a); 108 specimens. Similar to 12b, but with sculpture considerably reduced. A few closely approach form *desculpta.*

C11cd. Quite abundant (176 specimens). Bleached and rather small. A very large proportion approach form *desculpta,* and in several specimens the spiral sculpture is absent on the last whorl.

C10. Infrequent; living specimens mainly on Cereus and under rocks at the base of these cacti (95 specimens). Big, heavy shells, usually with well developed sculpture, although a few show an approach to *desculpta.* Very much bleached in color and stained with a rusty deposit; even more so than *Tudora aurantia wassauensis* from B9, where the conditions are somewhat similar.

Cb10. Rare (2 specimens).

Tudora megacheilos kabrietensis, new subspecies

Type locality: (C3) low, limestone escarpment near shore of Caracas Baai, and a short distance north of Fort Beekenburg, southern Curaçao.

Distribution: Curaçao; near western shore, from New Port to Caracas Baai (C1, 3), north of which it intergrades slightly with typical *megacheilos.* 69 specimens collected.

Color: similar to *megacheilos,* but bleached; pattern obscure. Sculpture of last whorl (figs. xiii–E): numerous, compressed, angular, spiral ridges, surmounted by the growth sculpture, which develops slight, subpyramidal cusps at the intersections. Interior of aperture: white to dark orange and light chocolate; usually with markedly darker, spiral bands. Peristome: more deeply and extensively expanded than in *megacheilos.* Other characters similar to typical subspecies.

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male								
(type)	13.9	72(10.0)	54(7.5)	57(7.9)	94(7.4)	34(4.7)	79(3.7)	4
female	16.5	66(10.8)	54(8.9)	49(8.0)	96(7.7)	32(5.3)	79(4.2)	4½

C3. Frequent (44 specimens). Type lot (see Table VI); bleached and dull-colored.

C1. Infrequent (25 specimens). Lighter ground color and brighter spiral bands. This lot does not appear to approach *T. pilsbryi* any closer than does that from C3.

Tudora pilsbryi H. Burrington Baker

(1924; Naut., XXXVII, 94)

Type locality: (C2a) at base of northern cliffs of the Tafelberg of Santa Barbara, southern Curaçao.

Distribution: Curaçao; only collected near the base of the escarpments on the northern and western sides of the Tafelberg (C2). Quite common; under limestone rocks, in crevices of the talus, and buried deeply in the soil; a few on the trunks of the larger trees; a distinctly terrestrial species. 195 specimens collected.

Shell (fig. xiii–F): subacuminate, obovate-conic; much thinner and more depressed than *megacheilos,* but extremely variable in dimensions. Color: vivid lemon-yellow to bright salmon and dark plum-colored; usually uniform, but some of the lighter shells show darker, spiral bands of variable width, while others show darker varices; sculpture white; eroded apex and apical plug usually much darker, but of similar color to the remainder of the shell. Whorls: about 7, of which 3½ are usually retained; very convexly rounded and with very deeply impressed sutures; last whorls increasing more rapidly in diameter than the subacuminate, earlier ones, although, as in many species with a scalariform tendency, this character is very variable. Sculpture of last whorl (fig. x–39): regular, compressed growth-riblets, which are quite closely spaced but are narrower than their interspaces; spiral

sculpture of numerous (19 to 28 counted), regular, compressed, angular ridges, which are more widely spaced on the base than at the sides of the whorl, and heavier and slightly higher than the growth-riblets, which surmount them; intersections developed as very prominent, sharp, pyramidal cusps. Earlier whorls: spiral and growth sculpture weaker and about equal; distinctly cancellate; cusps at intersections finer, but high and sharp. Subapical whorls: sculpture and shape similar to *megacheilos* (*i.e.*, apical angle similar to *aurantia*). Umbilicus: much larger than in *megacheilos,* and but little hidden by the peristome. Aperture: inner outline almost circular; internally light buff to dark chocolate, usually with darker, spiral bands. Peristome: roughly triangular and markedly undulate; parietal angle produced and lobate; palatal emargination a marked sinus; lower palatal wall extensively developed but scarcely expanded; basal wall abruptly expanded; basal angle flattened; columellar wall auriculate below, but narrowed abruptly a short distance from the parietal wall; internal callus very poorly developed, practically absent on parietal wall.

Operculum (fig. xi–44): about 4 whorls; similar to *megacheilos,* but with inner surface (thin, chondroid plate) slightly convex, and outer surface (calcareous plate) deeply and quite regularly concave over its entire surface.

Radula: similar to *megacheilos.*

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	13.2	85(11.2)	64(8.5)	61(8.1)	93(7.5)	41(5.4)	80(4.3)	3¾
female (type)	16.0	78(12.4)	63(10.1)	57(9.1)	98(8.9)	39(6.2)	81(5.0)	3¾

Tudora fossor fossor H. Burrington Baker

(1924; Naut., XXXVII, 94)

Type locality: (Cb17b) valley between Seroes Palomba and Baha Hoendoe, northern Curaçao.

Distribution of species: Curaçao; western side north of Bullen Baai, and east in the northern hill to (at least) the Tafelberg of Sint Hyronimus. A single, dead specimen (accidental?) from Seroe Spreit. Aruba: all of the limestone portion and narrowly invades the metamorphic rocks. Almost entirely terrestrial in habits. 1,460 specimens collected.

Distribution of subspecies: Curaçao; north of Landhuis of Campo Sint Kruis; mainly restricted to wooded valleys and rocky hillsides in the central region of older rocks (Cb16, 17abc; 20); also a somewhat different form from the Tafelberg of Sint Hyronimus (C20). Frequent in well-wooded valleys; aestivates deep down in the talus and rock crevices; comes to the surface during rains but appears never to go far from the ground, even on the trunks of the larger trees. 282 specimens collected.

Shell (fig. xiii–G): elongate-conic; rather thin. Color: last whorl dark plum-colored (dark, smoky amber by transmitted light), shading on the penultimate whorl into the dark horn color of the earlier whorls, which show indefinite, dark, spiral bands; sculpture tipped with bluish white; eroded apex and apical plug dark horn color to orange and plum color. Whorls: 6 (in one, entire, male shell), of which about 3½ are retained; more convexly rounded and with deeper suture than in *megacheilos*; the diameter increases gradually and regularly from the first to the last. Sculpture of last whorl (fig. x–37): similar to *pilsbryi*; regular, compressed growth-riblets, which are closely spaced but much narrower than their interspaces; spiral sculpture of numerous (15 to 21 counted), regular, compressed ridges, which are more widely spaced in the umbilical region than on the sides, and are considerably heavier than the growth-riblets but are surmounted by them; intersections developed as lanceolate cusps. Earlier whorls: similar to *pilsbryi*; cusps at intersections less pronounced. Subapical whorls (young shells): sculpture similar to those of *megacheilos*; not so slender (*i.e.*, apical angle greater). Umbilicus: smaller than in *megacheilos*; partially hidden by peristome. Aperture: relatively smaller than in *megacheilos*, but similar

in shape; internally light to dark chocolate, when light it shows darker, spiral bands; peristomal callus white. Peristome: palatal and basal walls rather narrowly but quite abruptly expanded; columellar region more extensively expanded (although less so than in *megacheilos*); parietal angle produced; palatal emargination very slight (fig. xiii–K); internal callus extensive but very thin, practically absent on parietal wall.

Operculum: 3½ whorls; similar to *megacheilos,* but nuclear erosion more extensive, calcareous portion slightly smaller than chondroid plate, and entire outer surface (calcareous plate) distinctly concave, although much less so than in *T. pilsbryi.*

Radula: similar to *megacheilos.*

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male								
(type)	13.0	58(7.5)	48(6.2)	45(5.9)	93(5.5)	37(4.8)	79(3.8)	6(entire)
female	15.0	61(9.2)	49(7.3)	48(7.2)	93(6.7)	35(5.3)	76(4.0)	4

Cb17b. Frequent (195 specimens collected). Typical lot (see Table VII); coloration very uniform.

Cb17a. Apparently infrequent, but the abundance of this sub-species can only be judged during rain-storms (13 specimens). Typical *fossor.*

Cb16. Very rare; 1 dead, bleached specimen.

Cb20. Apparently quite rare (3 specimens). Typical *fossor* reaches an altitude of around 1,200 feet on Sint Christoffelberg.

C20. Frequent (70 specimens). Slightly larger, with lighter ground-color, and much more variegated color; a quite divergent form.

Tudora fossor djerimensis, new subspecies

Type locality: (C17b) top of shore cliffs between Knip Baai and Plaja Djerimi, northern Curaçao.

Distribution: Curaçao; western limestone rim from both sides of Plaja Abau to Salinja Sint Marie (C13, 14, 15, 16, 17); also one, dead, bleached specimen from Seroe Spreit (C8). Quite infrequent to very rare; under limestone rocks; almost completely terrestrial. 207 specimens collected.

Shell (figs. xii–I): slightly larger and considerably heavier than typical *fossor*. Ground color: bleached; white to light pinkish; spiral bands absent or present, entire or with blotches united to form bands parallel to the growth line; eroded apex and apical plug light buff, to orange and deep indigo. Whorls: about 3¾ retained. Sculpture: similar to *fossor* throughout, but heavier and with comparatively less prominent cusps; spiral ridges usually less crowded on sides of last whorl. Aperture: internally light orange to light chocolate; usually darker, spiral bands can be seen. Peristome: more extensively but less abruptly expanded than in *fossor*; internal callus much heavier, continuous. Other characters as in *fossor*.

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	13.7	63(8.6)	50(6.8)	48(6.6)	88(5.8)	35(4.8)	79(3.8)	3¾
female								
(type)	18.0	62(11.2)	48(8.7)	45(8.0)	93(7.4)	32(5.8)	76(4.3)	4½
C8								
(male)	14.7	60(8.8)	48(7.0)	47(6.9)	91(6.3)	lacking		4½

C17bc. Quite infrequent (58 specimens collected). Type lot (see Chart VII).

C17a. Quite infrequent, on top of Seroe Djerimi (42 specimens). Typical.

C16. Infrequent (23 specimens). A little larger than the typical lot.

C15. Infrequent; accidentally mixed with a lot from the eastern escarpment of Seroe Djerimi (C15 and C17a; 57 specimens). Like C16.

C14. Very infrequent (17 specimens). Rather large.

C13. Quite rare (10 specimens). Smaller, but otherwise typical.

Tudora fossor westpuntensis, new subspecies

Type locality: (C18) small limestone remnant, less than a kilometer north of Plaja Abau, northern Curaçao.

Distribution: Curaçao; limestone rim north of Plaja Abau (C18, 19). Under limestone rocks, and, during rains, on bases of vegetation; almost completely terrestrial. 252 specimens collected.

Shell (fig. xiii–H): females about as large as males of *fossor*. Ground color: light buff to pink, orange and light

plum-color; blotches of broken spiral bands, when present, usually united to form irregular bands parallel to the growth lines; eroded apex and apical plug buff to orange and deep indigo. Growth sculpture of last whorl: heavier, higher and more closely-spaced than in *fossor*; whorl distinctly cancellate; cusps less prominent than in *fossor*. Whorls: about 3½ retained. Umbilicus: less hidden by peristome than in *fossor*. Aperture: internally light buff to vivid orange; broken, spiral bands usually shown. Peristome: less abruptly expanded than in *fossor*. Other characters as in *fossor*.

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male								
(type)	9.8	65(6.4)	52(5.1)	45(4.4)	93(4.1)	32(3.2)	80(2.5)	3½
female	13.5	62(8.3)	49(6.6)	46(6.2)	92(5.7)	34(4.6)	78(3.6)	4

C18. Frequent (145 specimens collected). Type lot (see Table VII); these smallest specimens, peculiarly enough, come from a habitat where *Cerion uva* attains greater than average size.

C19. Infrequent; under limestone slabs at the very edge of the shore cliffs (107 specimens). Slightly larger; bleached and stained with a dark brownish deposit.

Table VII. Dimensions of Tudora fossor[40]

Subspecies	*arubana*	*canashit-ensis*	*westpunt-ensis*	*fossor*	*djerim-ensis*
Locality	A2ab	A4ab	C18	Cb17b	C17bc
Number of individuals	80	38	68	76	13
	120	64	77	119	45
Mean number of whorls retained	3.5	3.4	3.4	3.5	3.6
	3.7	3.5	3.6	3.6	3.9
Extremes, ditto	3.0–4.0	3.0–6.0	3.0–3.8	3.0–6.0	3.3–4.3
	3.3–4.3	3.0–5.5	3.0–4.5	3.3–4.3	3.3–4.5
Mean altitude	13.2	11.4	10.5	12.0	12.6
	15.7	13.4	12.4	14.1	15.0

[40] The upper horizontal row under each heading contains the data for the males; the lower, those for females.

Table VII.—(Continued)
Dimensions of Tudora fossor

Subspecies	*arubana*	*canashit-ensis*	*westpunt-ensis*	*fossor*	*djerim-ensis*
Locality	A2ab	A4ab	C18	Cb17b	C17bc
Mean min. diam. index	52	52	53	53	52
	52	52	52	52	51
Mean min. diam.	6.9	5.9	5.5	6.3	6.6
	8.1	6.9	6.4	7.3	7.6
Extremes, ditto	6.0–7.4	5.5–6.3	5.1–5.9	5.9–6.7	6.1–6.8
	7.5–8.8	6.4–7.6	6.0–7.1	6.8–8.1	6.9–8.8
Mean altitude; 3½ whorls	13.2	11.3	10.7	12.3	12.6
	15.3	13.3	12.2	13.7	14.0
Extremes, ditto; 3½ whorls	11.8–14.4	10.6–11.9	9.6–11.6	11.4–13.1	11.6–13.7
	14.2–17.0	11.9–14.4	11.2–13.5	12.3–14.9	13.2–14.6
Mean min. diam. index; 3½ whorls	52	52	52	52	52
	53	52	52	52	52
Extremes, ditto; 3½ whorls	49–56	50–54	50–54	49–55	50–54
	50–56	50–55	50–55	50–55	50–54

Tudora fossor arubana, new subspecies

Type locality: (A2b) spur of Seroe Pretoe, between Roois Spoki and Hundoe, southern Aruba.

Distribution: Aruba; limestone deposits southeast of Spaansch Lagoen (A1, 2). Quite common; mainly under limestone rocks, but also on trunks and the larger branches of trees in well-wooded places (A2); more nearly arboreal than the other subspecies. 490 specimens collected.

Shell (fig. xiii–K): averages the largest in the species, but scarcely as heavy as *djerimensis*. Ground color: cream to salmon and orange, the reddish tints predominate; spiral bands present or absent, continuous or broken, often with blotches joined to form varices; eroded apex and apical plug buff to (usually) deep indigo. Sculpture of last whorl (fig. x–38): prominent to almost confluent, closely-spaced to contiguous, regular growth-threads, which are more rounded

than in the other subspecies; spiral sculpture of low, weak, rounded to subangular ridges, which are often obsolescent, and are scarcely surmounted by the growth threads; intersections without cusps. Earlier whorls: closely-spaced, growth sculpture obscures the weaker, spiral ridges. Subapical whorls: like *fossor*. Umbilicus: even less hidden by the peristome than in *westpuntensis*. Aperture: internally light orange to dark chocolate, usually vivid orange; spiral bands inconspicuous. Peristome: quite deeply but gradually expanded; internal callus quite heavy, continuous. Other characters as in *fossor*.

Measurements

	Shell		Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male	13.0	65(8.4)	52(6.7)	51(6.6)	91(6.0)	35(4.5)	73(3.3)	3½
male	13.7	63(8.6)	50(6.9)	48(6.5)	91(5.9)	36(4.9)	74(3.6)	3½
female (type)	16.2	62(10.0)	50(8.1)	47(7.6)	95(7.2)	33(5.3)	76(4.0)	4

A2ab. Common (200 specimens collected). Type lot (see Table VII); many specimens have the spiral sculpture considerably reduced (fig. xiii–5),

A2c. Quite common; under limestone slabs (161 specimens). Slightly larger, but otherwise typical.

A1. Quite infrequent; under limestone slabs (129 specimens). Bleached; almost half of the shells uniform whitish to pinkish. Heavier, with more prominent sculpture, and with especially well-developed peristomal callus.

This subspecies is, by itself, distinct enough to be a separate species, but the next form, which is plainly a geographical variety of it, is so close to *westpuntensis* that it was thought best to regard all of the Aruba specimens as subspecies of *fossor*.

Tudora fossor canashitensis, new subspecies

Type locality: (A4b) top of Seroe Canashito, Aruba.

Distribution: Aruba; limestone rim from Spaansch Lagoen and Boedoei north; narrowly invades region of older rocks at the Hooiberg (A3–8). Under rocks; a distinctly terrestrial form. 229 specimens collected.

Shell (fig. xiii–I) : somewhat smaller than *fossor*. Ground color: buff to salmon; the reddish tints predominate; spiral bands absent or present, usually with the blotches of the broken bands united to form varices parallel to the growth lines; eroded apex and apical plug buff and light orange to (usually) dark plum-color. Whorls: about 3½ retained. Sculpture of last whorl: growth-ribs closely spaced, and heavier than in *fossor*, but scarcely surmounting the spiral sculpture which is weaker than in *fossor*; intersections seldom developed into cusps. Umbilicus: like *arubana*. Peristome: columellar expansion weaker than in *westpuntensis*. Other characters as in *westpuntensis*.

Measurements

	Shell			Aperture		Operculum		Whorls
	alt.	maj.diam.	min.diam.	alt.	diam.	long	wide	
male								
(type)	12.5	57(7.1)	48(6.0)	44(5.5)	89(4.9)	32(4.0)	78(3.1)	6(all)
female	14.4	58(8.3)	49(7.1)	45(6.5)	89(5.8)	33(4.8)	77(3.7)	3¾

A4ab. Quite infrequent; more common on top than at the base of the escarpment (102 specimens collected). Type lot (see Table VII).

A5. Infrequent; under limestone slabs near the edge of the shore cliffs (45 specimens). Slightly smaller.

A6. Rare (10 specimens). Although dead shells are frequent throughout the plantations of aloes, living specimens are very rare.

A7a. Rare (2 specimens). Bleached and stained.

A7b. Quite rare (12 specimens). Bleached, and stained with a rusty deposit; very close to *westpuntensis* from C19.

A7c. Very rare; 1 dead, bleached specimen.

A3. Frequent; at the base of the escarpments (57 specimens). Similar to those from A4b; but somewhat approaches *arubana*.

AMNICOLIDAE

Potamopyrgus parvulus (Guilding)

Paludina parvula Guilding (1828; Zool. Jour., III, pp. 537–8; Suppl. Pl. xxviii, figs. 1–3). *Paludina jamaicensis* C. B. Adams (1849; Cont. Conch. 42). *Paludestrina crystallina* Smith (1898; Proc. Mal. Soc., III, 113); first Bonaire record; collected by Hartert.

Type locality: St. Vincent, Lesser Antilles.

Distribution: Jamaica, Haiti, St. Thomas, St. Vincent, Grenada. Curaçao: Sint Marie Spring (Cc13). Aruba: reservoir and brook at Fontein (Ac2). Bonaire: well in Kralendijk (not collected), and Pos Baca (Bc1). Klein-Bonaire: Pos di Cas (Kc1).

Guilding's figures 1 and 2 show both the shell and the animal; figure 3 is apparently a young specimen. They all represent the smooth form, but show evident, spiral striations. From authentic specimens in the A. N. S. P. (no. 67466, from C. B. Adams), *P. jamaicensis* appears to be a synonym. This species is more slender and slightly smaller than *P. coronatus* (Pfr.); *parvula* is, of course, the older name. Although the original figure looks very much like *parvulus, Paludestrina valenciae* Preston (1909; Ann. Mag. Nat. Hist., III, p. 513, fig. 16), from Lake Valencia, Venezuela, is still smaller and more slender; its last whorl is shorter in proportion to the spire, and the aperture is more nearly circular (A. N. S. P., no. 99401, three cotypes).

All of my specimens are dull greenish in color. Those from Curaçao, Aruba and Bonaire belong to the typical, smooth form (figs. xi–45, 46), but the lot from Klein-Bonaire contains a small proportion of weakly spinose shells (fig. xi–47). However, none is as markedly angulate as *P. coronata,* and the black-margined thread-carina is simply crenulated into low, triangular cusps. In my specimens, this carina begins as a slightly raised line on the penultimate whorl, gradually develops into the crown of spines, and then dies out again towards the aperture.

	Measurements				
	alt.	maj. diam.	alt. apert.	diam. apert.	whorls
Figure 45	4.62	54(2.49)	37(1.73)	78(1.35)	6
Figure 46	4.48	49(2.19)	36(1.63)	76(1.25)	6¼
Figure 47	3.60	58(2.10)	41(1.47)	77(1.13)	5½

PLANORBIDAE

Planorbis pallidus C. B. Adams

Planorbis pallidus C. B. Adams (1846; Proc. Boston Soc., II, 102). *P. pallidus* Clessin (1884; Chemn., II, p. 122, fig. xi–7). *P. circumlineatus*

"Shuttleworth" Clessin (*op. cit.*, p. 211, fig. xxxii–6); Sowerby (1878; Conch. Icon., XX, fig. vi–48). *Planorbis* sp.? Smith (1898; Proc .Mal. Soc., III, 113); first Curaçao record of genus; collected by Hartert.

Type locality: Jamaica.

Distribution: Jamaica, Haiti, Porto Rico, St. Thomas. Curaçao: cement tank in front of Landhuis Wilhelmina (Cc2); dammed pool on northwest side of Seroe Papaja (Cc11; dead shells only); dammed pool, Campo Lagoen (Cc17). Bonaire: Pos Baca (Bc1). The water in all of these places is slightly brackish to the taste, but it is used for stock animals; that from the first is quite drinkable.

Measurements[41]

	Shell			Aperture		Whorls
	alt.	maj. diam.	min. diam.	alt.	diam.	
P. pallidus						
Adams (1846)	3.2	320(10.2)				3(*sic*)
Clessin (1884)	2.3	370(8.5)				4
P. circumlineatus						
Clessin	2.5	360(9.0)				4–5
P. weilandi						
Pfr. (1876)	2.5	320(8.0)	220(5.5)		(3.0)	4
P. kühnianus						
Clessin	2.0	325(6.5)				4
P. meridaensis						
Preston	2.7	300(8.0)		110(3.0)	1.5(sic)	3½
Cc17(largest)	3.0	355(10.6)	285(8.6)	120(3.6)	110(4.0)	5
	2.9	300(8.7)	255(7.4)	120(3.5)	110(3.9)	4¼
Bc1 (largest)	2.6	360(9.4)	310(8.1)	130(3.4)	115(3.9)	4½

Cc1. Quite abundant (33 specimens collected). Thin, transparent and rather small. As the tank is artificial and its water supply comes from a well, the shells must have been introduced by some extraordinary means of dispersal.

Cc11. (6 dead shells collected). Opaque and rather heavy; similar to the next lot.

Cc17. Infrequent (3 living and 15 dead shells). Large, rather heavy

[41] The altitude in my measurements is that opposite the aperture; from their figures, this seems to correspond most closely with that used by the older writers. The altitude given for *P. meridaensis* is estimated from the figure.

and stained with brownish. The whorls of this lot and the preceding one are somewhat higher and more swollen than in the other shells.

Bc1. Quite common (34 specimens collected). Thin, white and transparent; thickly covered with gelatinous material and usually with one to three egg-masses stuck to the shell. Mostly with one to four rather heavy white varices, which must correspond to resting periods in the growth of the shell; at these places, the plane in which the whorls are coiled is apt to change slightly but sharply, so that an irregular shape results. In the umbilical region of some specimens, the last whorl completely covers a portion of the penultimate whorl.

Description of Curaçao specimens. Shell: dextral in form. Color: clear white and transparent, or opaque and stained with brownish; when alive it appears reddish with coppery shadows, as the color of the animal shows through. Whorls: 4 to 5; quite rapidly increasing in diameter; sutures shallow on umbilical side but deeper above. Last whorl: somewhat flattened above, less so below; rounded to scarcely subcarinate; growth sculpture regular and well marked; impressed, spiral lines irregular and sometimes almost obsolete; not hispid. Earlier whorls: rounded above and below, but the succeeding whorls obscure the convexity in the umbilicus. Apical whorls: easily seen in umbilicus, but deeply sunken and scarcely visible from apical side. Umbilicus: shallowly and regularly concave; less than 1/3 the major diameter of the shell. Aperture: oblique, very variable in shape; elliptical to semilunate; usually twisted downwards, sometimes markedly so, but may even project slightly upwards. Peristome: simple, sharp; parietal callus thin.

P. pallidus has a characteristic tendency for each whorl to twist slightly downward from the plane of the preceding one; the amount of this is often irregular so that the umbilicus may be markedly elliptical and the exposed portions of the earlier whorls very variable in width. Adams described this species as scarcely 3-whorled, but he must have counted the whorls as visible from the apical side, as smaller specimens in the A. N. S. P. (no. 62014, from Kingston, Jamaica, and other lots) show 4 whorls, are dull horn-colored, and more closely

approach Clessin's description and figure. *P. circumlineatus* Clessin is apparently a synonym, but Sowerby's figure, although he also quotes Shuttleworth MSS., looks like a Planorbula. Specimens from St. Thomas (A. N. S. P., 123885) approach the Curaçao shells in size, color and texture. In *P. weinlandi* Pfr. (1876; Mal. Bl., XXIII, p. 172, fig. ii–9, 10, 11), from a brook near Jeremie, Haiti (A. N. S. P., 91455, one specimen from Weinland), the aperture encloses less of the penultimate whorl than in typical *pallidus*, but this character is very variable in the Curaçao shells. *P. meridaensis* Preston (1907; Ann. Mag. Nat. Hist., XX, pp. 493, 497, fig. 18), from Merida, Venezuela, is a heavier shell with more swollen whorls, and with the umbilicus more deeply sunken and showing better impressed sutures (A. N. S. P., 98195; three cotypes). This last form is slightly larger than *P. kühnianus* (+ *kühnerianus*) "Dunker" Clessin (*op. cit.*, 108, fig. xi–12), from Surinam, but otherwise appears to satisfy the description and figure. All of these planorbes have sinistral shells, if the visibility of the first whorls is taken as the criterion of the apex. Otherwise, they appear to fall into the section Gyraulus, although the epidermis is not hispid.

PUPILLIDAE[41a]

Gastrocopta longurio (Crosse)

Pupa longurio Crosse (1872; J. de C., XX, 158); Crosse and Bland (1873; J. de C., XXI, fig. I–2).

Type locality: "Curaçao," probably the Schaarlo (C5e), back of Willemstad.

Distribution: Curaçao, Aruba, Bonaire, Klein-Bonaire; almost everywhere under limestone rocks; apparently with preference for the more arid situations (C1–6, 10–13, 15, 17, 18; A2–5, 8; B1–5, 8; K1).

Numerous specimens of Gastrocopta and Pupoides were collected, and have been submitted to Dr. H. A. Pilsbry for study.

[41a] See Addenda page 116.

The relationships and variation of the present species, and the identification of the next, will be discussed by him in a future paper.

Pupoides sp?

Pupa fallax Gibbons (1879; J. of C., II, 131); first Curaçao record. *Pupoides simoni*? H. B. Baker (1923; this series, no. 137, p. 5).

Distribution in the islands: Curaçao, Aruba, Bonaire, Klein-Bonaire; with the preceding but not as abundant nor in quite as arid situations (C3–6, 12, 17; A3–5, 8; B2, 4, 8; K1). This species is probably not limited to the islands, although it is omitted from the list in the discussion of zoögeographical affinities.

SUCCINEIDAE

Succinea gyrata Gibbons

(1879; J. of Conch., II, 136, fig. I–2)

Type locality: "at St. Ann's, Curaçao"; probably the Schaarlo (C5c), back of Willemstad.

Distribution: Curaçao (C5, 6, 11, 17; Cb6, 17); Bonaire (B3; Bb5); Klein-Bonaire (K1). Rare to quite infrequent; under stones and the bark of dead trees, and in the crevices of the bark of living ones; abundance entirely independent of the nature of the underlying rocks. Most of the living specimens were juvenile or small, which leads me to believe that this species only attains maturity during the wet season. 62 specimens collected.

In what is here regarded as the type locality, the typical, elongate form of this species integrades with more globose specimens with relatively larger aperture, such as are represented by the measurements of those from C11 (see below). The whorls are convex and the suture is deeply impressed, almost channeled. The surface has a peculiar, satiny luster, due to a microscopic sculpture of irregular, raised punctuations. The growth wrinkles are prominent and, towards the aperture, are often very pronounced, almost subcostate, and

irregular. The shell is rendered imperforate by a slight, thickened reflection of the columella in the parietal region, where it is continued by a thin callus that connects the ends of the peristome.

	Measurements				
	alt.	maj. diam.	alt. apert.	diam. apert.	whorls
Gibbons (1879)	12.0	54(6.5)	58(7.0)	64(4.5)	4
Cb6 (dead)	9.3	52(4.8)	60(5.7)	65(3.7)	3¼
C11 (dead)	13.5	57(7.7)	65(8.8)	66(5.8)	3½
C11 (dead)	11.4	56(6.4)	70(8.0)	64(5.1)	3¼
Bb5 (living)	9.3	57(5.3)	65(6.0)	67(4.0)	3

The radular formula (fig. xiv–48) of a medium-sized specimen is 24–1–24. The central tooth is symmetrical and tricuspid. The 1st to 7th laterals are asymmetrical but also tricuspid; the entocone is small, slightly below the level of the mesocone, and is obscured by the refraction of the edge of the tooth. All of the cusps are elongate and very sharp. The 8th lateral usually adds a minute, outer, 4th cusp. Beyond this, the number of cusps becomes very variable, as is illustrated by the three figured examples of the 14th tooth, which occur within four consecutive transverse rows. The 24th tooth is a mere denticle.

The jaw (fig. xiv–49) of the same specimen is double, and consists of a rounded-oblong, emarginate, basal plate and the recurved, arcuate true jaw. The latter bears a triangular median thickening or low rib, and two, transverse, lateral ones; these slightly undulate both margins of the recurved portion. The outer surface is closely, but irregularly, striate; these markings converge towards the apex of the central triangle, and are parallel to the sides of the lateral thickenings.

ZONITIDAE

Guppya molengraaffi, new species

Type locality: (Cb20) just west of the summit of Sint Christoffelberg, northern Curaçao, at an altitude of about 1,200 feet.

Distribution: Curaçao; one specimen collected at type locality.

Shell (fig. xv–54): small, depressed turbinate; light horn-colored; thin and shining. Whorls: 4¼; convex; gradually and regularly increasing; suture shallow. Growth striae: well marked, especially on the base, which shows quite regularly spaced, impressed lines. Spiral striae: present, but much weaker and more irregular than is usual in the genus. Umbilicus: small, about 1/12 of the major diameter of the shell; circular. Aperture: subvertical, reniform. Peristome: simple, sharp, incomplete.

Radula: C/3; L5/3; M19/3 + 4/4 + 1/1; or 25–5–1–5–23. Form of teeth very similar to those of *G. gundlachi* (Pfr.),[43] although the lateral cusps of the central are somewhat more acuminate and the outer cusp of the first marginal is smaller and more distant from the two larger ones. Jaw: much as in *G. gundlachi* (*l. c.*, fig. 3).

Measurements

altitude	maj. diam.	min. diam.	alt. apert.	diam. apert.	whorls
1.63	150(2.40)	130(2.13)	63(1.03)	120(1.22)	4¼

The practical absence of spiral sculpture makes this species appear closest to *Guppya miamiensis* Pilsbry (1903; Naut., XVII, 77) from Florida, but the Curaçao shell is more globose, with a more depressed spire and shallower suture. The regularity of the impressed striations on the base is also a noticeable difference.

HELICIDAE

Thysanophora crinita arubana, new subspecies

Type locality: (A4a) at base of northern escarpment of Seroe Canashito, Aruba.

[43] 1922; *Occ. Papers Mus. Zool. Univ. Mich.*; no. 106, p. 45, fig. xvii–1.

Distribution: Aruba; very rare; 6 specimens under limestone rocks at type locality.

Shell (fig. xv–56): small, sub-discoid, rather heavy; dark horn-colored. Whorls: 4¼, markedly flattened above but scarcely subangulate; gradually increasing; suture deeply impressed vertically; last whorl slightly descending. Sculpture of last whorl: closely spaced, compressed, undulate and rarely anastomosing, cuticular riblets, which are slightly more oblique than (and cross) the obscured growth wrinkles. Penultimate whorl: in addition, with the broken bases of what, in young specimens (fig. xv–55), are long (.33 mm.), sparsely and irregularly scattered, white hairs, which extend even into the umbilicus. Embryonic whorls: 1¼; with regular, somewhat heavier, cuticular costae, which are slightly more oblique than the obscured growth wrinkles and extend to the very apex. Umbilicus: large, about 3/10 the major diameter of the shell; circular. Aperture: oblique, subcircular. Peristome: incomplete, very slightly thickened; parietal callus very weak.

Measurements

altitude	maj. diam.	min. diam.	alt. apert.	diam. apert.	whorls
2.09	190(3.93)	160(3.38)	61(1.27)	140(1.76)	4¼

These shells are certainly very closely related to *Trichodiscina crinita* Fulton (1917; P. Mal. Soc., XII, 240), from Carthagena, Colombia. However, the Aruba form is evidently a larger shell (even after making allowance for the greater number of whorls); its last whorl is markedly flattened above instead of evenly convex; the incomplete peristome is slightly thickened; and the parietal callus is very weak, almost absent (from Fulton's figure, it would appear that the peristome of his shell is continuous, but I suspect that it simply has a heavy, parietal callus). Both *crinita* and *arubana* must have similar sculpture to that in *Trichia venezuelensis* Jousseaume (1889; Mem. Soc. Zool. France, II, p. 248, figs. ix–12, 13) and *Trichia rojasi* Jousseaume (*l. c.*, p. 249, figs. ix–9, 10), both from Venezuela; although *venezuelensis* is described as hirsute, the figure of *rojasi* is the one that shows

the hairs. On the other hand, the shape of these two forms is closer to that of *Thysanophora vanattai* (see below).

The sculpture of all of these species is somewhat similar to that in *T. fuscula* (C. B. Adams), *T. proxima* Pilsbry, and *T. canalis* Pilsbry (*cf.* 1922; Occ. Papers Mus. Zool. Univ. Mich., no. 106, p. 56), but the subdiscoid shape of *crinita* and *arubana* is more like that of the generic type, *T. conspurcatella* (Morelet). The haphazard distribution of the long hairs is very peculiar, but these are only present in the young shells of *arubana.*

Thysanophora vanattai, new species

Type locality: (A4a) at base of northern escarpment, Seroe Canashito, Aruba.

Distribution: Aruba; Baranca Alto (A2c; very rare, 1 specimen), Rooi Frances (A3; quite infrequent, 33 specimens), Seroe Canashito (A4; quite rare, 22 specimens). Under limestone rocks, in protected places.

Shell (fig. xv–57): small, depressed turbinate, thin and translucent; very light horn-colored, almost white; epidermis thin, but usually incrusted heavily with reddish material and even small particles from the surrounding rocks. Whorls: 4¾, quite evenly rounded; very gradually increasing; suture well impressed; last whorl very slightly descending. Sculpture of last whorl: rounded growth-wrinkles, separated by fine, impressed lines; crossed by more oblique striae, which are very weak and short. Embryonic whorls: 1½; practically smooth, although with extremely minute, irregular punctations, which have a slight tendency towards spiral arrangement. Umbilicus: open, circular; about ¼ the major diameter of the shell. Aperture: slightly oblique, broadly elliptical. Peristome: incomplete, simple and sharp.

Radula (fig. xiv–50): C/3, L6/2, M2/3 + (4/4 +) + 1/1; or 10–6–1–6–10. Central: symmetrical, with rather slender, sharp cusps. First lateral: similar but asymmetrical, with entocone lacking; on the inner side of the mesocone is a narrow

expansion, which becomes broader in the successive laterals until, in the 7th tooth, it develops a small cusp. This cusp becomes larger on the 8th, while, in the 9th, the ectocone also becomes bifid. In the outer marginals, the ectocone breaks up still more, but the inner two cusps remain about the same. The outermost tooth is a mere denticle. Jaw (fig. xiv–51): thin, slightly arcuate; consists of 25 to 27, transverse plates, which serrate the margins, but appear to be well fused together.

Measurements

altitude	maj. diam.	min. diam.	alt. apert.	diam. apert.	whorls
2.58	165(4.19)	150(3.92)	55(1.43)	135(1.95)	4¾

This species appears to be somewhat similar to the small Thysanophorae of Porto Rico and the northern Lesser Antilles, such as *T. subaquila* (Shuttleworth). It is smaller and has a relatively larger umbilicus.

BULIMULIDAE

Drymaeus virgulatus (Férussac)

Helix elongata "Bolten" Roeding (1798; Mus. Bolt., 107). *Helix virgulata* Férussac (1821; Tabl. Syst., 54; Hist. fig. cxlii, 1–7). *Bulimulus apiculatus* Gray (1834; P. Z. S., 66); the form with the bluish apex. *H. ludovica* "Rang" Beck (1837; Index, 66); reddish, unicolor form. *Bulimus elongatus* Bland (1861; Ann. Lyc. Nat. Hist. N. Y., VII, 143); first Bonaire record. *Bulimus elongatus* Bland (1866; Amer. J. Conch., II, 143); first Curaçao record. *Bulimulus elongatus* Smith (1898; Proc. Mal. Soc., III, 114); first Aruba record; collected by Hartert.

Type locality: Porto Rico.

Distribution: Porto Rico; northern Lesser Antilles; Venezuela? Curaçao: in the richer places throughout the island (C1, 2, 4, 9, 11cd, 12a, 13–17, 20; Cb16, 17). Aruba: Seroe Canashito and Rooi Taki (A4a, 2c). Bonaire: in the better wooded places throughout the island (B3, 4, 5, 6, 7, 8; Bb3, 7). Usually found cemented to the trunks or branches of the larger trees; often found on the gumbo limbo (*Bursera gummifera*)

and guayacan. Quite independent of the nature of the underlying rocks.

Férussac apparently based his typical form on Lister's figure 2. This shows a rather small specimen with the color-varices broken by a tendency towards spiral bands. The figure (a) of Chemnitz (vol. IX, pl. 134, fig. 1225) shows a specimen with only the varices, while his figure (b) shows both these and the spiral bands.

In the series from the Dutch Leeward Islands, the color variation may be analyzed as follows:

Apex: every intergradation between pure white and quite dark, lilac-blue (*apiculatus*). Although both extremes commonly occur in the same locality, the colonies usually tend towards a preponderance of one or the other of these color forms. For instance, 97 per cent. of the specimens from Bonaire have dark apices, while none of those from Aruba show this tendency. Both forms are present in about equal numbers in Curaçao as a whole (53 per cent. white, 47 per cent. blue). As a rule, the blue-tipped shells are more strikingly banded, although some of the shells of this form from Bonaire are otherwise colorless.

Ground color: dead white in all of my specimens, but in some the band coloration is so diffuse as to tinge the last whorl with light chocolate. Shells in one lot in the A. N. S. P. (no. 2430, collected by Raven), from Bonaire, are salmon-pink and almost unicolor (*ludovica*).

Bands: in this species the spiral and growth sets of color banding seem to struggle for dominancy. When present, either set may be diffuse or sharply marked, narrow or broad, and may vary in color from light reddish brown to deep chocolate with a purplish tinge. Ten per cent. of my specimens are without bands. Nine per cent. have numerous, quite regular varices, which are usually quite narrow and sharply marked. This type of coloration is especially conspicuous near Landhuis Hato, Curaçao (C11cd). All of the shells show a distinct tendency to increase the density of the pigmentation during the periods of slower growth (this, by the way, is a character-

istic of most of the species in the Dutch Leeward Islands), and, as a result, the spiral bands are seldom continuous for any distance. Forty per cent. of the shells may be classed as flammulated. In this group are included the shells in which the varices are broken by non-pigmented spiral zones, and also those in which the continuous or broken varices are flammulated by spirally arranged blotches of color. In 30 per cent. of the shells, the broken, spiral bands and varices are about equally prominent, so as to form grid markings. Twelve per cent. may be classed as spirally banded, although only one specimen (from B8) has truly continuous, spiral bands for any distance. Usually, the spiral bands are lightest where the growth lines are farthest apart; this produces a series of contiguous, oblong blotches, each of which shades from light to dark in the direction of growth.

Peristomal callus and edge of columella: usually white, bordered internally by a dark, chocolate band; sometimes the entire callus is colored practically as dark as the interior of the aperture.

Interior of the aperture: almost white to dark chocolate, usually darker than the exterior of the shell, but varying in intensity of color with it. Commonly the spiral bands and varices are also darker and broader than on the exterior.

In addition to the color variation, the shells vary considerably in size and shape, and in solidity. The shells from Aruba are the lightest and smallest, while those from Bonaire are the largest and most solid. The comparatively small numbers of specimens make the following dimensions studies less trustworthy than in some of the other species. In addition, on account of the large numbers of immature specimens that were present among the adults, only the larger specimens were collected, and the sets are scarcely random lots.

The remarkably discontinuous distribution of *D. virgulatus* gives rise to the suspicion that it has been introduced into Curaçao by commerce; it is noteworthy that this species also occurs in St. Martin and St. Eustatius, two of the islands of the northern Lesser Antilles, which are also part of the Netherlands Colony of Curaçao (*cf.* Vernhout, *l. c.*, p. 184).

Table VIII. Dimensions of Drymaeus virgulatus

Comparison of Stations

place	nos.	whorls	altitude	index	maj. diam.
Lister; fig. 2		6 +	25.6	41	10.6
Férussac; pl. 142B, 1		7	32.1	42	13.6
C1	26	6.5(6.0–7.0)	25.5(23.1–29.3)	46(44–50)	12.1(11.1–12.8)
C2	25	6.4(6.0–7.0)	26.0(23.0–29.9)	47(44–50)	12.2(11.4–13.4)
C4	30	6.9(6.5–7.5)	25.9(22.5–29.8)	45(42–49)	11.8(10.9–13.1)
C9	4	6.8(6.5–7.0)	26.6(26.2–26.8)	46(45–48)	12.2(11.9–12.8)
C11cd	21	6.5(6.0–7.0)	25.9(23.6–28.3)	47(44–50)	12.2(10.6–13.0)
C12a	13	6.7(6.5–7.0)	26.3(23.4–27.9)	46(45–48)	12.0(10.7–12.7)
C13	7	6.6(6.0–7.0)	26.6(24.2–29.6)	47(43–49)	12.2(11.5–12.9)
Total; s. Curaçao	126	6.6(6.0–7.5)	26.1(22.5–29.9)	46(42–50)	12.1(10.6–13.4)
C14	3	6.3(6.3–6.5)	25.5(24.0–27.0)	48(46–50)	12.2(11.9–12.5)
C15, 17	24	6.6(6.3–7.3)	26.6(23.8–29.2)	46(43–49)	12.1(11.0–13.3)
C16	11	6.6(6.3–7.0)	27.8(26.6–30.6)	47(45–50)	13.1(12.5–13.8)
Cb16, 17	2	6.8(6.5–7.0)	28.4(27.5–29.3)	46(44–48)	13.0(12.9–13.2)
C20	8	6.8(6.5–7.0)	27.4(25.4–29.1)	45(44–46)	12.2(11.4–13.1)
Total; n. Curaçao	48	6.6(6.3–7.3)	27.1(23.8–30.6)	46(43–50)	12.5(11.0–13.8)
A2c	5	7.1(7.0–7.3)	25.6(24.3–27.4)	46(42–47)	11.6(11.3–12.1)
A4a	5	6.9(6.8–7.0)	23.8(22.7–25.3)	47(46–48)	11.2(11.0–11.7)
Total; Aruba	10	7.0(6.8–7.3)	24.7(22.7–27.4)	46(42–48)	11.4(11.0–12.1)
B3 to 7; Bb3, 7	64	7.0(6.5–7.8)	28.6(24.5–32.2)	45(40–50)	12.9(11.0–13.8)
B8	7	6.6(6.3–7.0)	27.2(25.2–28.2)	47(45–48)	12.6(12.1–13.6)
Total; Bonaire	71	6.9(6.3–7.8)	28.4(24.5–32.2)	45(40–50)	12.9(11.0–13.8)

C1. Quite infrequent. Bright, and sharply marked.

C2. Quite infrequent. Dull and diffuse coloration.

C4. Frequent, on trees and even the crotons. Sparsely but quite sharply marked.

C9. Very infrequent. Sharply marked.

C11cd. Infrequent. Sharply and finely marked.

C12a. Quite infrequent, on larger trees at base of the escarpment. Peristomal callus heavy; shells rather solid. Dark, broad sharply-marked bands and varices.

C13. Infrequent, mainly at base of northern escarpment. Bleached, diffuse coloration.

C14. Very infrequent. Similar to C13.

C15 and C17a, lots mixed. Frequent. Shells rather solid, with heavy peristomal callus. Coloration diffuse, to dark and sharply marked.

C16. Frequent. Shells solid with heavy callus. One specimen has the heaviest callus in the sets; the shell is 2 mm. thick on the palatal wall. Dark bands and varices.

Cb16, 17. Rare to infrequent; occurs in the richer valleys throughout the region of older rocks from Campo Sint Kruis to the Tafelberg of Sint Hyronimus. Quite heavy, with diffuse markings.

C20. Infrequent. Similar to Cb17.

A2c. Very rare; only found on Cereus in Rooi Taki. Thin and dull-colored.

A4a. Rare; on trees at base of northern escarpment. Similar to A2c.

B3–7; Bb3, 7. Rare to frequent. In the richer localities, both over limestone and in the interior region. The largest shells collected; solid with heavy peristomal callus. Usually rather dull colored.

B8. Quite infrequent. Somewhat smaller than the preceding.

From the comparison of dimensions (Table VIII), it will be seen that typical *D. virgulatus*, as judged by the figures, is a considerably more slender shell than that represented by the mean of the Curaçao specimens, and, in fact, corresponds to the most slender shells from the Dutch Leeward Islands. It would be interesting to compare a large lot from Porto Rico.

The radular formula (fig. xiv–52) of a specimen from Seroe Papaja (C11c) is: 86–1–86. The central is asymmetrical and tricuspid. Almost all of the laterals are also tricuspid, but, as is usual in the genus, the ectocone is very variable and may be entire and bifid in two consecutive teeth; as a rule, the outer teeth are more variable than the inner, but the first lateral itself may be 4-cusped, while the 83rd tooth is commonly tricuspid. The transverse rows run obliquely backwards to the 54th tooth, which is peculiarly elongate and lacks the entocone; with the 55th, the rows curve abruptly forward so that the entire row has the shape of a broad W (see line under scale in figure). In the 1st to the 53rd teeth, the entocone is markedly larger than the ectocone and is quite widely separated from the mesocone, but the teeth beyond the 54th are more nearly symmetrical. In addition, the bases, in each portion, are almost parallel to the direction of the row, so the teeth of the outer and inner limbs are quite markedly different in ap-

pearance. The outermost teeth are strongly compressed transversely. This radula is very similar to that figured by Pilsbry (1902; Man. Conch., XIV, fig. LX–16) for *D. interpunctus* (Martens).

Oxystyla maracaibensis imitator Pilsbry
(1899; Man. Conch., XII, p. 140, fig. xxx, 49–54)

Type locality: near Maracaibo, Venezuela.

Distribution: Maracaibo, Venezuela, and Santa Marta, Colombia, to Peru. Aruba: subfossil in the aloe fields on the western side of the island. Four specimens collected about 1 km. south of Seroe Canashito. From the localities listed, this appears to be a desert form.

Although all of my specimens are badly bleached, from one to three spiral bands and two or three varices can be made out. One specimen is almost a perfect duplicate of fig. 54 in Pilsbry (*l. c.*).

Measurements

altitude	maj. diam.	min. diam.	alt. apert.	diam. apert.	whorls
45.4	61(27.5)	52(23.7)	56(25.5)	69(17.6)	7

ACHATINIDAE

Genus Neosubulina, subgenus s. s.

Neosubulina Smith (1898; P. Mal. S., III, p. 115); monotype *Neosubulina harterti* Smith, from Bonaire.

Shell: ovate-turrite; light-colored and translucent. Whorls: numerous. Growth-wrinkles of last whorl: well defined. Embryonic shell (dissected out from parent): 2¼ to 2½ whorls; with delicate and regular growth-wrinkles crossed by spiral striations, which extend to the very apex. Umbilicus: rendered imperforate by expansion of columellar-parietal callus. Peristome: thin, sharp, incomplete; lower palatal wall broadly and slightly emarginate; with a twisted thickening around the columella, which is present even in the embryonic shell; parietal wall with a spiral lamella in the adult. Repro-

duction: ovoviviparous; eggs relatively very large, with a white, granulate capsule. Radula: very similar to that of Opeas, but with multicuspid marginals.

In this genus (see *N. harterti*), the inner laterals are tricuspid and almost symmetrical, while the outer ones are reduced in size and slightly more tilted inwards; in Leptinaria (*cf.* Pilsbry; 1907; Man. Conch., XVII, fig. xli–4), the entocone is very much reduced on the inner laterals, while the outer ones are extremely elongate. Although the lingual armature is known only in the typical group, I believe that Neosubulina includes three subgenera: Pelatrinia Pilsbry (*l. c.*, p. 324), monotype *Leptinaria helenae* Pilsbry from Venezuela; Neosubulina s. s. (redescribed above) from the Dutch Leeward Islands; and Ischnocion Pilsbry (*l. c.*), monotype *Leptinaria triptyx* Pilsbry from Colombia. In the first of these, the shell is subacuminate-turrite; the embryonic whorls are vertically striate; and only the columellar twist is present in the adult. In the second, the shell is ovate-turrite; the embryonic shell is vertically and spirally striate; and a spiral lamella is present on the parietal wall of the adult. In the third, the shell is subcylindric-turrite; the embryonic whorls are practically smooth; and the adult develops a palatal fold in addition to the columellar twist and the parietal lamella.

Neosubulina harterti Smith

(1898; Proc. Mal. S., III, p. 115, fig. II); collected by Hartert

Type locality: Bonaire; probably near Kralendijk (B1, 2).

Distribution: Bonaire; in the richer localities (B3–6), buried deeply in limestone talus. The species of this genus inhabit the rotten mould that fills the deeper crevices of the detritus; they seldom occur among the cleaner rock fragments near the surface, although the latter is the stratum where most of the other genera were found. For this reason, it is very difficult to estimate the abundance.

Shell (fig. xvi–61); light horn-colored, quite transparent; tapers quite regularly from last whorl to apex. Whorls: 9 (maximum observed); later whorls elongate, slightly and

evenly convex; suture oblique, shallow except near the apex. Sculpture of last whorl: growth-wrinkles fine, regular and thread-like, vaguely and very lightly crenulated by a few, spiral striations. Aperture: elongate-ovate, with long axis slightly oblique to that of shell. Peristome: columellar truncation slight in adults but relatively prominent in the embryonic shell; parietal lamella compressed, present as a thin lamella on the central axis of the last but dying out on the penultimate whorl of the adult, present as a fine, internal thread in a young shell of 5½ whorls, not developed in embryonic shell (fig. xvi–58).

Radula (fig. xiv–53): C/3, L7/3, M4/ + (10/4 +): or 21–1–21. Very similar to that of *Opeas beckianum* (*cf.* 1923; this series, no. 135, fig. I–6), but the cusps of the inner laterals are broader and heavier; the teeth in each transverse row decrease more rapidly in size towards the outside; and, in the marginals, the entocone (first), ectocone and mesocone become subdivided into minor cusps (all usually tricuspid in Opeas).

Jaw (fig. xvi–64): thin, transparent, arcuate, crossed by numerous, well-impressed lines, which separate rounded, granulate riblets.

Measurements

	alt.	maj. diam.	alt. apert.	diam. apert.	whorls
embryo (fig. 58)	1.8	60(1.07)	58(1.04)	53(0.55)	2¼
largest, B6 (fig. 61)	11.5	20(2.33)	22(2.57)	54(1.39)	9
Smith (1898)	9.0	25(2.25)	22(2.0)		8

As Smith (*l. c.*) was apparently unfamiliar with the description of *N. gloynii,* he did not differentiate the two species. As a result, his species would be unrecognizable without the locality. The absence of the parietal lamella in the embryonic shell indicates that *N. harterti* is more distantly related to *N. gloynii* and *N. scopulorum* than they are to each other. The specimens from the northern localities on Bonaire (my measurements and figures) average slightly larger than do those from the more southern stations (probably typical *harterti*). Although considerable search was made for it, this species was not obtained on Klein-Bonaire.

Neosubulina gloynii (Gibbons)

Cionella gloynii Gibbons (1879; J. of Conch., II, p. 135, fig. I–1); W. G. Binney (1883; Ann. N. Y. Acad. Sci., III, p. 101, fig. vii–3); radula. *Leptinaria gloynii minuscula* Pilsbry (1907; Man. Conch., XVIII, p. 323, fig. xlvii–18); small form. *Leptinaria gloynii* H. B. Baker (1923; this series, no. 137, p. 5, figs. I, 1–3).

Type locality: "St. Ann's, numerous under stones," Curaçao; probably the Schaarlo (C5c), back of Willemstad.

Distribution: Curaçao; in the richer localities, both on limestone (C1–6, 11, 12, 15, 17, 20) and in the central region (Cb2, 6, 17, 20); not found near the shore but reaching an altitude of 1,200 feet on Sint Christoffelberg. Habits as in *harterti.* This is the only species that was found in the groves of poisonous manzalienja trees along the inland water-courses; it was found in only one such locality (Cb2), although the thick layers of fallen leaves in these places look like rather favorable localities for land molluscs.

Shell (fig. xvi–62): cloudy pearl-colored, usually more opaque than the other two species; averages larger and tapers more abruptly near the apex than does *harterti.* Whorls: 9¾ (maximum observed); later whorls slightly stouter (especially near the middle of the shell) and lower than in *harterti,* each convex above the middle and tapering and flat-sided below so that they appear to telescope into each other; suture more pronounced and slightly less oblique. Sculpture of last whorl: growth-wrinkles coarser but more obscure and irregular than in *harterti,* also more oblique and markedly arcuate just below the suture; spiral sculpture quite absent. Aperture: slightly more elongate and with long axis more oblique to that of shell. Peristome: columellar truncation of the adult more pronounced; parietal lamella heavier than in *harterti,* developed as a marked angulation (*cf.* 1923, *l. c.,* fig. 3) on the central axis of last and penultimate whorls, low but distinct on the smaller embryonic shell (fig. xvi–59); lower palatal emargination more pronounced than in *harterti.*

In the more barren localities, the shells are usually somewhat smaller and may be included in the form *minuscula* (Pilsbry).

Otherwise the species appears quite constant throughout the island.

	Measurements				
	alt.	maj. diam.	alt. apert.	diam. apert.	whorls
embryo (fig. 59)	1.6	62(0.97)	58(0.91)	59(0.53)	2½
largest, C11 (fig. 62)	12.7	21(2.65)	22(2.84)	52(1.48)	9¾
Gibbons (1879)	13	23(3)			9–10

Neosubulina scopulorum, new species

Type locality: (A3) at base of right wall of entrance to Rooi Frances, Aruba.

Distribution: Aruba; richer localities on the limestone (A2–4). Habits as in *harterti.*

Shell (fig. xvi–63): bright horn-colored, quite transparent; tapers abruptly near the apex as in *gloynii,* but is also constricted noticeably just below the middle; attains a much larger size (and greater number of whorls) than do the other two species. Whorls: 11¾ (maximum observed); apical and subapical quite similar to *gloynii*; those just below the middle markedly elongate, convex below the suture but flat-sided and tapering below the convexity so that the telescopic appearance is even more marked than in *gloynii*; suture more pronounced and oblique. Sculpture of last whorl: growth-wrinkles more closely-spaced and angular than in *gloynii,* but coarser than in *harterti,* slightly less oblique than in the former but similarly arcuate just below the suture; spiral sculpture only indicated by broad and obscure constrictions. Aperture: shaped much as in *gloynii,* but with long axis slightly less oblique to that of shell. Peristome: columellar truncation and parietal lamella of adult higher and larger than in *gloynii,* relatively as pronounced in the larger embryonic shell (fig. xvi–60) as in the adult; lower palatal emargination as in *gloynii.*

Radula: C/3, L9/3, M12/4 + ; or 21–1–21. Very similar to that of *harterti,* but the laterals decrease in size more gradually and the first 9 teeth are tricuspid. Jaw: very similar to *harterti.*

The embryonic shells figured (figs. xvi, 58–60) were all dissected out of the bodies of the parent shells. As large eggs

were rarely found in specimens from Curaçao (June), but were more common in those from Aruba (July), and were present in a large proportion of the individuals from Bonaire (August), it seems probable that the eggs are laid near the beginning of the wet season. The adult figured (figs. xvi–61, 62, 63) is, in each species, the largest specimen collected. In all of the species, the spire is often curved out of line with the lower whorls, but this asymmetry is most common in *N. scopulorum.*

Measurements

	alt.	maj. diam.	alt. apert.	diam. apert.	whorls
Embryo (fig. 60)	1.7	62(1.07)	52(0.90)	60(0.54)	2½
Type, largest (fig. 63)	16.9	16(2.69)	18(2.99)	52(1.57)	11¾

UROCOPTIDAE

Brachypodella raveni raveni (Crosse)

Cylindrella raveni "Bland" Crosse (1872; J. de C., XX, 157); Crosse and Bland (1873; J. de C., XXI, fig. I–4); collected by Raven. *Brachypodella raveni* Pilsbry (1903; Man. Conch., XVI, fig. ix–14); radula.

Type locality: Curaçao; probably the Schaarlo (C5c), back of Willemstad.

Distribution of species: Curaçao, Aruba; under limestone rocks near the surface, in all but the most barren localities.

Distribution of subspecies: Curaçao; from New Port north to Landhuis Hato (at least C1, 3, 4, 5, 6, 7, 11, 12).

Shell (fig. xvii–67): brownish in color with lighter ribs, opaque; subacuminate-turrite, greatest diameter at 2½ to 3 whorls from aperture. Whorls: 14 (in a rather small specimen), of which about 9 are usually retained; moderately convex with well-impressed sutures; last whorl with basal carina below a peripheral emargination. Sculpture of later whorls: fine, but well-marked growth-riblets, which are usually as wide or wider than their interspaces and slightly crested over the basal carina. Embryonic whorls (fig. xvii–73): apparently 3, of which the 2nd is as broad or broader than the 3rd; thin, translucent, amber-colored; sculpture of fine, closely-spaced,

regular growth-riblets. Plane of aperture considerably in front of periphery of last whorl.

Radula (fig. xvi–65): C/3–4, L2/2, M7/2 + 1/0; or 8–2–1–2–8. Central: with very slender base; the outer cusps are large, but one or two, very variable, smaller cusps lie between them; this seems to indicate a tooth that is becoming bicuspid by the suppression of the central cusp of the tricuspid type. The accessory cusp of the inner lateral is aculeate in shape, while that of the outer lateral is broader and more hoe-shaped. The slender bases of the small marginals are very irregular at their posterior ends, while the lateral corner of the anterior margin is produced into a sharp point. 124 rows of teeth counted in a radula which lacks the unformed, posterior portion.

Jaw: consists of about 44, thin, slender, subrectangular, overlapping plates, which are shorter near the center where they form a triangle.

Measurements

	Shell		Spire	Aperture		Whorls
	alt.	maj. diam.	maj. diam.	alt.	diam.	
C11, entire (fig. 67)	8.98	29(2.63)	24(2.17)	16(1.46)	104(1.52)	14
C5, largest	7.83	34(2.64)	28(2.76)	21(1.68)	104(1.74)	8

Typical *raveni* attains the largest size and has the most closely spaced riblets of any of the forms in the Dutch Leeward Islands; all of these are placed by their apical sculpture in the mainland group of Brachypodella s. s. (*cf.* Pilsbry, *op. cit.*). As will be noted from the measurements of this and the following forms, the few complete shells obtained are considerably below the maximum size. The largest shells also appear to have developed the greatest number of whorls.

Brachypodella raveni sanctaebarbarae, new subspecies

Type locality: (C2a) at base of northern escarpment of the Tafelberg of Santa Barbara, southern Curaçao.

Distribution: Curaçao; only found at the base of the northern and western escarpments of this Tafelberg (C2).

Shell (fig. xvii–68): considerably smaller and much thinner and more polished and translucent than *raveni*. Growth-riblets of later whorls much lower, more rounded, and more widely spaced. Aperture relatively larger. Otherwise as in *raveni*.

Measurements

	Shell		Spire	Aperture		Whorls
	alt.	maj. diam.	maj. diam.	alt.	diam.	
C2, type (fig. 68)	7.75	30(2.32)	26(2.00)	18(1.38)	108(1.49)	13½
C2, largest	7.76	28(2.84)	28(2.19)	23(1.77)	103(1.83)	8

The several hundred specimens collected from the type locality are all quite distinct from typical *raveni*, but they do intergrade slightly with those from near New Port (C1), which are connected by intermediates with those from the more northern localities. With equal reason, these two subspecies could be considered as separate species which produce hybrids at their point of contact.

Brachypodella raveni knipensis, new subspecies

Type locality: (C17a) Seroe Djerimi, northern Curaçao.

Distribution: Curaçao; north of Seroe di Boca (at least C15, 17, 20).

Shell (fig. xvii–69): averages considerably smaller than *raveni*; greatest diameter at about the 3rd whorl above the aperture. Carina and peripheral emargination carried higher on the whorls. Growth-riblets of later whorls more widely spaced and slightly heavier. Otherwise as in *raveni*.

Measurements

	Shell		Spire	Aperture		Whorls
	alt.	maj. diam.	maj. diam.	alt.	diam.	
C17, type (fig. 69)	7.97	30(2.39)	26(2.05)	16(1.27)	118(1.50)	13½
C17, largest	7.24	36(2.61)	29(2.10)	21(1.51)	107(1.61)	8

Aperture formation in Brachypodella appears to be hastened by injury and specimens with peculiarly distorted peristomes are not uncommon. In the present subspecies, quite a number of the specimens, although apparently uninjured, are almost perfectly conical, with the last whorl well rounded and larger than any of the preceding ones; a single specimen (fig. xvii–72) also has the peristome adnate to the last whorl.

Brachypodella raveni arubana, new subspecies, and form **sinistrorsa,** new

Type locality: (A2b) Seroe Pretoe, between Roois Hundoe and Spoki, Aruba.

Distribution: Aruba, under limestone rocks. All of the specimens from A2, and A3, and 93 per cent. of the 105 shells from A4 are dextral (typical form); 7 per cent. of those from Seroe Canashito (A4), and all from the shore-cliffs between Perkietenboseh and Kralendijk (A5, quite rare) are sinistral (form *sinistrorsa*).

Shell (xvii–70): similar in size to *raveni,* but usually more cylindric; greatest diameter usually above the 3rd whorl; surface more highly polished. Whorls: 14½ (in a medium-sized specimen), of which about 10 are usually retained; later whorls less convex than in typical *raveni*; carina and peripheral emargination carried much higher on the shell. Growth-riblets of last whorl: usually closely-spaced, but much lower and more rounded than in *raveni*; carinal crests poorly developed or absent. Peristome: reflection broader than in *raveni.*

Radula and jaw: similar to *raveni,* but the intermediate cusps of the central tooth are usually smaller.

Measurements

	Shell		Spire	Aperture		Whorls
	alt.	maj. diam.	maj. diam.	alt.	diam.	
A4, complete	8.85	24(2.39)	22(1.99)	18(1.59)	107(1.70)	14½
A2, type, largest (fig. 70)	8.32	32(2.67)	26(2.19)	21(1.75)	101(1.76)	8

The specimens from southern Aruba are quite distinct from any of the other subspecies, but those from the central portions are usually smaller, often have more distinct riblets, and intergrade slightly with *knipensis*. The sinistral shells are similar in sculpture and size to the dextral specimens from Seroe Canashito (A4), but their definite distribution seems to require recognition as at least an incipient local race. The type locality of form *sinistrorsa* is the top of the low shore-cliffs just south of Kralendijk (A5c).

Brachypodella gibbonsi, new species

Cylindrella raveni Gibbons (1879; J. of C., I, 340); first Bonaire record.

Type locality: (B3) base of western escarpment of Montagne, Bonaire.

Distribution: Bonaire (B3–6, 8), Klein-Bonaire (K1); under limestone rocks.

Shell (fig. xvii–71): considerably smaller, more acuminate, and lighter in color than *raveni*; greatest diameter at the penultimate whorl. Whorls: 12¾ (in a medium-sized specimen), of which about 8 are usually retained; more convex and with deeper sutures than *raveni*; last whorl relatively more elongate. Growth-riblets of later whorls: much higher, heavier, and more distant than in *raveni*; expanded into heavy, white crests over the basal carina. Plane of aperture about on a level with the periphery of the last whorl (*i. e.*, although the last whorl is equally tangential, it is not carried as far forward as in *raveni*). Peristome: heavier. Embryonic whorls and other characters as in *raveni*.

Radula (fig. xvi–66) and jaw: very similar to *raveni*, but the centrals are usually bicuspid although a rounded projection is sometimes developed in the shallower notch. 148 transverse rows counted in a complete specimen.

This species has more distant riblets than *B. raveni sanctaebarbarae*, while they are heavier than those of the subspecies *knipensis*. Although this species does not intergrade with either, it appears more closely related to the northern and southern forms than to typical *raveni* of central Curaçao.

Measurements

	Shell		Spire	Aperture		Whorls
	alt.	maj. diam.	maj. diam.	alt.	diam.	
B3, type, entire (fig. 71)	7.64	34 (2.61)	26 (2.01)	20 (1.50)	99 (1.49)	12¾
B3, largest	7.10	37 (2.61)	31 (2.22)	22 (1.56)	100 (1.56)	8

Microceramus bonairensis bonairensis (Smith)

Pineria bonairensis Smith (1898; Proc. Mal. Soc., III, p. 114, fig. I); collected by Hartert.

Type locality: Bonaire, probably near Kralendijk (B1, 2).

Distribution of species: Bonaire, Klein-Bonaire, Curaçao, and Aruba. Under superficial limestone slabs; this species is apparently next to the Pupillidae, among the smaller shells, in its ability to withstand aridity.

Distribution of subspecies: Bonaire (B1–8) and Klein-Bonaire (K1).

Shell (fig. xvii–74): ovate-lanceolate; penultimate whorl slightly the broadest. Color: light corneous, marked with opaque, milky-white, irregular patches. Whorls: about 9; quite convex; suture well marked. Sculpture of later whorls: regular, almost contiguous, quite prominent, rounded growth-riblets, which are not much obscured by the relatively inconspicuous, opaque thickenings; basal whorl with slight, spiral angulation, which is first evident just below the parietal angle of the aperture. Embryonic whorls: corneous; convex, with impressed sutures; first half-whorl smooth and polished, remainder with minute, regular, well-marked, and quite closely-spaced growth-riblets. Umbilicus: distinctly rimate. Aperture: subcircular, but distinctly broader than high. Peristome: whitish; slightly thickened and reflected; incomplete; thickened and most reflected on the columellar wall. Columella inside of whorls: slender, with a slight, spiral thickening.

Measurements

	Shell		Aperture		Whorls
	alt.	maj. diam.	alt.	diam.	
Type (Smith, 1898)	6.0	42 (2.5)	25 (1.5)		8½
Fig. 74 (B2)	6.49	49 (3.17)	27 (1.74)	112 (1.95)	8¼

Typical *bonairensis* (Table IX, B2) from southern and central Bonaire (B1, 2, 7) and Klein-Bonaire (K1) is quite distinct in form and sculpture from any of the other subspecies. However, those from the more northern localities (B5, 6, 8) are more slender and elongate (Table IX, B8), and the growth riblets of the lower whorls are weaker and less regular, so these shells intergrade somewhat with the series from Curaçao, especially with the lots from the more northern localities of that island.

In Table IX, the minor diameter is used because of its greater constancy and on account of the difficulty in the measurement of the major diameters of these small shells by means of calipers. Throughout this paper, all measurements that involve two decimal places were made from camera-lucida drawings under considerable magnification. It will be noted that I did not obtain any specimens as small as Smith's measurements would indicate, but this may be due to the fact that his figures are only to the nearest half-millimeter.

Table IX. Dimensions of Microceramus bonairensis

Place	Nos.	Whorls	Altitude	Index	Min. Diam.
B2	20	9.0(8¼– 9¾)	7.0(6.3– 7.9)	42(37–44)	2.9(2.8–3.1)
B8	18	9.7(8¾–10½)	7.7(6.5– 8.7)	37(31–43)	2.8(2.7–3.0)
C5	94	10.0(8¾–11¼)	8.0(6.4–10.2)	36(32–42)	2.8(2.6–3.3)
C17	50	9.5(8¾–10½)	7.2(6.3– 9.2)	37(32–41)	2.7(2.5–3.1)
A4	56	10.8(10 –12¼)	8.6(7.1–10.0)	33(30–36)	2.8(2.5–3.2)

Microceramus bonairensis curacoanus H. Burrington Baker

Macroceramus inermis Gibbons (1879; J. of C., II, 136); first Curaçao record; W. G. Binney (1883; Ann. N. Y. Acad. Sci., III, 126); radula. *Microceramus bonairensis curacoana* H. B. Baker (1923; Occ. Papers Mus. Zool. Univ. Mich.; no. 137, p. 6–7; figs. I–4, 5).

Type locality: (C5c) Schaarlo, back of Willemstad, Curaçao.

Distribution: Curaçao; under limestone rocks (C1–7, 11–13, 17, 20).

Shell (fig. xvii–75): more elongate but slightly smaller than typical *bonairensis*. Color: light corneous to dark brown; opaque calluses more conspicuous than in preceding. Whorls: about 10; less convex and with shallower suture than in

bonairensis. Sculpture of later whorls: growth-riblets low, irregularly-spaced, often almost obsolete on last whorl; the calluses often obliterate the interspaces and may be decorated with faint, spiral thickenings; basal angulation slightly more prominent than in *bonairensis.* Aperture: subcircular. Otherwise as in *bonairensis.*

	Measurements				
	Shell		Aperture		Whorls
	alt.	maj. diam.	alt.	diam.	
Type, fig. 75 (C5c)	8.20	37(3.02)	22(1.84)	109(2.01)	10¼
Fig. 76 (C17)	7.20	37(2.66)	23(1.64)	108(1.76)	9½

The radula of this form has been described and figured in a former paper (1923; *op. cit.,* fig. I–5). As indicated, it appears closest to that of *M. pontificus,* but it differs from the radulae of the more northern species in its simply unicuspid central. The 105 transverse rows are almost straight.

Typical *curacoanus* (Table IX, C5) is distributed throughout the limestone portions of central and southern Curaçao (C1–7, 11, 12). In the more northern localities (C13, 17, 20), it is represented by a smaller form (Table IX, C17; fig. xvii–76) with slightly more regular growth sculpture.

Microceramus bonairensis arubanus, new subspecies

Type locality: (A4b) top of Seroe Canashito, Aruba.

Distribution: Aruba; under limestone rocks (A2–5).

Shell (fig. xvii–77): more elongate than *curacoanus.* Color: lighter and more translucent, calluses less conspicuous than in preceding. Whorls: about 10¾; more convex and with better impressed suture than either of the other subspecies. Sculpture of last whorl: growth-riblets more regular than in *curacoanus* but much lower and more rounded than in *bonairensis*; calluses thin but widespread, usually with several spiral thickenings; basal angulation more noticeable than in the other subspecies. Otherwise as in *curacoanus.*

This (Table IX, A4) is the largest form of the species, and also develops the greatest number of whorls. Its sculpture

and form are much closer to *curacoanus* than that subspecies is to *bonairensis*.

	Measurements				
	Shell		Aperture		Whorls
	alt.	maj. diam.	alt.	diam.	
Type, fig. 77 (A4)	9.96	33(3.32)	20(2.02)	104(2.10)	12¼

Table X. Type Measurements of New Forms of Cerion uva

	Shell		Spire	Aperture		Whorls
	alt.	maj. diam.	diam.	alt.	diam.	
diablensis, fig. xviii–A2 (C12b)	19.4	40(7.8)	40(7.8)	30(5.7)	96(5.5)	11½
hatoensis, fig. xviii–F6 (C11d)	25.1	45(11.3)	45(11.2)	29(7.4)	99(7.3)	12½
djerimensis, fig. xix–A1 (C17c)	18.2	45(8.1)	45(8.1)	31(5.6)	95(5.3)	10¼
knipensis, fig. xix–F5 (Cb17b)	25.2	44(11.1)	44(11.1)	32(8.1)	97(7.9)	11¼
arubanum, fig. xx–C3 (A2c)	21.2	47(10.0)	44(9.3)	33(6.9)	91(6.3)	11¾
kralendijki, fig. xxi–A2 (B1)	18.9	46(8.7)	44(8.4)	32(6.0)	102(6.1)	10
bonairensis, fig. xxi–F6 (B5)	26.9	42(11.3)	40(10.8)	32(8.7)	94(8.1)	12

CERIONIDAE

Cerion uva uva (Lin.)

Turbo uva Lin. (1758; Syst. Nat., X, 765); description unrecognizable but the first reference to a figure (Pet. gaz. t., 27, f. 2) is this species. *Cerion vulgare* "Bolten" Roeding (1798; Mus. Bolt., 90); the reference to Knorr 6, t. 25, f. 4. *Cerion apiarum* "Bolten" Roeding (*l. c.*); simply a reference to *Turbo uva* Gmelin. *Pupa uva* Schubert and Wagner (1829; Conch. Cab., XII, pl. 235, figs. 4122, 4123). *Pupa uva* Beck (1837; Index, 82); the first citation of Curaçao as the habitat. *Cerion uva* Moerch (1852; Cat. Yoldi, 33). *Turbo uva* Hanley (1855; Ipsa Linn. C., 343); Linnaean specimens like figures in Conch. Cab. (see above). *Cerion uva desculptum* Pils. and Vanatta (1896; P. A. N. S. P., pp. 318, 328; fig. xi–1); form with reduced sculpture.

Type locality: unknown; probably the Schaarlo (C5c), back of Willemstad, Curaçao.

Distribution of species: Curaçao; practically everywhere on the limestone, and also invading the region of the older rocks. Bonaire: as prevalent as on Curaçao. Klein-Bonaire: everywhere. Aruba: Perkietenboseh and Baranca Alto. Mainly on brush and cacti a short distance above the ground, but also on and under rocks. Very abundant in favorable localities; as many as 150 per square meter counted. 2,737 adults collected.

Distribution of subspecies: Curaçao; the southern portion, north of Kaap Sint Marie and Landhuis Hato (at least); mainly on limestone (C1–13), but also narrowly invades the region of the older rocks (Cb6, 10).

Extreme variability appears to be a characteristic of this genus. In order to obtain some statistical idea of the amount and character of the variation in *C. uva*, the altitude, major diameter (exclusive of aperture), and the number of whorls were ascertained in all of the Curaçao specimens collected. These data indicate that the variation may be immediately divided into two phases: the number of whorls and the diameter of the shell. The former would seem to be simply a function of the period of growth; while the latter expresses actual variation in size (dwarfing or gigantism). The diameter does not seem to be especially correlated with the number of whorls; in other words, the larger shells do not appear to develop more whorls, although this is not strictly true of the extremes in size. Inside of each subspecies, on the other hand, the altitude is very closely correlated with the number of whorls (see Table XI).

Table XII shows immediately that neither of these variations is geographical; colonies with low (or high) means occur in widely separated places. The explanation is, I believe, purely ecological. The size of the shells (*i.e.*, the diameter) appears to be directly dependent on the richness of the habitat. Almost without exception, the lots, with a mean major diameter of over 10 mm., occur in the most heavily wooded portions of the limestone or central region; these places are usually near the larger hills, which probably increase the rain-

fall in their near vicinity. The number of whorls (and the altitude) appears to be inversely proportional to the amount of exposure to the dry trade-winds; this factor probably acts through increase in the rate of evaporation, which would decrease the length of the active periods of the cerions. All of the lots, which have a mean number of whorls that approaches 12, are from the base of escarpments, usually on the lee side of the larger hills.

Typical *C. uva uva* probably comes from the hills behind Willemstad. This lot (Table XI) happens to give a mean size and the mean number of whorls near those of all of the lots taken together. Although the change in form, due to the number of whorls and the resultant difference in altitude, is very conspicuous (Plate XVIII), it is too variable to be of any racial importance; in fact, aperture formation appears to be hastened by injury. The actual size of the shells seems more important, and the extreme lots deserve recognition as ecological forms. The most dwarfed shells may be called form **diablensis,** new (fig. xviii–A2), with the top of Ronde Klip (C12b) as the type locality. The largest shells also have the heaviest sculpture, and may be included in the form **hatoensis,** new (fig. xviii–F6), with the eastern escarpment of Seroe Spelonk, near Landhuis Hato (C11d) as the type locality.

C. uva uva is mainly restricted to the limestone outcrops, but in a few places invades the borders of the central region of older rocks. In these localities (Cb6, 10), a rather large portion of the shells show a tendency to reduce the sculpture (figs. xviii–C6, D5), and even the sculptured shells are usually rather slender. Practically smooth shells occur, and have been described as *C. uva desculptum*; the exact type locality of this very conspicuous form is unknown, but it is probably somewhere around Sint Anna Baai (Cb6b).

Table XI. Variation in Cerion uva uva from Substations C5c, d[44]

A. Variation by Altitude Class

Whorl Class (by half-whorls)

Alt. Class	10.0	10.5	11.0	11.5	12.0	12.5	13.0	Mean Whorls
17.0	1	3						10.4
17.9	1	5	4					10.6
18.8		10	19	5				10.9
19.7		5	49	25	2			11.1
20.6		3	27	48	14			11.4
21.5			5	49	24	3		11.6
22.4			2	11	35	4		11.9
23.3					4	7		12.3
24.2					1	2		12.3
25.1							2	13.0
Mean Altitude	17.4	18.8	19.8	20.8	21.8	22.8	25.1	

B. Variation by Major Diameter Class

Whorl Class (by half-whorls)

Maj. Diam. Class	10.0	10.5	11.0	11.5	12.0	12.5	13.0	Mean Whorls
8.6	1	4	3	1	2			11.0
9.0		3	15	19	12	1		11.4
9.4		7	37	47	25	6	1	11.5
9.8	1	8	34	47	26	7		11.4
10.2		4	14	20	11	2	1	11.5
10.6			3	4	2	1		11.5
Mean Maj. Diam.	9.2	9.4	9.6	9.6	9.6	9.7	9.8	

C. Variation by Major Diameter Index Class

Whorl Class (by half-whorls)

Index Class	10.0	10.5	11.0	11.5	12.0	12.5	13.0	Mean Whorls
56		2						10.5
53	1	5	10	1				10.8
50	1	11	39	23	3			11.1
47		8	47	64	14	1		11.3
44			10	46	42	8		11.7
41				4	18	7	1	12.1
38					1	1	1	12.5
Mean Index	51	50	48	46	44	43	39	

[44] The columns of figures in the central portions of the subtables give the number of individuals which fall into each category.

Table XII. Mean and Extreme Dimensions of Cerion uva uva

Comparison of Stations

Place	Nos.	Whorls	Altitude	Index	Maj. Diam.
C11d	57	11.8(10.5–13.0)	22.1(18.8–25.0)	46(42–54)	10.3(9.3–11.3)
C11c	104	11.6(10.5–13.0)	21.0(18.5–24.1)	48(40–60)	10.2(9.1–11.4)
C6c	77	11.5(10.0–12.5)	21.2(17.6–23.6)	48(41–60)	10.2(8.9–11.2)
C1	32	11.1(10.0–12.0)	20.0(16.8–23.4)	51(43–59)	10.2(9.3–11.2)
C12a	53	12.0(11.0–13.0)[a]	23.1(20.6–25.3)	44(39–51)	10.1(9.4–11.0)
C4	103	11.6(10.5–13.0)	21.8(18.7–25.2)	46(39–55)	10.1(9.1–11.1)
C8	60	11.8(10.5–13.0)	22.1(19.1–15.1)	45(40–52)	10.0(9.2–11.2)
C2	122	11.9(10.0–14.0)	21.8(17.6–26.4)	46(37–60)	9.9(8.2–10.9)
C11ab	70	11.2(10.0–12.5)	20.0(16.5–23.7)[b]	48(41–55)	9.9(8.2–10.6)
C7ab	95	11.3(10.5–12.5)	21.0(18.3–24.0)	47(41–53)	9.8(8.9–10.8)
C13	51	12.2(10.5–13.5)	22.1(17.0–26.6)	44(37–56)	9.7(8.9–10.7)
C9	10	11.3(10.5–12.5)	19.6(17.5–21.5)	49(45–59)	9.7(9.2–10.2)
C6ab	67	11.6(10.0–12.5)	21.3(18.1–24.7)	45(39–52)	9.6(8.6–10.4)
C5cd	370	11.4(10.0–13.0)	20.7(17.0–25.2)	46(38–56)	9.6(8.6–10.8)
C5ab	110	11.4(10.5–12.5)	20.3(17.9–24.2)	46(40–54)	9.6(8.6–11.2)
Cb6	52	11.6(10.5–12.5)	21.3(19.3–24.7)	44(37–50)	9.5(8.7–10.1)
C3	54	11.4(10.5–12.5)	20.0(17.3–23.1)	47(40–55)	9.5(8.4–10.3)
Cb10	45	11.7(10.5–13.5)	21.3(18.7–25.5)	44(37–52)	9.4(8.4–10.3)
C10	48	11.3(10.0–12.5)	19.8(16.8–23.6)[c]	47(38–54)	9.2(8.5–10.1)
C12b	63	11.5(10.5–12.5)	20.1(17.4–22.6)	45(39–52)	9.1(7.8–10.0)
Total	1643	11.6(10.0–14.0)	21.0(16.5–26.6)	46(37–60)	9.8(7.8–11.4)

[a] Bimodal: 11.5 and 12.5; [b] bimodal: 19.7 and 21.5; [c] bimodal: 18.8 and 21.5.

Cerion uva knipensis, new subspecies

Type locality: (Cb17b) valley between Seroes Palomba and Baha Hoendoe, northern Curaçao.

Distribution: Curaçao; north of Seroe Grandi; both on limestone (C14–20), and in the higher hills on outcrops of the older rocks (Cb16, 17, 20). Similar in habits to *uva,* but burrowing more deeply in the talus of the older rocks. 429 adults collected.

This subspecies (Plate XIX) has higher whorls than typical *uva.* In the statistical study, the data for each lot were arranged in three tables, with vertical columns for the whorl classes and transverse rows to indicate, in the different tables, the altitude, major diameter and index classes (*cf.* Table XI). This brought out the fact that, in *C. uva uva,* the altitude was very closely correlated with the number of whorls, but did not

vary greatly with the diameter. Although considerable individual variation is present, the means show that *C. uva knipensis* (Table XIII) quite consistently has a greater altitude for the same number of whorls. The only lots of *C. uva uva* that tend to approach them, in this particular, are the very large shells from near Landhuis Hato (C11c, d, and C12a).

The typical specimens (fig. xix–F5) of this subspecies come from the wooded valleys of the higher hills, in the region of the older rocks. These shells are very large, and have a peculiar, porcellanous texture, which contrasts rather markedly with the chalky surface of most of the shells from the limestone outcrops. In addition, a few specimens show a slight tendency to reduce the sculpture, although most of them are quite as heavily sculptured as typical *C. uva uva.*

C. uva knipensis (Table XIII) shows the same type of ecological variation discussed in *C. uva uva* (Table XII). Many of the animals mature with a smaller number of whorls than do any of the typical subspecies. In addition, there is a similar amount of variation in the major diameter. The smallest specimens may be called form **djerimensis,** new (fig. xix–A1), with the top of the shore cliffs near Plaja Djerimi (C17c) as the type locality.

Table XIII. Mean and Extreme Dimensions of Cerion uva knipensis

Comparison of Stations

Place	Nos.	Whorls	Altitude	Index	Maj. Diam.
C18	24	11.2(10.5–12.0)	21.3(18.3–23.6)	49(44–55)	10.5(9.5–11.2)
Cb17, 20	72	11.9(11.0–13.0)	24.0(20.5–27.8)[a]	43(34–50)	10.3(9.3–11.2)
Cb16	16	11.4(11.0–12.5)	22.8(20.9–26.1)	45(37–49)	10.1(9.6–10.6)
C20	31	11.5(10.5–12.5)	22.5(19.8–25.6)	45(37–51)	10.0(9.1–10.7)
C16	34	11.2(10.5–12.5)	21.7(19.4–25.6)	46(39–51)	10.0(9.0–10.5)
C17a	55	11.1(10.5–12.5)	21.2(18.8–24.8)	47(42–53)	9.9(9.1–11.0)
C15, 17a	81	11.1(10.0–12.5)	21.2(18.3–24.2)	46(39–53)	9.7(8.7–10.6)
C19	41	10.5(9.5–11.5)	20.2(17.6–22.7)	48(44–55)	9.6(8.8–10.5)
C14	54	10.8(9.5–12.0)	20.0(17.2–24.3)	47(37–53)	9.4(8.6–10.6)
C17bc	21	10.5(9.5–11.5)	19.7(17.2–24.3)	46(39–53)	9.1(8.1–10.1)
Total	429	11.1(9.5–13.0)	21.5(17.2–27.8)	46(34–55)	9.9(8.1–11.2)

[a] Bimodal: 22.4 and 25.1.

Cerion uva arubanum, new subspecies

Cerion uva Smith (1898; Proc. Mal. Soc., III, 114); the first Aruba record; collected by Hartert.

Type locality: (A2c) Baranca Alto, Aruba.

Distribution: Aruba; living shells only found in a colony at the type locality and in another just north of Perkietenboseh (A2c, A5a); subfossil throughout the limestone portions of the island. Similar in habits to *uva.* 322 adults collected.

Although considerable individual variation (Plate XX) occurs, the last whorl near the aperture tends to jut out tangentially in this subspecies, so that the palatal wall of the peristome usually projects out from the preceding whorls to a greater extent than in *C. uva uva* and *knipensis.* As a result of this, the umbilicus is usually larger and more open in the specimens from Aruba. In making the measurements of the major diameter in the two subspecies from Curaçao, the calipers seldom touched the aperture, while in *C. uva arubanum,* the palatal wall almost always interfered. In all cases, the major diameter was taken exclusive of the aperture, so the true greatest width of *C. uva arubanum* is slightly larger than the data in Table XIV would indicate. In other particulars, this form is similar to the smaller and more slender lots of *C. uva uva,* although the whorls tend to be slightly lower than in any of the Curaçao lots except those from station C13.

The peculiar restriction of the living cerions on Aruba to two isolated colonies is very puzzling, especially since this species very evidently was almost universally distributed on the island in former times. Subfossil shells occur almost everywhere on the limestone, and also are cemented into blocks of phosphate near Culebra (A1). It does not seem possible that this former distribution has been reduced by the extensive cultivation of aloes, as living shells actually occur on this plant in station A4c, while they are absent from the large, limestone plateaus east of Savaneta and Sint Nicolaas, and these hills appear to be mainly undisturbed by man. Although Aruba has a more arid climate than the other islands and appears

to be more subject to pronounced dry periods, it is rather difficult to understand how such a resistant species as *Cerion uva* could have been partially exterminated by these factors. In addition, the living colonies are not in the most heavily wooded places.

The specimens from the two colonies differ slightly from each other in dimensions, and one lot is lighter in color than the other. However, these divergences hardly seem worthy of rank as separate forms. Some specimens show a slight approach towards *C. uva desculptum.*

Cerion uva bonairensis, new subspecies

Type locality: (B5) Porta Spaño, Bonaire.

Distribution: Bonaire; everywhere on limestone (B1 to B9), and in the richer habitats on the older rocks (Bb3, 7, 9). Klein-Bonaire: everywhere (K1). 343 adults collected.

Table XIV. Mean and Extreme Dimensions of Cerion uva arubanum and bonairensis

		Comparison of Stations			
Place	Nos.	Whorls	Altitude	Index	Maj. Diam.
A2c	200	11.9(11.0–13.5)	21.6(18.7–25.9)	44(37–51)	9.4(8.3–10.3)
A5a	122	12.2(11.0–14.0)	22.5(20.0–27.4)	43(36–50)	9.6(8.7–10.8)
Totals, Aruba	322	12.0(11.0–14.0)	22.0(18.7–27.4)	43(36–51)	9.5(8.3–10.8)
Bb3	12	11.7(11.0–12.5)	24.1(22.2–25.8)	43(40–48)	10.3(9.9–10.7)
B5	39	11.5(10.5–12.5)	22.2(19.6–26.8)	44(39–53)	10.3(8.9–11.0)
B8	58	11.3(10.5–12.5)	21.8(19.7–24.4)	45(38–49)	9.9(9.0–10.8)
B7	51	11.5(10.5–12.0)	22.4(19.6–25.4)	44(39–50)	9.8(9.0–10.9)
Bb7	20	11.5(10.5–13.0)	22.3(19.7–25.4)	44(39–50)	9.7(9.0–10.2)
B4	17	11.4(10.5–12.5)	21.9(19.2–24.1)	44(37–51)	9.7(8.4–10.3)
K1	28	11.2(9.5–12.0)	21.2(16.0–24.2)	46(41–61)	9.7(8.9–10.7)
B3	44	10.9(9.5–12.0)	21.0(17.1–23.1)	47(41–55)	9.7(8.9–10.5)
B6	6	10.8(10.5–11.5)	19.7(19.2–20.2)	49(47–51)	9.6(9.1–10.1)
B9, Bb9	28	11.1(10.0–12.0)	20.4(18.2–23.9)	45(38–53)	9.1(8.2–10.2)
B1	31	10.9(10.0–11.5)	20.0(17.8–21.2)	46(41–52)	9.1(8.4– 9.6)
B2	9	10.7(10.0–12.0)	19.7(17.2–23.1)	47(42–51)	9.1(8.4–10.1)
Totals, Bonaire	343	11.2(9.5–13.0)	21.6(16.0–26.8)	45(37–61)	9.7(8.2–11.0)

In this subspecies (Plate XXI), as in *arubanum*, the palatal wall of the peristome projects out markedly from the preceding whorls. However, the aperture is usually broader, instead of twisted tangentially, so that the umbilicus is smaller, and more like that of the typical subspecies. Also, *C. uva bonairensis* (Table XIV) has high whorls similar to *knipensis*, and the cleaned surface of the shell resembles dead-white enamel while that of the other species is chalky-white or porcellanous. As in the subspecies from Curaçao, the Bonaire lots vary in size with the richness of the locality. Typical *bonairensis* (fig. xxi–F6) includes the larger shells of the series, while the smaller lots may be called form **kralendijki**, new (fig. xxi–A2), with the recent limestone just south of Kralendijk (B1) as the type locality. Although the cerions of Bonaire invade the central regions of older rocks to a considerable extent, the form *desculptum* appears to be quite absent.

Introduced and Doubtful Species

Outside of the hofje of Campo Knip, and a few borders near the highways, no detailed examination of the cultivated ground was made. A more thorough study of the irrigated fields and gardens would probably add considerably to the following list. Some of the coco plantations and orchards are several acres in extent, and the borders of the better watered ones have developed considerable leaf mould. However, such introduced species have no bearing on the zoögeographical affinities of the islands and, while interesting, would certainly add very little to our knowledge of the natural fauna.

TRUNCATELLIDAE

Truncatella bilabiata (Pfeiffer)

The last 1½ whorls of a bleached shell, from the hofje of Campo Klein Piscadera (Cb7). This belongs to the almost smooth form of the species, and the growth-ribs are only represented by buttresses near the suture.

HELICIDAE

Thysanophora crinita arubana H. Burrington Baker

One dead, bleached specimen, from the hofje of Klein Pisca-

dera (Cb7), is probably this form, although its condition does not permit of its certain identification. In this connection, it is at least interesting that the only amphibian collected in Curaçao, *Pleurodema brachyops* (Cope), is said by the inhabitants to have been introduced from Aruba in sand for construction.

Pleurodonte lima (Férussac)

Helix lima Férussac (1821; Tabl. Syst., 32; Hist., fig. xlvi–1, 2). *H. lima* Pfr. (1848; Mon. Helic. Viv., I, 266); exclusive of var. β. *Pleurodonte lima* Pilsbry (1889; Man. Conch., V, 58); exclusive of *Otala asperula*, in synonymy, and the reference to Curaçao.

As discussed under the next species, there is no reason for the citation of *P. lima* from Curaçao.

Pleurodonte incerta (Férussac)

Helix lima "variété et jeune age" Férussac (Hist., fig. xlvi, A–4, 5). *Helix incerta* Férussac (Hist., fig. cv–2). *Otala asperula* Beck (1837; Index, 36); founded on "*H. Hgen. lima*, var. notabilior Fér.; F. H., xlv, A, 4–5." *Helix lima*, var. β Pfr. (1848; Mon. Helic. Viv., I, 266). *H. lima* var. *notabilis* "Fér." Pfr. (*l. c.*); in synonymy. *H. incerta* var. *notabilis* Albers-Martens (1860; Die Heliceen, 144). *Pleurodonte incerta* Pilsbry (1889; Man. Conch., V, 57–58). *Pleurodonte incerta* Vernhout (1914; Notes Leyden Mus., 179). *P. lima* Vernhout (*l. c.*).

In the Histoire, Férussac illustrated his typical form of *H. lima* on Plate 46, but also figured an unnamed "variety" on Plate 46A. Beck founded his *Otala asperula* on this "notabilior" variety,[45] and added "I. Curaçao" as the type locality of his new species. Pfeiffer placed Beck's species, along with "*H. lima* var. *notabilis* Fér." (the first use of the latter name), in the synonymy of his *H. lima*, var. β, and quoted Curaçao as the locality. On the other hand, Albers-Martens regarded *notabilis* as a variety of *H. incerta*, and so, very naturally, included Curaçao as the habitat. Pilsbry followed Albers-Martens in the disposition of *notabilis*, but copied Pfeiffer in the inclusion of *Otala asperula*, and its locality, under *H. lima*.

[45] xlv, A is obviously a misprint for Plate 46A.

Thus all of the Curaçao citations of either of these two species, and Vernhout's quotation of both of them, may be traced back to Beck's exceedingly dubious record. Finally, if Férussac's variety requires a name, it must be called *Pleurodonte incerta asperula* (Beck); this form is now known to occur in Porto Rico.

BULIMULIDAE

Drymaeus multilineatus (Say)

Bulimus multilineatus Say (1825; Jour. A. N. S. P., V, 119). *Bulimus torallyi,* var. *B. sisalensis* Bland (1868; Amer. J. Conch., 192); first Curaçao record.

Type locality: southern part of east Florida.

Distribution: southern Florida and Yucatan to northern South America.

This species has been quoted from Curaçao by several authors, and two lots in the A. N. S. P. (no. 25896 and 25900; Swift Collection, collected by Raven) are certainly nothing else (*cf.* Pilsbry; 1899; Man. Conch., XII; p. 29 and fig. xi–32). In 1920, I collected two dead bleached specimens on the Schaarlo (C5c), at the edge of Willemstad, but no additional specimens were obtained in 1922. It may still occur in the gardens in Willemstad, or on some of the irrigated plantations. This species thrives in cultivated places, and I have no doubt that it has been introduced into many parts of its present range. It does not appear to be established, under natural conditions, on Curaçao.

Liguus virgineus (Lin.)

This Hispanolan species has been listed from Curaçao by Vernhout (1914; Notes Leyden Mus., 179, 180). As I did not obtain it, I can only add that, as yet, it does not appear to have escaped from cultivation.

ACHATINIDAE

Opeas micra (D'Orbigny)

Stenogyra octonoides Gibbons (1879; J. of Conch., II, 136); first record from Curaçao.

Two dead specimens were obtained from leaf mould along the road at Campo Klein Piscadera (Cb7). This species has been widely distributed by commerce.

Zoögeographical Affinities of the Molluscan Fauna

In the study of the terrestrial, molluscan fauna of these islands, five, salient characteristics appear. (1) There is a very high percentage of endemism. (2) Sublittoral, limestone-loving species preponderate. (3) Typically South American groups are completely absent. (4) Several Antillean groups form conspicuous components of the total population. (5) Nevertheless, the closest affinities shown by any of the individual species are with forms from northern South America.

Two genera (Stoastomops and Cistulops), three subgenera (Bonairea, Neosubulina s. s., and Cerion s. s.), and a section (Tudora s. s.) are, as far as known, endemic to the Dutch Leeward Islands. Only three of the well-established species, *Drymaeus virgulatus, Thysanophora crinita* and *Oxystyla maracaibensis,* are known to extend their range beyond the islands. The first of these is a species of Porto Rico and the northern Lesser Antilles. Although it is certainly widespread in the undisturbed portion of the Dutch Leeward Islands, its remarkably discontinuous distribution, as already indicated, arouses the suspicion that its dissemination may be due to the agency of man. The last two are species of northern South America, and only reach Aruba (although *T. crinita* was found in ruderal conditions on Curaçao); the Oxystyla appears to be entirely subfossil.

The endemism of the fauna of Bonaire, Klein-Bonaire and Curaçao is readily accounted for on the basis of their geographic isolation. As already described, the depth of ocean between these islands and the mainland indicates a separation at least as remote as that between South America and the northern Lesser Antilles. Aruba, on the other hand, lies in quite shallow water, and it is rather remarkable that its fauna does not contain an even larger proportion of South American invaders.

Practically all of the molluscs of the islands show a marked preference for limestone rock, and most of them do not occur in localities where the soil is non-calcareous. *Drymaeus virgulatus, Succinea gyrata* and *Guppya molengraaffi* are the conspicuous exceptions to this general rule. The first two appear to be mainly dependent on the development of trees and brush, while the last was only found near the summit of Sint Christoffelberg (Cb20). Although several species invade the more heavily wooded portions in the higher hills of the older rocks, they are much rarer in these places than on the limestone. The deep aestivation of *Tudora fossor* and the loss of sculpture in *Cerion uva* have already been correlated with this species.

In addition, the fauna is characteristic of coastal conditions. Cerion, especially, is usually limited, throughout its distribution, to the near vicinity of the seashore. The highland rain-forest elements of both the Antilles and South America have not obtained a footing on the present islands, although *Guppya molengraaffi* appears to be limited to the region where such conditions are most nearly approached. In places where such a mesophytic fauna is present, its more hardy members may invade the coastal region, but in the Dutch Leeward Islands the opposite is true, and even the cerions reach to the highest altitudes (1,200 feet).

As a result of these ecological limitations, the fauna is only comparable to that of similar regions in the Antilles and on the mainland. This type of habitat has been quite thoroughly studied in the former, but, in South America, collectors have directed most of their attention to the richer inland forests. A detailed study of the calcareous portion of the shore zone of northern South America (*cf.* W. Sievers; 1896; *l. c.,* pl. X) might add considerably to our knowledge of the Antillean elements in this region. On the basis of the present data, it can only be stated that Aruba, as well as the other Dutch Leeward Islands, is markedly isolated ecologically from the known portions of the mainland. The similarity of the fauna of Aruba and that of the other islands and its lack of resemblance

to the known South American fauna, can only be explained on this basis.

As already indicated, one of the most notable features of this island fauna is the total absence of typically South American groups, such as the Streptaxidae and the Strophocheilinae, and the paucity of others, such as the Achatinidae and Bulimulidae. In fact, not a single, characteristically South American genus reaches these islands, although four (Drymaeus, Oxystyla, Thysanophora and Guppya) might be considered as widely distributed, tropical or subtropical groups which penetrate South America to a considerable extent.

On the other hand, Cerion is practically limited to the northern Antilles and Florida, although a single species, *Cerion antonii* (Kuester), has been described from Guiana. Microceramus is another Antillean genus, which reaches the mainland of North America but is apparently lacking from the southern Antilles and South America. Stoastomops is, I believe, most closely related to Stoastoma from Jamaica, while Cistulops appears to have distant affinities with Troschelvindex from central Cuba. The Chondropominae are also a characteristically Antillean group, although they reach the mainland in many places around the Caribbean and the Gulf of Mexico. In addition, the two freshwater species, *Potamopyrgus parvulus* and *Planorbis pallidus,* are widely distributed in the Antilles, although they are represented by closely related species in northern South America.

Although the molluscan fauna of these islands is thus mainly Antillean in its general affinities, some of the individual groups are most closely related to those of northern South America. For example, *Tudora rupis, T. muskusi* and *T. aurantia* are placed in the section Tudorata, along with *Tudora plicatula* from Venezuela. Also, the genus Neosubulina is known only from the Dutch Leeward Islands and northern South America, while *Brachypodella raveni* and *gibbonsi* belong to the mainland group of their genus. Finally, *Oxystyla maracaibensis imitator* and *Thysanophora crinita* have already been listed as South American species that also occur in Aruba.

These peculiarities of distribution may be explained by the hypothesis that the molluscan species of the Dutch Leeward Islands are considerably changed remnants of the ancient Antillean fauna of Archiguiana (*cf.* Von Ihering, 1907; Archhelenis and Archinotis, p. 111). On the mainland, this fauna is largely replaced by Brazilian and northern, continental elements, although it may still be represented by Brachypodella, various Pomatiasidae, probably such groups as Sericea, Analcadia and Tamsiana among the Helicinidae, and the Lesser Antillean group of Amphicyclotus among the Cyclophoridae. The Oleacinid group Ravenia from Los Roques is another Antillean group of this same general region. In addition, there are a number of doubtful species, such as *Eutrochatella semilirata, Helicina kieneri* and *Chondropoma subauriculatum*, described as from Venezuela (*cf.* no. 137 of this series), and *Cerion antonii,* cited above, which arouse the suspicion that a more thorough study of the northern coast of South America may bring a greater number of these "relics" to light.

However, it is somewhat doubtful if the Dutch Leeward Islands could have retained their species as the direct and continuous descendants of the faunas of such a land mass. The present altitude of such late Tertiary coral formations as the cap of the Tafelberg of Sint Hyronimus (C20) seem to indicate a possibility that the islands were completely submerged in comparatively recent times. Much of the present fauna of the Dutch Leeward Islands and the presence of Antillean elements in northern South America is also explicable on the basis that these are all comparatively recent arrivals by drift or other occasional means of dispersal, and that some of them are only able to gain a foothold in places where they do not come into competition with the continental species. This is especially true of the fresh water species; their presence in artificial ponds and reservoirs certainly indicate extraordinary means of dispersal, such as carriage by birds. But, such endemic groups as Cistulops, Stoastomops, Bonairea and Cerion s. s. can scarcely be explained by this alternative

hypothesis. The question must be left in abeyance, at least until a thorough examination of the remainder of the Leeward Islands and the northern coast of South America has been made.

Distribution within the Islands

As most of the species of the Dutch Leeward Islands are almost entirely limited to the limestone rim, breaks in this establish quite definite barriers to intermigration. Especially on the island of Curaçao, the sunken valleys permit penetration by arms of the sea, so that the rim is cut up into a series of quite isolated ridges. As a result, the facies of certain species of the land shells changes slightly at each "baai" or "lagoen." After several successive breaks, the species of Tudora, especially, often change so much that there is no intergradation between lots from the colonies so separated. It is on such changes that the various subspecies are based.

The largest island, Curaçao, can be divided into three, quite distinct, faunal areas, which appear to have been populated from central hills, which must have been separate islands during periods of higher strand-line. Aruba, on the other hand, is almost a unit, although Spaansch Lagoen roughly coincides with a slight break in the molluscan fauna (see Plate I, map of Aruba). Bonaire and Klein-Bonaire together form a similar unit.

The most southern area of Curaçao centers around the Tafelberg of Santa Barbara (C2). *Tudora rupis rupis, T. pilsbryi* and *Brachypodella raveni sanctaebarbarae* were only found at the base of the northern and western escarpments of this mesa. The first species is also represented by the subspecies *newportensis* near New Port (C1), although the remainder of the fauna of the shore zone is more like that of central Curaçao. In addition, *Cistulops raveni* appears to be absent from southern Curaçao.

The central area (C1, 3–12) may be considered to center around Ronde Klip (C12) and the Hato ridge (C11). It is characterized by the absence of the section Tudorata, and by

the presence of *Tudora megacheilos* (4 subspecies) and *Brachypodella raveni raveni.*

The northern area (C13–20) was probably populated from the Sint Christoffel complex, which undoubtedly was formerly fringed or covered by a limestone reef, such as is still present on the Tafelberg of Sint Hyronimus (C20). This region is differentiated by *Tudora muskusi* (3 subspecies), *Guppya molengraaffi,* 3 subspecies of *Tudora fossor, Brachypodella raveni knipensis* and *Cerion uva knipensis.*

Neosubulina gloynii and *Microceramus bonairensis curacoanus* occur throughout Curaçao. The northern and central areas agree in the occurrence of *Cistulops raveni raveni,* while the central and southern possess *Cerion uva uva* in common. The presence of the section Tudorata, and the resemblance of the subspecies of Brachypodella and the species *Tudora fossor* and *pilsbryi,* appear to relate the northern and southern areas more closely to each other than to the central portion. The first two peculiarities of these terminal regions also seem to indicate affinities with the island of Bonaire.

The island of Aruba has, for peculiar forms, *Neosubulina scopulorum, Thysanophora vanattai, Cistulops raveni arubana, Brachypodella raveni arubana* and the form *sinistrorsa, Microceramus bonairensis arubanus, Cerion uva arubanum,* two subspecies of *Tudora fossor,* and the two South American forms, *Thysanophora crinita arubana* and *Oxystyla maracaïbensis imitator.* In general, the molluscan fauna of this island is most closely related to that of northern Curaçao, with which it possesses *Tudora fossor* in common; the subspecies of *Brachypodella raveni* are also similar. However, *Cerion uva arubanum* appears most closely related with *C. uva uva* from central Curaçao and Tudorata is similarly absent in both regions.

Bonaire and Klein-Bonaire together form the most distinct of all of the areas, with the genus Stoastomops, the subgenus Bonairea, *Tudora aurantia, Neosubulina harterti* (the most remote of the three species), *Brachypodella gibbonsi, Microceramus bonairensis bonairensis, Cerion uva bonairensis,* and

the absence of Cistulops and Tudora s. s. as points of difference. In this connection, it is at least interesting that the direction of the ocean current is from Bonaire towards Curaçao, and from the latter to Aruba; it is considerably stronger between the two more western islands.

Bonaire and Curaçao agree in the absence of Thysanophora and Oxystyla, and in the presence of the section Tudorata and the species *Succinea gyrata.*

These differences in molluscan fauna appear to be almost purely geographical; that is, they are coincident with degrees of present or former isolation. The greatest ecological differentiation is between the abundance of individuals and species on the calcareous substrata and their paucity or absence on the non-calcareous soil. Except for certain minor edaphic phases, represented by the forms of *Cerion uva,* the formation on all of the islands is practically identical, as are also most of the factors of the environment. In other words, the formation content (the molluscan association or society) changes with the area, although its general aspect remains the same.

As an illustration of this, the habits of Tudora on Curaçao may be cited. In northern and southern Curaçao, the species of Tudora s. s. (*T. fossor* and *T. pilsbryi*) are almost purely terrestrial, while the species of Tudorata (*T. rupis* and *T. muskusi*) are markedly subarboreal. In central Curaçao, Tudorata is absent, but *T.* (s. s.) *megacheilos* differs from its closest relatives in a well-developed tendency to climb the trees and brush, so that it practically occupies both the ground and lower arboreal strata. *Tudora fossor arubana* also shows this tendency, although it is much less prominent.

In this connection, it may be remarked that *Cerion uva* is also an adept climber during the rains, but appears to migrate down to fasten itself near the base of the trees and brush during the dry periods. *Drymaeus virgulatus,* on the other hand, commonly glues itself to the highest branches; this is perhaps related with its restriction to the more protected stations. Finally, the subarboreal species of Tudora wander up the trees in the rainy weather, but have not developed the opposite

reaction. However, with the operculum closed, they are unable to attach themselves firmly to the branches and so are usually shaken out in a few days by the wind. Nevertheless, specimens often remain in hollows and crevices of the bark, although their survival in such places appears to be comparatively rare. *Cerion uva* appears more resistant to dessication, but the secretive habits of Tudora enable it to withstand an equal amount of aridity; the exposed cerions are dwarfed in the most arid localities, but size in Tudora appears to have little or no edaphic significance.

In conclusion, the most remarkable case of parallel functions, in different "cenoses" but in the same "mores" is furnished by *Cistulops raveni* (Curaçao and Aruba) and *Tudora maculata* (Bonaire and Klein-Bonaire). These two distantly related species are almost identical in habits and must occupy practically the same position in their respective societies. Although they differ in radula, operculum and peristome, they resemble each other so closely in form, size, color and sculpture, that, when I first found *T. maculata,* I spent some time in a search for specimens with well-developed apertures, under the impression that I was collecting immature specimens of *C. raveni* or some closely related species! As already indicated, Thomas Bland probably neglected to publish his "*Cistula maculata*" for the very same reason.

Addenda

Since the preceding paper was finished, Dr. H. A. Pilsbry has worked up the Pupillidae collected, and is publishing their descriptions in the Proc. Acad. Nat. Sci. Philadelphia (1924). As indicated below, he recognizes three species of Gastrocopta, instead of *G. longurio,* and one species of Pupoides.

Gastrocopta curacoana Pilsbry

Widely distributed on Curaçao (C1–6, 11–15, 17), Aruba (A2, 4, 5, 8), Bonaire (B1–5, 8) and Klein-Bonaire (K1). Type locality: Fort Nassau, Curaçao (C5d); new name for *Pupa longurio* Crosse (1872), not Moquin-Tandon (1855).

Gastrocopta octonaria Pilsbry

Widely distributed on Curaçao (C1, 2, 5, 6, 10–15, 17, 18), Aruba (A2–4, 8) and Bonaire (B3, 4, 8). Type locality: Fort Nassau, Curaçao (C5d).

Gastrocopta barbadensis hojeda Pilsbry

Curaçao: Tafelberg of Santa Barbara and north of Playa Abau (C2, 18). Aruba: Rooi Frances and Seroe Canashito (A3, 4). Type locality: base of western escarpment of the Tafelberg of Santa Barbara, Curaçao (C2b).

Pupoides marginatus nitidulus (Pfr.)

Distribution in the islands as indicated under *Pupoides* sp.? in the main body of this paper (C3–6, 12, 17; A3–5, 8; B2, 4, 8; K1). This is a widely distributed, mainly West Indian species. According to Dr. Pilsbry, *Pupoides simoni* (Jousseaume) is probably a synonym. *G. barbadensis* and *P. marginatus* add two more to the list of non-endemic species of the islands.

PLATE I

FIGURE 1

1–A. New Port (C1).
2–B. Tafelberg, Santa Barbara (C2).
C. Manzalienja arroyo (Cb2).
D. Tank, Campo Wilhelmina (Cc2).
E. Spaansche Baai; Spaansch Water.
3–F. Hill near Fort Beekenburg (C3).
G. Caracas Baai.
4–H. Seroe Mansigna (C4).
I. Lagoen Jan Tiel.
5–K. Seroe Spanjo (C5a).
L. Seroe Salinja Abua (C5b).
M. Schaarlo (C5c).
N. Fort Nassau (C5d).
O. Willemstad.
P. Sint Anna Baai.
R. Schottegat.
6–S. Seroe Quinta, Overzijde (C6a).
T. Seroe Domi (C6b).
U. Seroe Pretoe (C6c).
V. Veerisberg.
W. Piscadera Baai.
X. Campo Marchena (Cb6a).
Y. Hill, Campo Blenheim (Cb6b).
7–Z. Jack Evertzsberg (C7a).
A. Sint Michielsberg (C7b).
B. Sint Michiel Baai; Salinja.
C. Campo Klein-Piscadera (Cb7).
8–D. Seroe Spreit (C8).
9–E. Seroe Popchie (C9).
F. Bullen Baai.
G. Salinja Sint Marie.
10–H. Seroe Boca (C10).
I. Sint Joris Baai.
K. Hill (Cb10).
11–L. Seroe Markita (C11a).
M. Ridge north of Ronde Klip (C11b).
N. Seroe Papaja (C11c).
O. Near Landhuis Hato (C11d).
12–P. Ronde Klip (C12).
13–R. Seroe Largoe (C13).
S. Sint Marie Spring (Cc13).
T. Kerk Sint Willebrordus.
U. Kaap Sint Marie.
14–V. Seroe Grandi (C14).
W. Sint Jan Baai.
15–X. Seroe di Boca (C15).
Y. Sint Martha Baai.
16–Z. Seroe Baha So (C16).
A. Sint Kruis Baai.
B. Hill Campo Sint Kruis (Cb16).
17–C. Seroe Djerimi (C17a).
D. Knip Baai (C17b).
E. Plaja Abau (C17c).
F. Plaja Djerimi (C17b).
H. Landhuis Knip (Cb17c).
I. Hofje, Campo Knip (Cb17d).
L. Pond, Campo Lagoen (Cc17).
18–K. Hill (C18).
19–M. Westpunt (C19).
20–N. Tafelberg, Sint Hyronimus (C20).
P. Sint Christoffelberg (Cb20).

FIGURE 3

A. Culebra (A1).
B. Sint Nicolaas.
C. Boca Grande, and sand dunes.
D. Near Butucoe (A2a).
E. Spur of Seroe Pretoe (A2b).
F. Baranca Alto (A2c).
G. Isla (A2c).
H. Fontein (Ac2).
I. Savaneta.
J. Seroe Jamanota.
K. Rooi Taki (A2c).
L. Rooi Frances (A3).
M. Spaansch Lagoen.
N. Seroe Canashito (A4).
O. Near Perkietenboseh (A5a).
P. Southeast of Oranjestad (A5b).
R. Oranjestad.
S. Limestone near Tanki Schipau (A6).
T. Bubali.
U. Kerk Sint Anna.
V. Shore near Malmok (A7a).
W. Seroe Annaboei (A7b).
X. Seroe Hudishibana (A7c).
Y. Campo Westpunt.
Z. Limestone near Boedoei (A8).

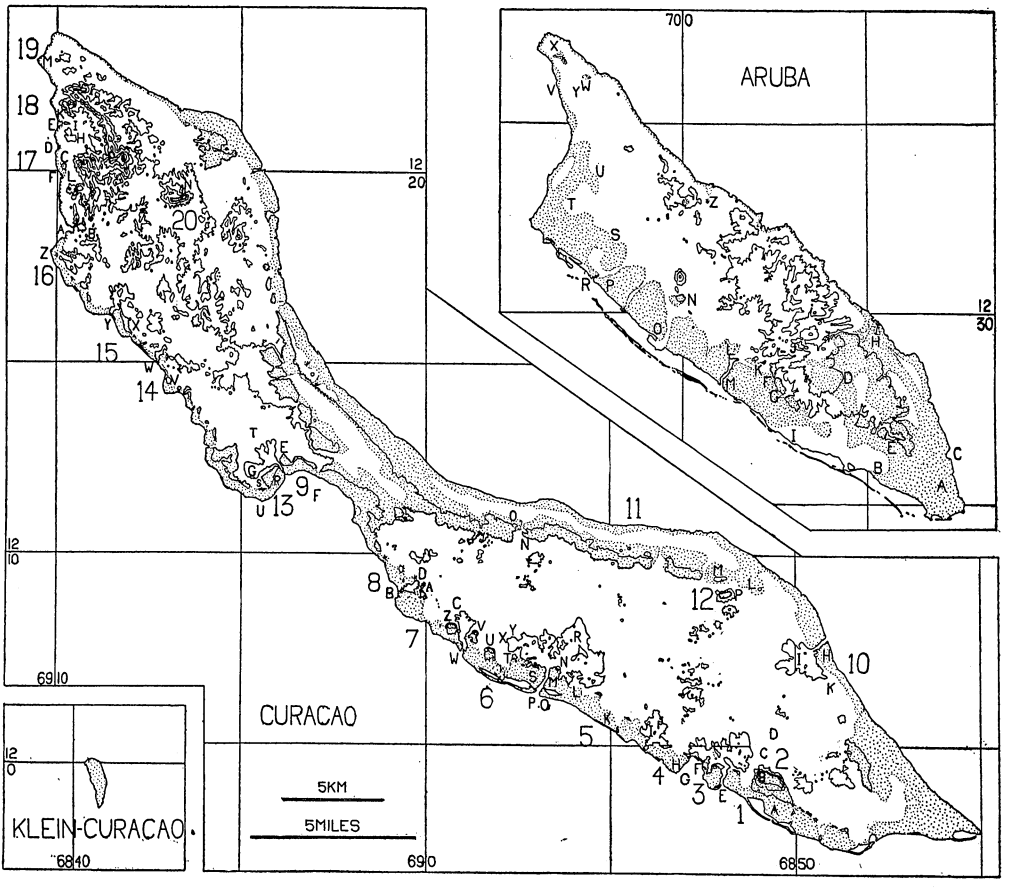


FIG. 1. Map of Curaçao, adapted from Netherlands Government 1/20000 topographic maps. Contour intervals 50 meters. The stippling indicates the approximate extent of the limestone.

FIG. 2. Map of Klein-Curaçao, reduced from U. S. Hydrographic Office chart, number 2154. Scale as in fig. 1.

FIG. 3. Map of Aruba. Source, contour interval, scale, and stippling as in fig. 1.

PLATE II

FIGURE 4

A. Pekelmeer, Lacre Punt.
B. South of Kralendijk (B1).
C. Pos Baca (Bc1).
D. Pos Frances.
E. Kralendijk.
F. Along shore near Campo Hato (B2).
G. Southeastern escarpment, Montagne (B3a).
H. Kibrá di Montagne (B2).
I. Seroe Grandi (Bb3).
J. Rincon.
K. Wooded valley (B4).
L. Seroe Largoe or Montagne.
M. Porta Spaño (B5).
N. Traai Montagne (Bb5).
O. Campo Bolivia.
P. Fontein (north of B6).
R. Punta Blanco (B7).
S. West of Punta Blanco (Bb7).
T. Seroe Wassau (B8).
U. Salinja Goto.
V. Seroe Grandi (B9).
W. Seroe Brandaris (Bb9).
X. Playa Foenshi.
Y. Klein-Bonaire (K1).
Z. Pos de Cas, Klein-Bonaire (Kc1).

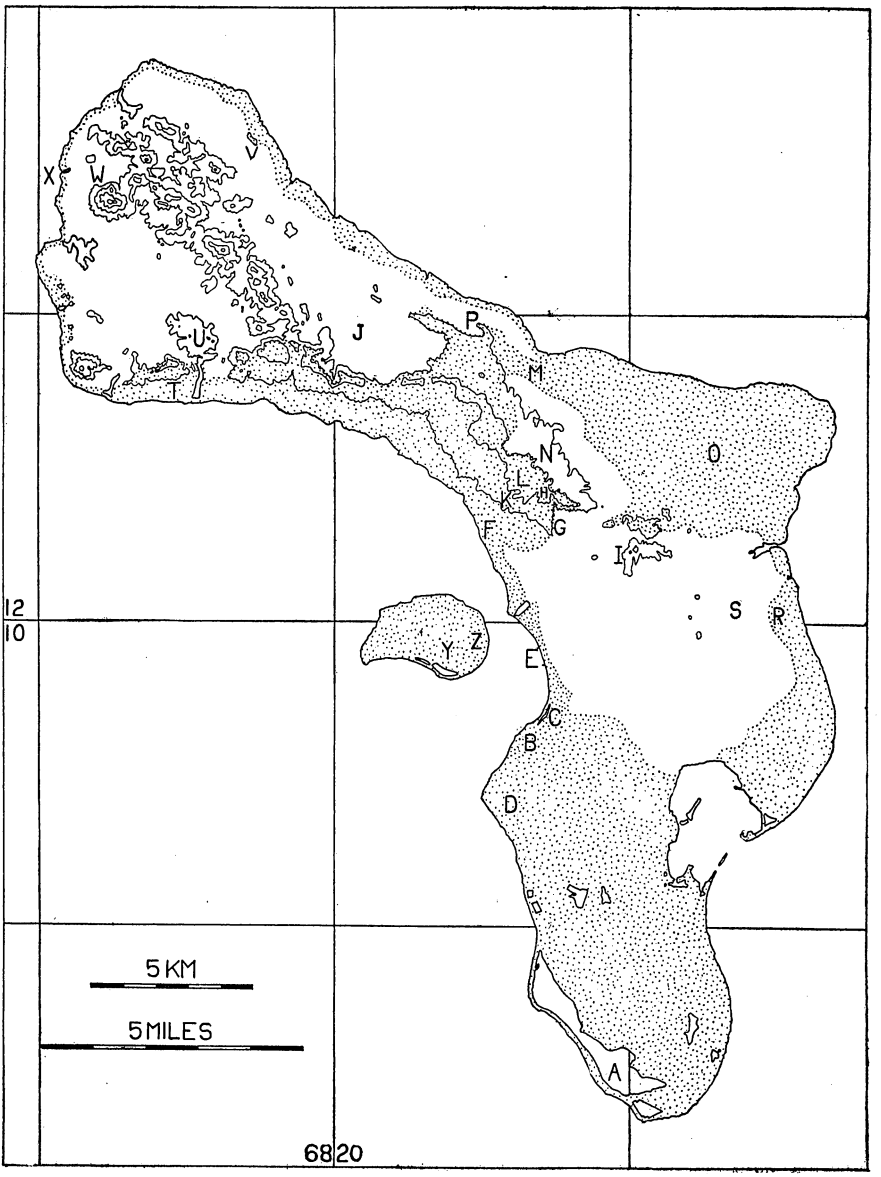


FIG. 4. Map of Bonaire and Klein-Bonaire. Source, contour interval, and stippling as in fig. 1.

PLATE III

FIG. 5 (top). Southeast from Jack Evertzsberg, southwestern Curaçao. In the foreground is the seaward slope of the older limestone (C7a); in the background are the similar monadnocks of Veerisberg, Seroe Pretoe (C6c; note the fossil beaches), Seroe Domi (C6a), and Fort Nassau (C5d); while in the far distance, to the right of the center, is the Tafelberg of Santa Barbara (C2). A bit of the Schottegat, and the lower inland country, are visible between Jack Evertzsberg and Veerisberg.

FIG. 6 (middle). South from Landhuis Knip, northwestern Curaçao. In the foreground is one of the richer, open valleys of northern Curaçao; the dark masses of vegetation are mainly divi-divi trees, while the interjacent portions are choked with acacias and Opuntia. To the left of the background are the seaward slopes of Seroes Palomba and Bientoe (Cretaceous outcrops), separated by a hidden valley (Cb17a). Farther back to the right is the limestone mesa of Seroe Djerimi (C17a).

FIG. 7 (lowest). The northern escarpment of the Schaarlo (C5c), southwestern Curaçao. The foreground shows a protected portion of the recent limestone, with a rather dense growth of crotons and acacias. The more barren crest of the Schaarlo is at the extreme right. In the left background is a bit of the Schottegat with the rounded hills of the inland country and the hofjes of the richer valleys; the Tafelberg of Santa Barbara (C2) is also visible.

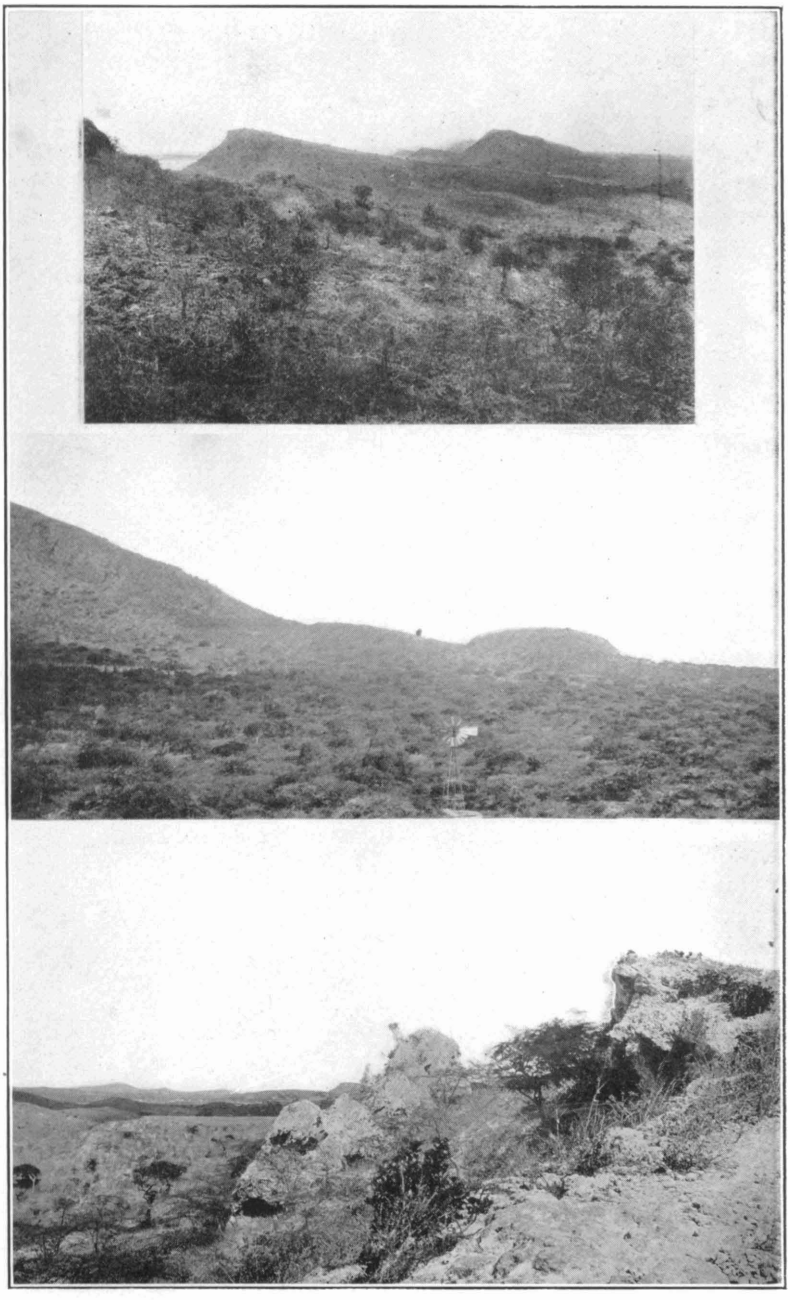


PLATE IV

FIG. 8 (top). Eastern escarpment of Seroe Canashito (A4), Aruba. In the foreground are the slopes of the older rocks, planted with aloes, and with a Cereus fence at the base. In the center are the high, excavated, ancient limestone cliffs of Seroe Canashito, with the separated blocks that are characteristic of these escarpments. The cacti on the summit are 15 to 20 feet in height.

FIG. 9 (middle). North towards Kibrá di Montagne (B3b), Bonaire. Another view, taken from the same locality as the next. One of the better wooded valleys in the limestone.

FIG. 10 (lowest). Southeastern escarpment of Montagne (B3a), Bonaire. These low, broken cliffs of the older limestone are rather well wooded. This and figure 8 are quite representative of the main escarpments of the western limestone rims on all of the islands.

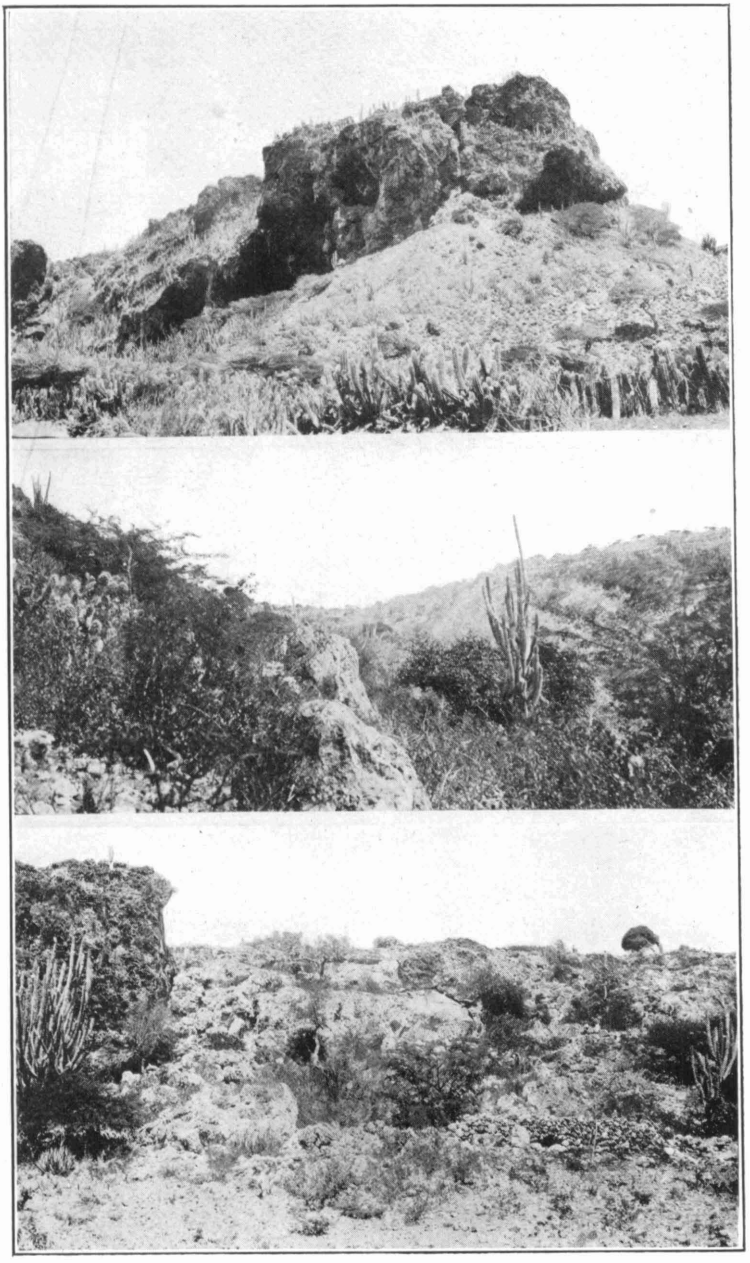


PLATE V

FIG. 11. Timberline at Fontein (Ac2), northeastern side of Aruba. In the foreground and at the right are the very barren regions of the exposed, northeastern shores (compare C10, C20, and A7). The wind-distorted thornbushes depend on the small streams; a few tops of coco-palms locate the hofje of Fontein. In the left background is a small sand dune.

FIG. 12. Near Perkietenboseh (A5a), southwestern side of Aruba. This shows the zone of natural vegetation near the summit of the low shore cliffs, on the recent limestone. Much of the ground vegetation consists of *Jatropha urens* and Opuntia. The divi-divi trees are characteristically distorted by the wind. Coral-reef islands are visible in the background.

FIG. 13. Northern escarpment of Seroe Spelonk (C11d), northeastern side of Curaçao. The foreground illustrates the rather luxuriant vegetation near Landhuis Hato; a small, leafless Bursera is conspicuous at the left. In the background are the overhanging, older limestone cliffs of the flat-topped Hato ridge (C11, a–d). Although the physiographic location of this picture is very similar to that in figure 11, the north-facing escarpment is farther from the barren shore and offers considerably more protection to the vegetation (see location on maps).

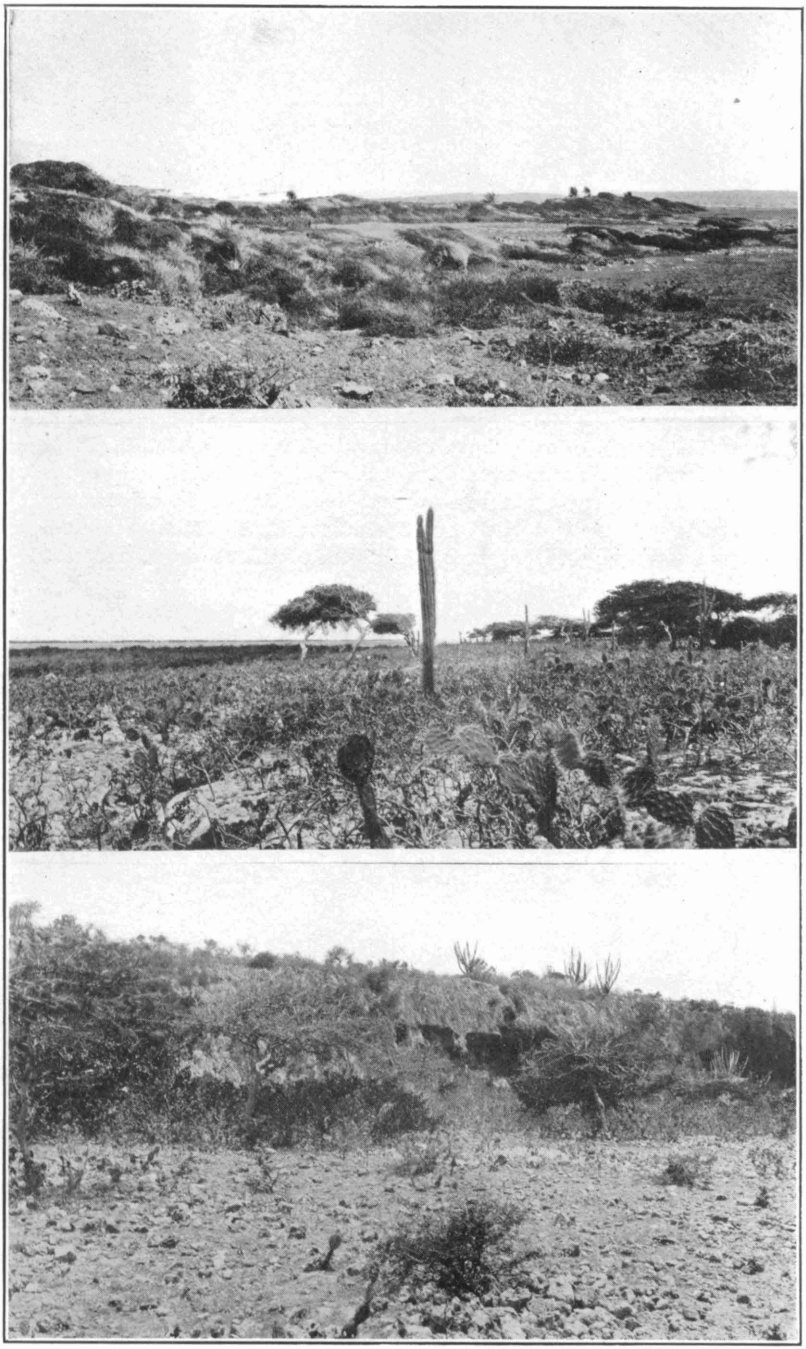


PLATE VI

FIG. 14 (top). South from the summit of the shore-cliffs, Plaja Djerimi (C17b), northwestern Curaçao. The foreground shows the typical, honey-combed exposures of the older limestone; acacias are especially prominent at the very edge of the cliffs. The background illustrates the very narrow zone of limestone, with the high, undercut shore-cliffs, along the western shore of northern Curaçao. At the right and in the distant background are the higher hills of older rocks, with indistinct, fossil beaches on their slopes.

FIG. 15. Pos Baca (Bc1), southern Bonaire. This is one of the larger, shallow sink-holes in the recent limestone. Most of the foreground is bare, due to intermittent flooding, but the background shows the same kind of country that is illustrated by the next figure.

FIG. 16 (bottom). Southern Bonaire (B1). The brush in the background is characteristic of the better protected portions of the low plains of recent limestone, south of Kralendijk and on Klein-Bonaire (K1). The crotons are especially conspicuous. The foreground is flooded during heavy rains.

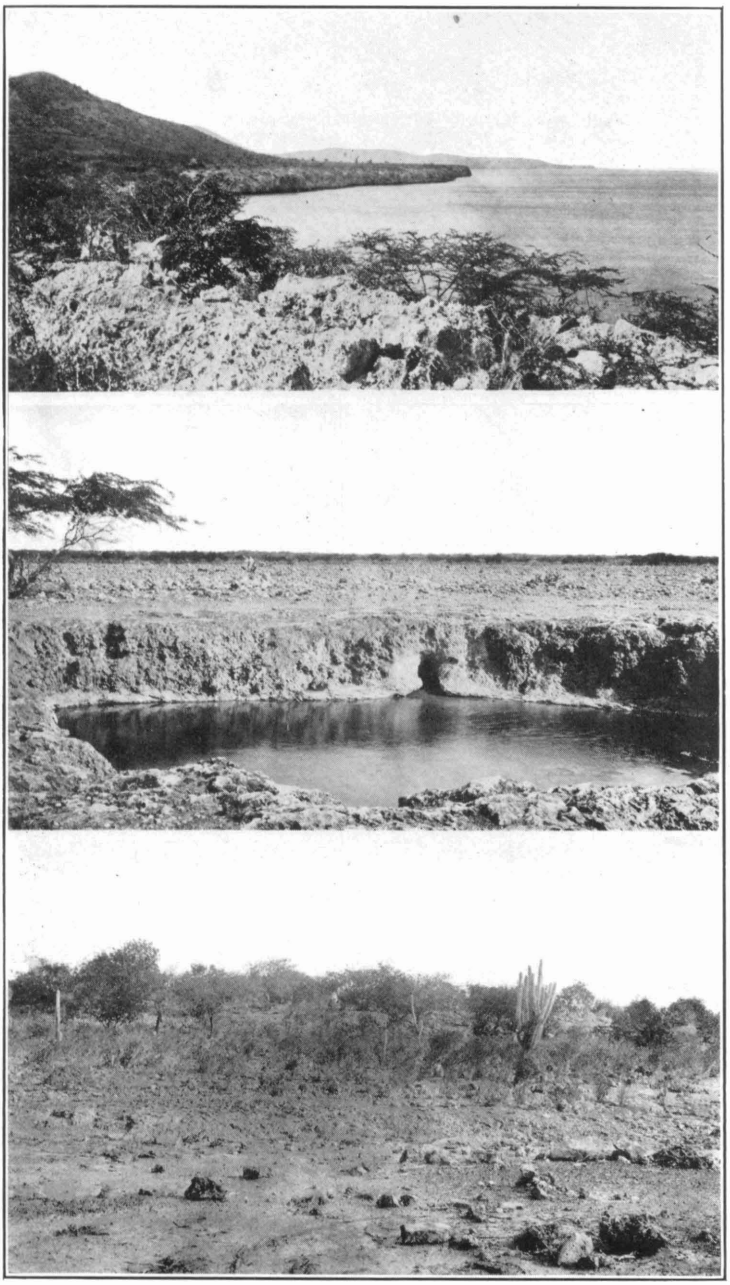


PLATE VII

FIG. 17 (top). Central, diabasic plains of southeastern Curaçao. These grassy, rolling plains are practically without molluscan life.

FIG. 18. To the leeward of Seroe Papaja, southeastern Curaçao. This is an example of the protected borders of the central plains, where the reddish residue in the soil indicates the recent erosion of the limestone cap (compare Cb6 and Cb10). A bit of the Hato ridge (C11) is shown at the extreme left of the background.

FIG. 19. Valley between Seroes Palomba and Bientoe (Cb17a), northwestern Curaçao. This is one of the richer valleys of the Christoffel complex. An epiphyte (Tillandsia) is growing on the brush near the center of the picture. It will be noted that much of the vegetation is leafless, as is usual during the dry season.

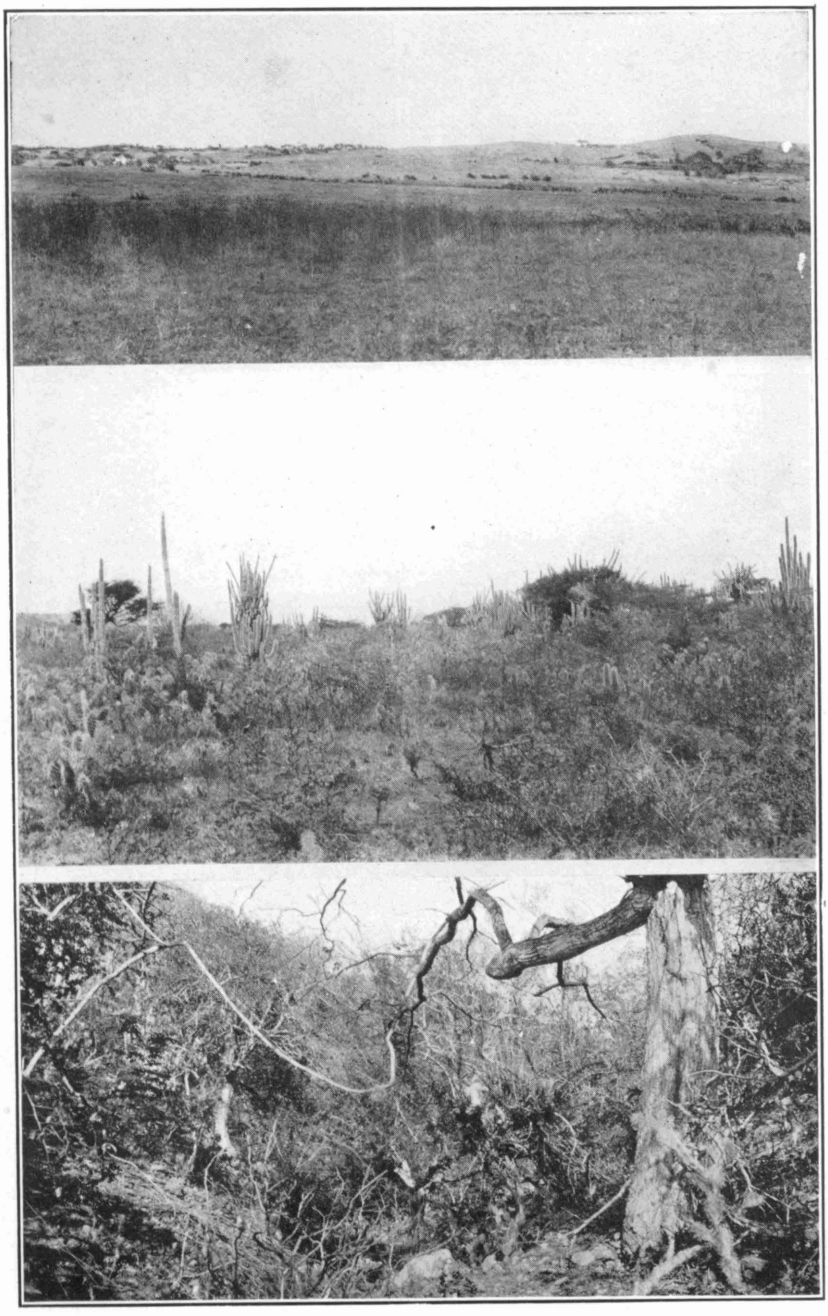


PLATE VIII

The scales represent lengths of one millimeter.

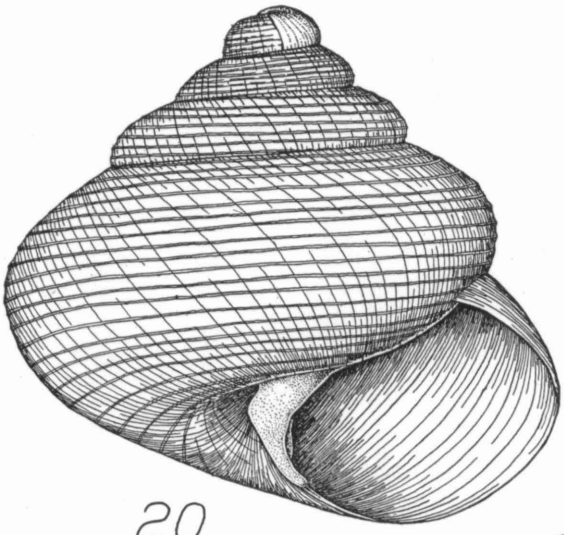
FIG. 20. *Stoastomops walkeri.* The type specimen from B4.

FIG. 21. *Stoastomops walkeri.* Inner view of operculum; the calcareous portion is viewed through the horny plate.

FIG. 22. *Tudora maculata.* The type, from B3a, with operculum in place.

FIG. 23. *Tudora maculata.* Median view of operculum.

FIG. 24. *Tudora maculata.* Outer surface of the operculum.



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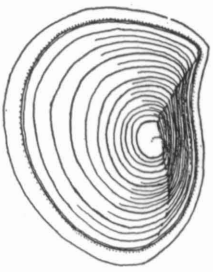

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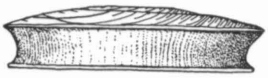

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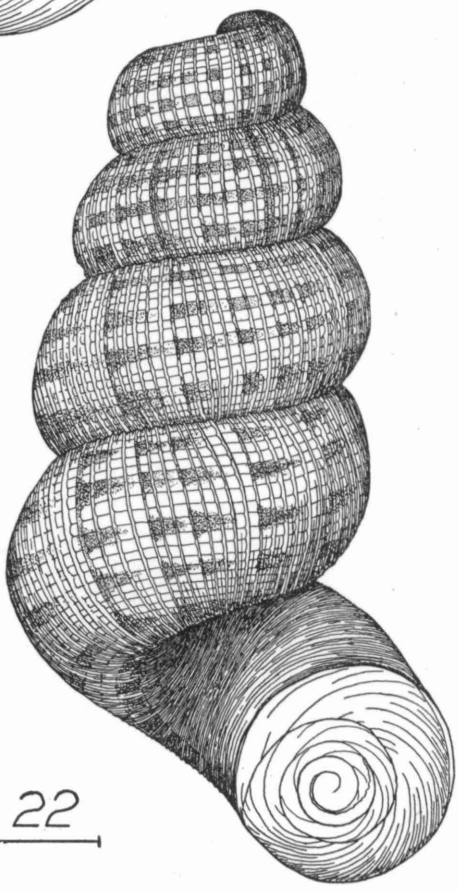


22

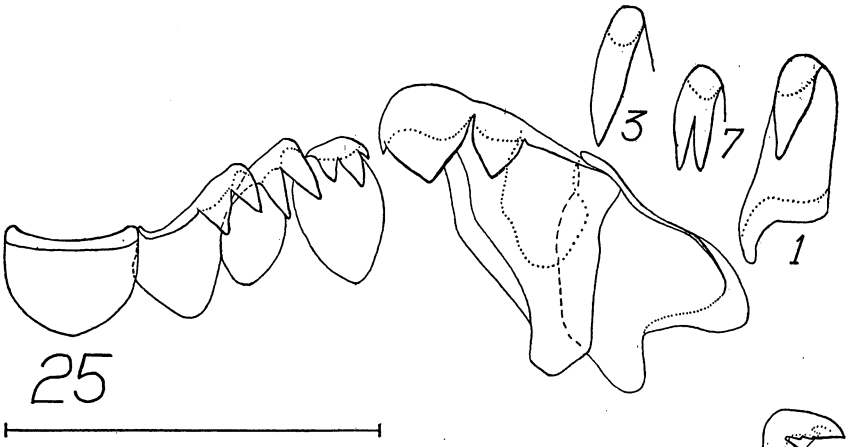
PLATE IX

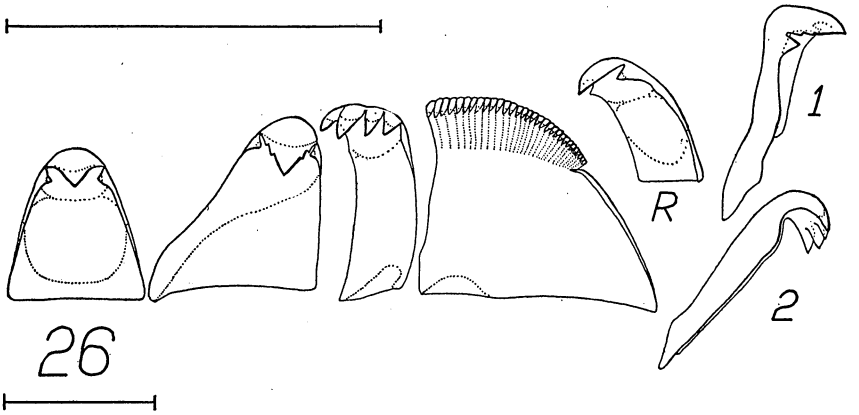
The scales represent lengths of 50 microns (.05 mm.).

FIG. 25. *Stoastomops walkeri.* Radula from type locality (B4). Central field and laterals in approximately their relative position; first marginal and blades of 3rd and 7th uncini.

FIG. 26. *Cistulops raveni.* Radula from C11; except the tilted view of the outer lateral which is from *C. raveni arubana* (A2). Half row, with teeth slightly separated laterally. At the right is shown a lateral view of the central (R), and median views of the inner (1) and outer (2) laterals.

FIG. 27. *Tudora megacheilos.* Radula from C5c. Teeth of half row, each in position usually seen. Also, lateral views of inner (1) and outer (2) laterals, and inner profile of marginal (M).


3
7
1
25


1
R
2
26

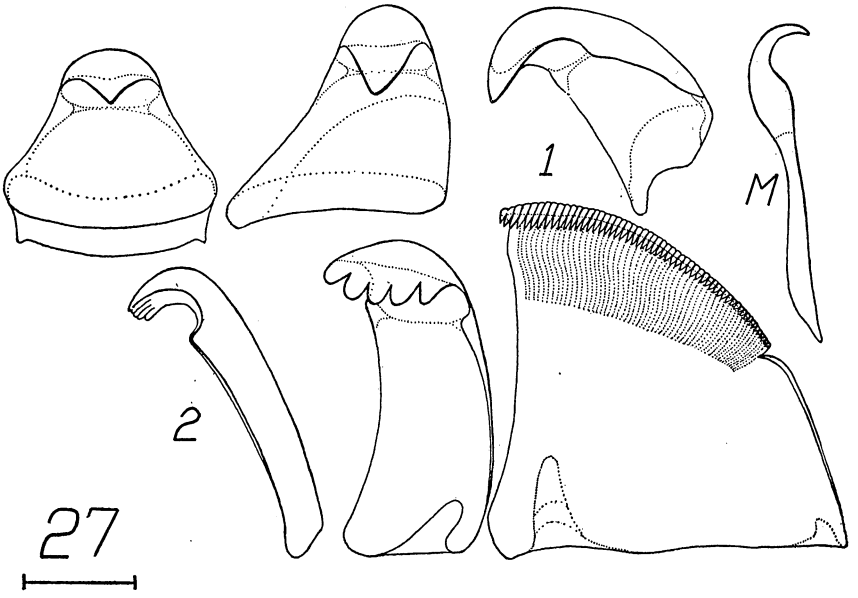

1
M
2
27

PLATE X

SCULPTURE OF THE LAST WHORL IN TUDORA

The scale, shown under fig. 32, indicates a length of one millimeter; the rectangles are all approximately one by one and a quarter millimeters.

FIG. 28. *Tudora aurantia wassauensis.* Female cotype, from B8.

FIG. 29. *Tudora rupis rupis.* Type, from C2a.

FIG. 30. *Tudora rupis newportensis.* Female cotype, from C1.

FIG. 31. *Tudora muskusi muskusi.* Type, from C17b.

FIG. 32. *Tudora muskusi grandiensis.* Type, from C14.

FIG. 33. *Tudora muskusi bullenensis.* Type, from C13.

FIG. 34. *Tudora megacheilos,* form *desculpta.* Type, from C5c. The sculpture of typical *megacheilos* consists of similar growth cords, which either surmount slightly or extend between the spiral thickenings, which are similar to those shown in fig. 36.

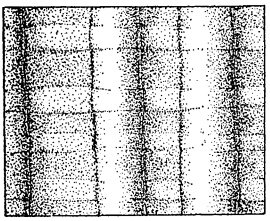
FIG. 35. *Tudora megacheilos spreitensis.* Type, from C8.

FIG. 36. *Tudora megacheilos rondeklipensis.* Type, from C12a.

FIG. 37. *Tudora fossor fossor.* Female cotype, from Cb17b.

FIG. 38. *Tudora fossor arubana.* Type, from A2b.

FIG. 39. *Tudora pilsbryi.* Type, from C2a.



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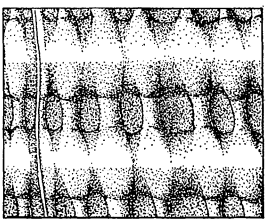

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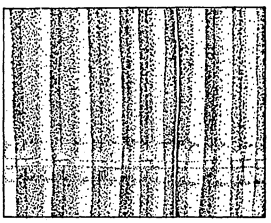

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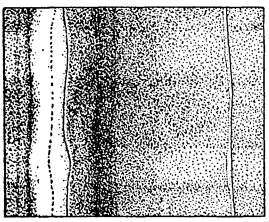

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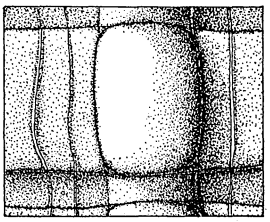
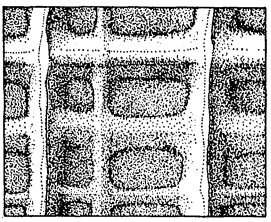


32



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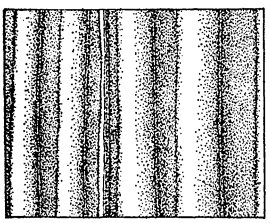

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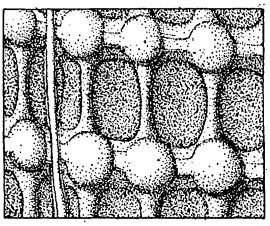

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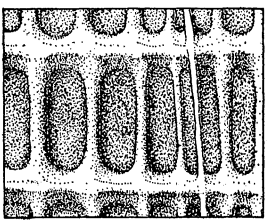

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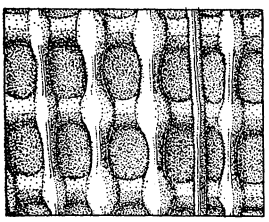

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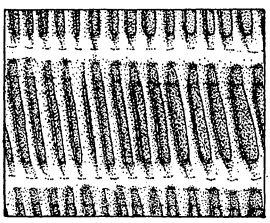

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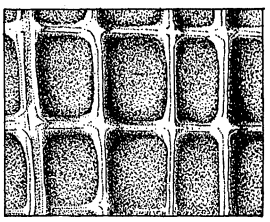

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PLATE XI

The scales of figs. 40 and 41 represent a length of 50 microns (.05 mm.), while those of figs. 42 to 47 indicate one millimeter.

FIG. 40. *Tudora maculata.* Central and laterals; radula from B4. Also outer lateral in profile; lateral view.

FIG. 41. *Tudora muskusi muskusi.* Central and laterals; radula from C17b.

FIG. 42. *Cistulops raveni.* Exterior surface of operculum; from C5c.

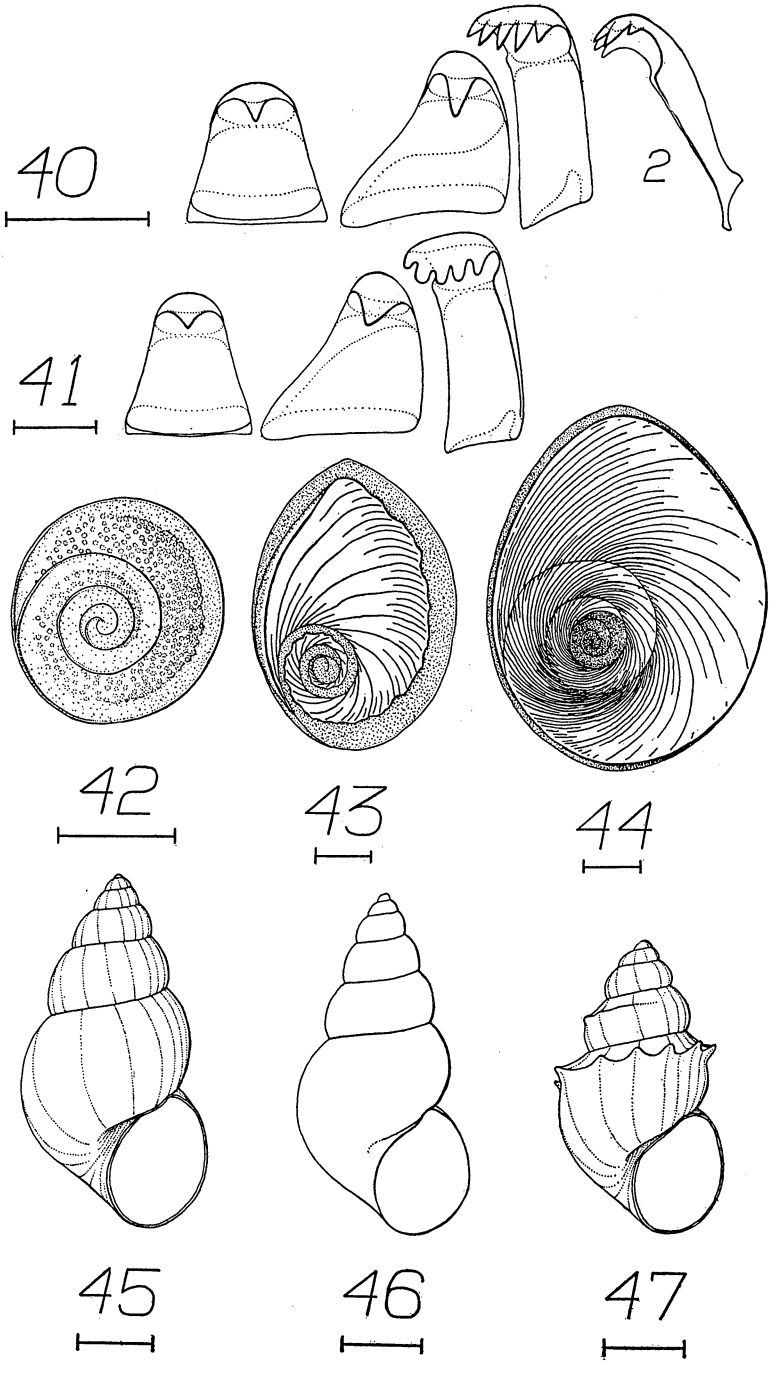
FIG. 43. *Tudora muskusi muskusi.* Exterior surface of operculum; from C17b.

FIG. 44. *Tudora pilsbryi.* Exterior surface of operculum; from C2a.

FIG. 45. *Potamopyrgus parvulus.* Large, globose form, from Bc1.

FIG. 46. *Potamopyrgus parvulus.* Elongate form, from Kc1.

FIG. 47. *Potamopyrgus parvulus.* Spinulose form, from Kc1.


40
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41
42
43
44
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47

PLATE XII

The hair-line indicates a length of one centimeter; the dimensions of the shells figured are given in the text.

FIG. A. *Tudora aurantia aurantia.* Male and female, from B2.

FIG. B. *Tudora aurantia wassauensis.* Male and 2 females, from B8; the right-hand figure is the type.

FIG. C. *Tudora muskusi muskusi.* Male and 3 females, from C17b; the second figure from the left is the type.

FIG. D. *Tudora rupis newportensis.* Male (type) and 2 females, from C1.

FIG. E. *Tudora rupis rupis.* Male and female (type), from C2a.

FIG. F. *Tudora muskusi grandiensis.* Two males and two females, from C14; the right-hand figure is the type.

FIG. G. *Tudora muskusi bullenensis.* Male and female (type), from C13.

FIG. H. *Tudora muskusi* × *Tudora fossor djerimensis.* This specimen appears to be a hybrid between these two species. The operculum is also somewhat intermediate, but is much closer to *muskusi.* From C17b.

FIG. I. *Tudora fossor djerimensis.* Male and female (type), from C17b.

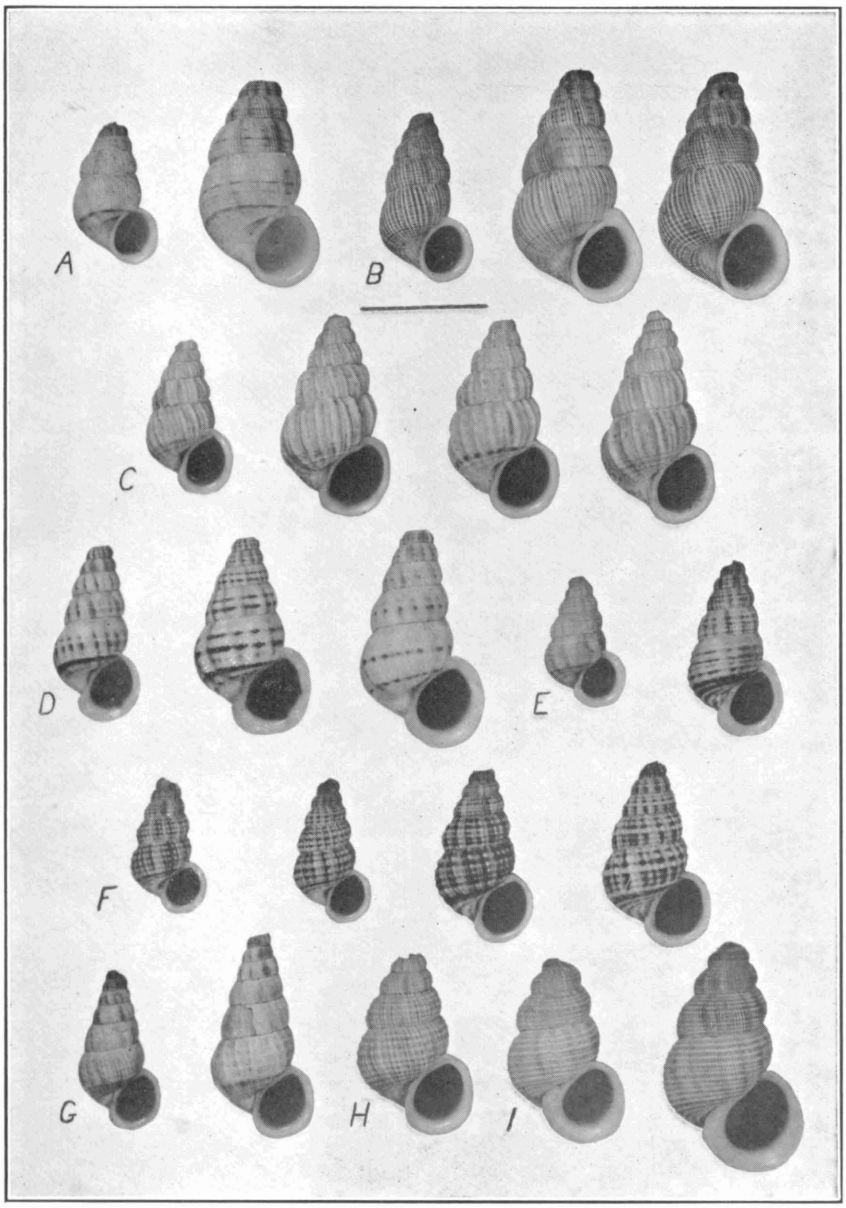

A
B
C
D
E
F
G
H
I

PLATE XIII

The hair-line represents a length of one centimeter; the dimensions of the shells figured are given in the text.

FIG. A. *Tudora megacheilos megacheilos.* Male and female, from C5c.

FIG. B. *Tudora megacheilos,* form *desculpta.* Male and female (type), from C5c.

FIG. C. *Tudora megacheilos spreitensis.* Male and female (type), from C8.

FIG. D. *Tudora megacheilos rondeklipensis.* Male and female (type), from C12a. The male is turned so as to show best the palatal emargination of the peristome in *T. megacheilos.*

FIG. E. *Tudora megacheilos kabrietensis.* Male (type) and female, from C3.

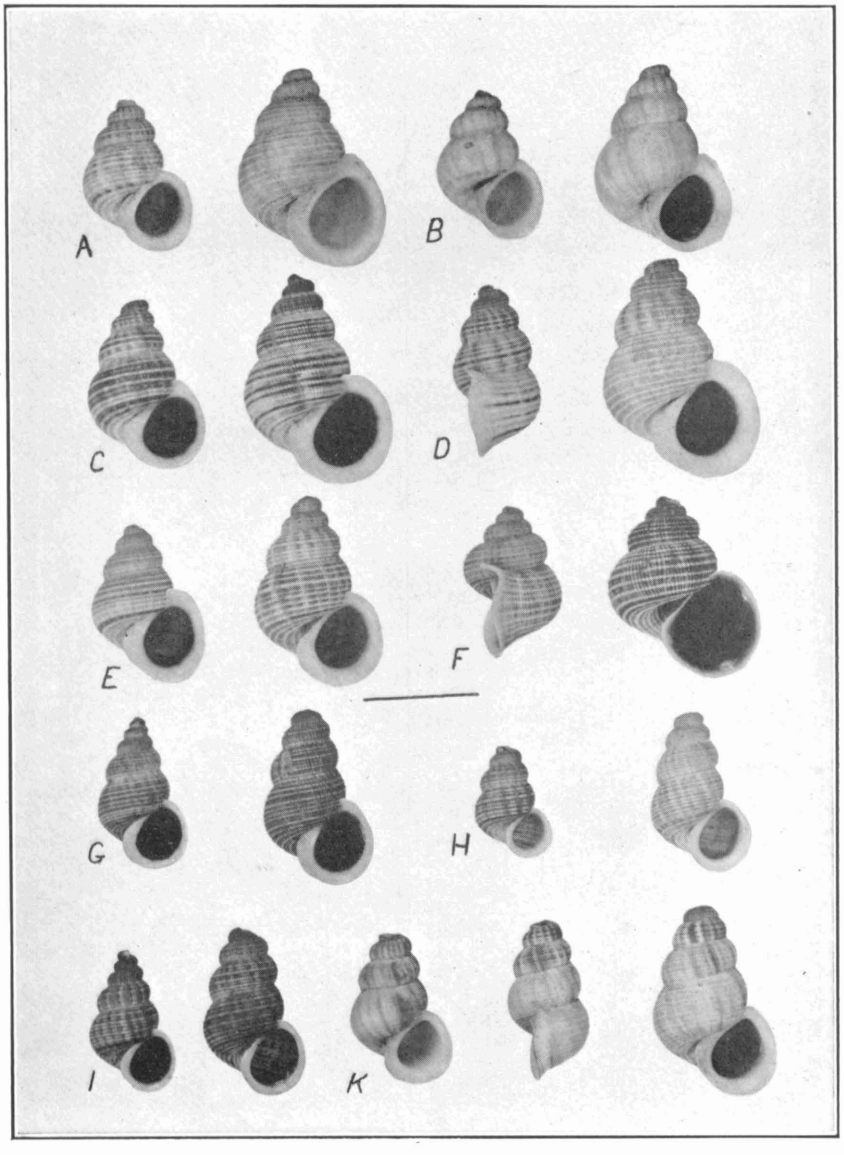
FIG. F. *Tudora pilsbryi.* Male and female (type), from C2a. The male is turned so as to show best the palatal sinus of the peristome in this species.

FIG. G. *Tudora fossor fossor.* Male (type) and female, from Cb17b. The type retains all of the whorls.

FIG. H. *Tudora fossor westpuntensis.* Male (type) and female, from C18.

FIG. I. *Tudora fossor canashitensis.* Male (type) and female, from A4b. The dimensions given in the text were taken when the type retained all of the whorls, but a bit of the apex crumbled away before the figure was made.

FIG. K. *Tudora fossor arubana.* Two males and a female (type), from A2b. One male (the left-hand figure) has the spiral sculpture very much reduced; the other is turned so as to show best the slight palatal emargination of the peristome, which is usually greater in *arubana* than in the other subspecies of *T. fossor.*


A
B
C
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F
G
H
I
K

PLATE XIV

The scales represent lengths of 50 microns (.05 mm.). The centrals and 1st laterals are shown in their proper relation to each other; the other teeth are simply oriented in regard to the long axis of the radula.

FIG. 48. *Succinea gyrata.* Radula of a medium-sized specimen from C5c. Central, 1st, 7th, 14th and 21st teeth. The three examples of the 14th tooth occur within four, consecutive, transverse rows.

FIG. 49. *Succinea gyrata.* Jaw from same specimen.

FIG. 50. *Thysanophora vanattai.* Radula from A3. Central, 1st, 7th and 14th teeth.

FIG. 51. *Thysanophora vanattai.* Jaw from same specimen.

FIG. 52. *Drymaeus virgulatus.* Radula from C11c. Central, both 1st, 3rd, 28th, 52nd, 54th, 57th and 84th teeth. The hair-line below the scale shows the shape of a transverse row.

FIG. 53. *Neosubulina harterti.* Radula from B5. Central, 1st, 7th, 14th and 19th teeth. The shapes of the smaller cusps of the outer marginal are, of course, indeterminate, as their diameter is less than half the length of light-waves, so they are only visible as points of light.

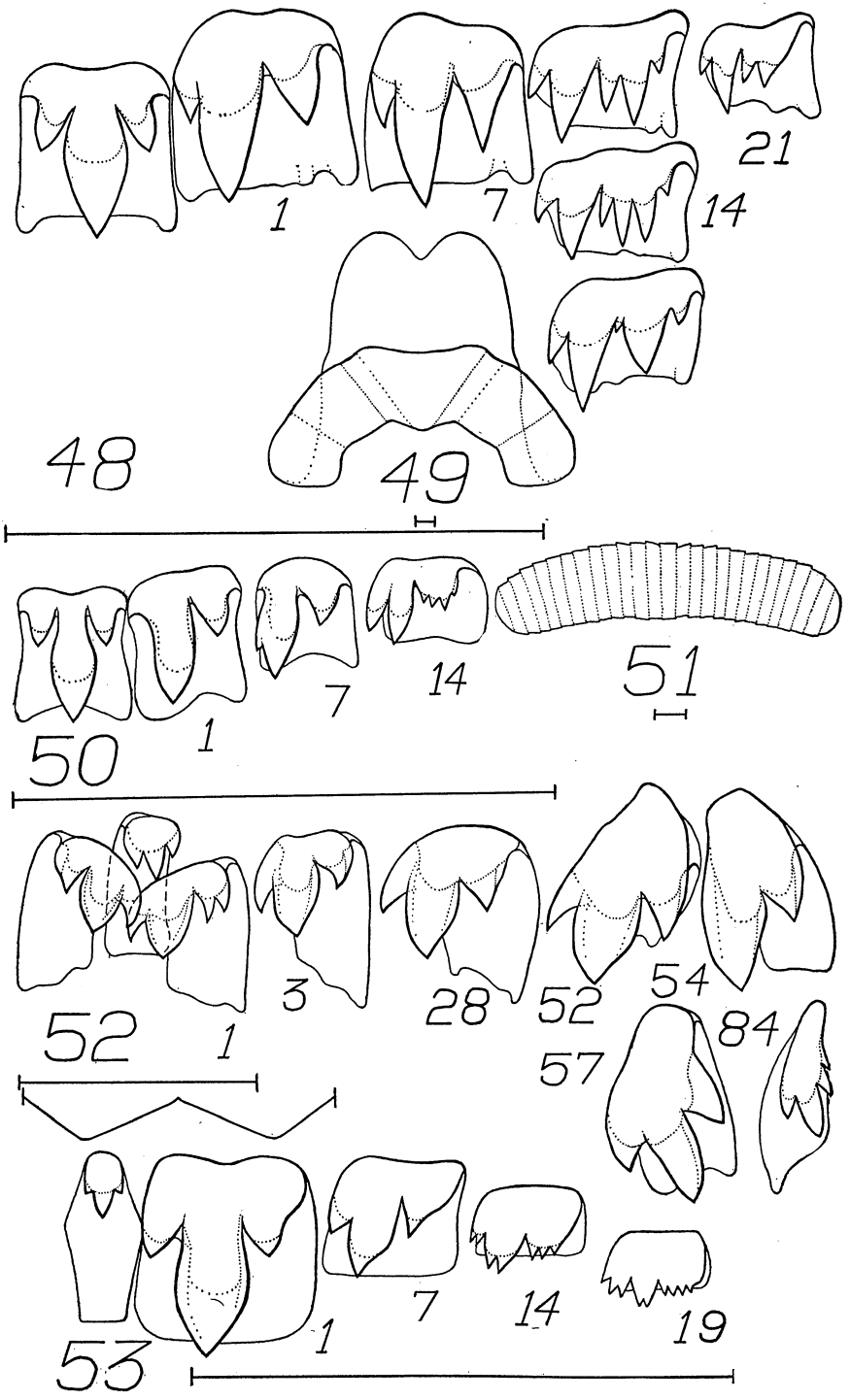

1
7
21
14
48
49
50
1
7
14
51
52
1
3
28
52
54
57
84
53
1
7
14
19

PLATE XV

Each scale indicates a length of one millimeter, except in fig. 55, where it represents 200 microns (.2 mm.).

FIG. 54. *Guppya molengraaffi.* Apical, basal and profile views of the type, from Cb20.

FIG. 55. *Thysanophora crinita arubana.* Profile view of hair and detail of sculpture on 3rd whorl of a young shell from A4a.

FIG. 56. *Thysanophora crinita arubana.* Apical, basal and profile views of the type, from A4a.

FIG. 57. *Thysanophora vanattai.* Apical, basal and profile views of the type, from A4a.

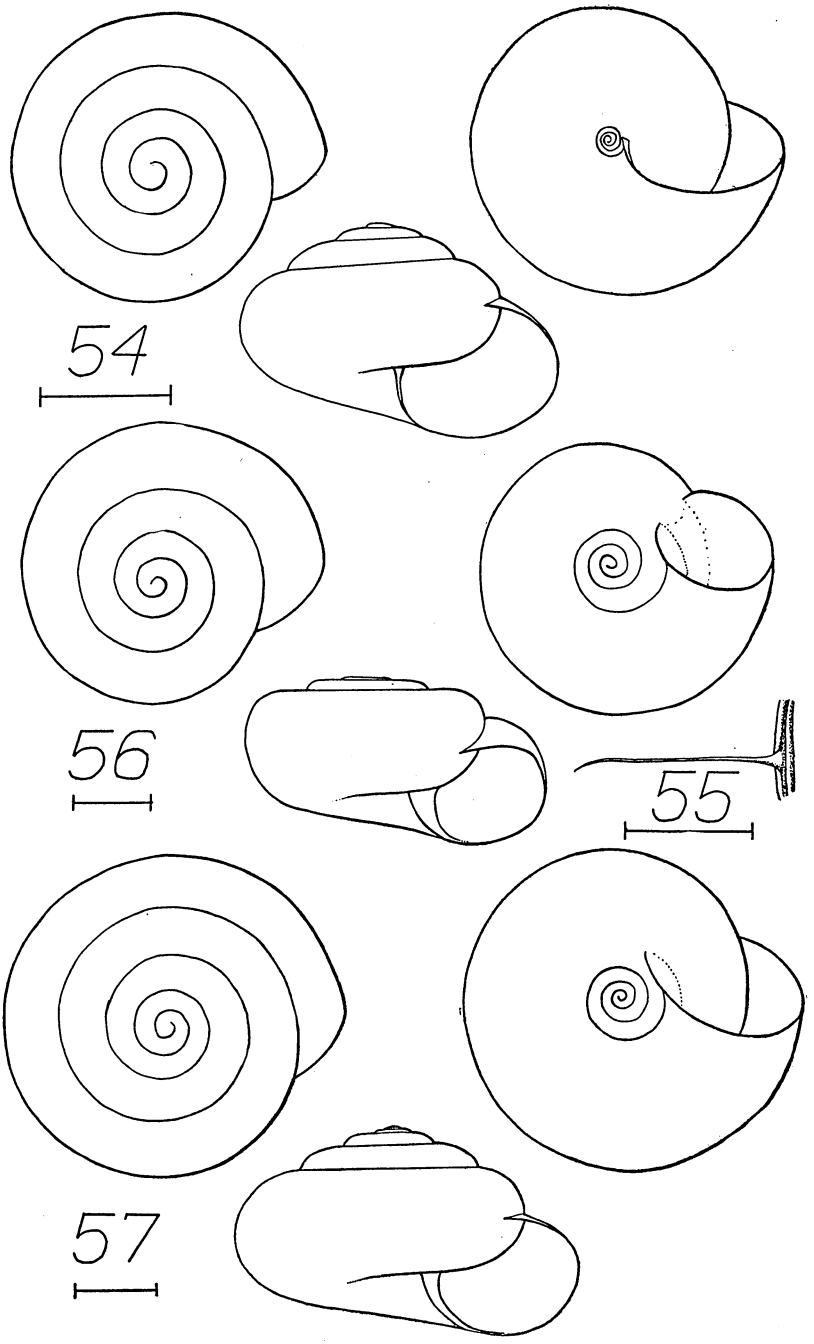

54
56
55
57

PLATE XVI

The scales in figs. 58–63 indicate lengths of one millimeter; those of 64–66, 50 microns (.05 mm.).

FIG. 58. *Neosubulina harterti.* Embryonic shell, from body of adult (B6).

FIG. 59. *Neosubulina gloynii.* Ditto (C17).

FIG. 60. *Neosubulina scopulorum.* Ditto (A3).

FIG. 61. *Neosubulina harterti.* Largest adult (B6).

FIG. 62. *Neosubulina gloynii.* Largest adult (C11).

FIG. 63. *Neosubulina scopulorum.* Type, largest adult (A3).

FIG. 64. *Neosubulina harterti.* Jaw (B6).

FIG. 65. *Brachypodella raveni raveni.* Radula (C5); entire view of central and tips of two others (C), inner lateral (1), outer lateral (2), 1st and 3rd marginals (3, 5). The teeth are simply oriented in regard to the long axis of the radula, and are not shown in relation to each other (*cf.* Pilsbry, *op. cit.*).

FIG. 66. *Brachypodella gibbonsi.* Radula (B3); tip of central. The scale also applies to the preceding figure.

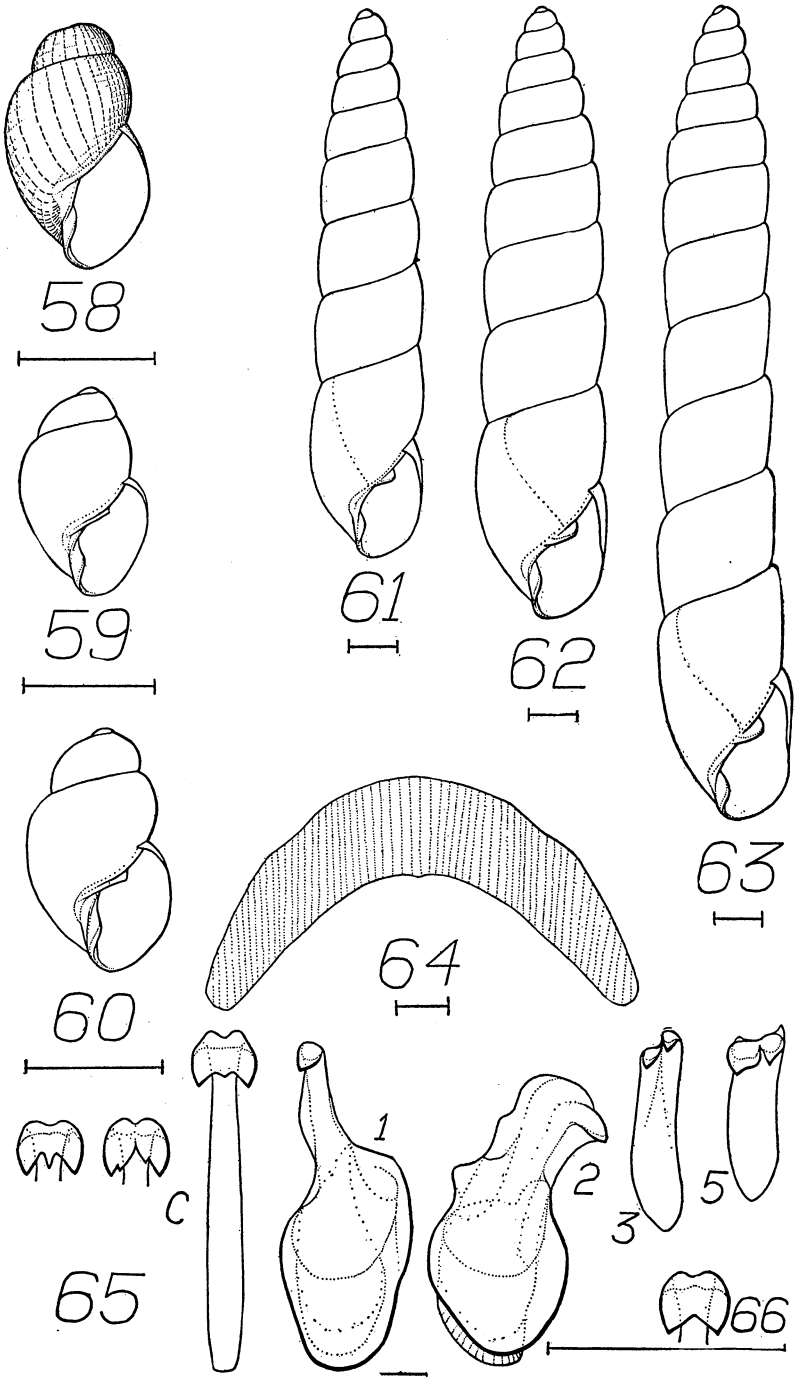

58
59
61
62
63
60
64
65
c
1
2
3
5
66

PLATE XVII

The scales indicate lengths of one millimeter; figs. 67–71 and 74–77 are drawn to the same scale.

FIG. 67. *Brachypodella raveni raveni.* Complete adult, from C11.
FIG. 68. *Brachypodella raveni sanctaebarbarae.* Type, from C2a.
FIG. 69. *Brachypodella raveni knipensis.* Type, from C17a.
FIG. 70. *Brachypodella raveni arubana.* Type, from A2b.
FIG. 71. *Brachypodella gibbonsi.* Type, from B3.
FIG. 72. *Brachypodella raveni knipensis.* Conical specimen, from C17.
FIG. 73. *Brachypodella raveni raveni.* Apical whorls, from C5c.
FIG. 74. *Microceramus bonairensis bonairensis.* Topotype, from B2.
FIG. 75. *Microceramus bonairensis curacoanus.* Type, from C5c.
FIG. 76. *Microceramus bonairensis curacoanus.* Specimen from C17.
FIG. 77. *Microceramus bonairensis arubanus.* Type, from A4b.

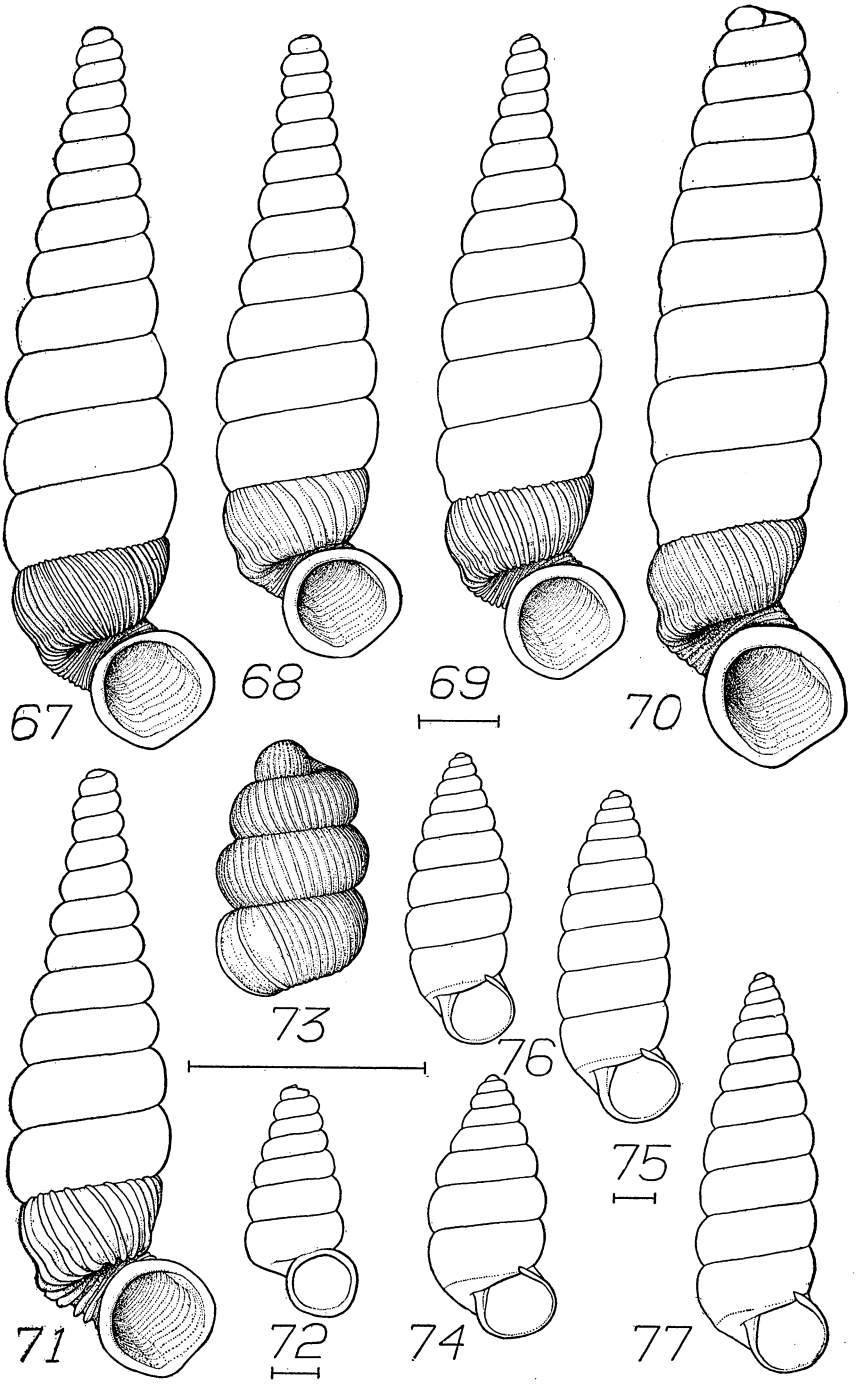

67
68
69
70
71
72
73
74
75
76
77

PLATE XVIII

Variation in *Cerion uva uva* (Tables XI, XII)
FIGS. C6, D5. *C. uva desculptum* (Cb6, Cb10).
FIG. A2. Type of form *diablensis* (C12b).
FIG. F6. Type of form *hatoensis* (C11d).

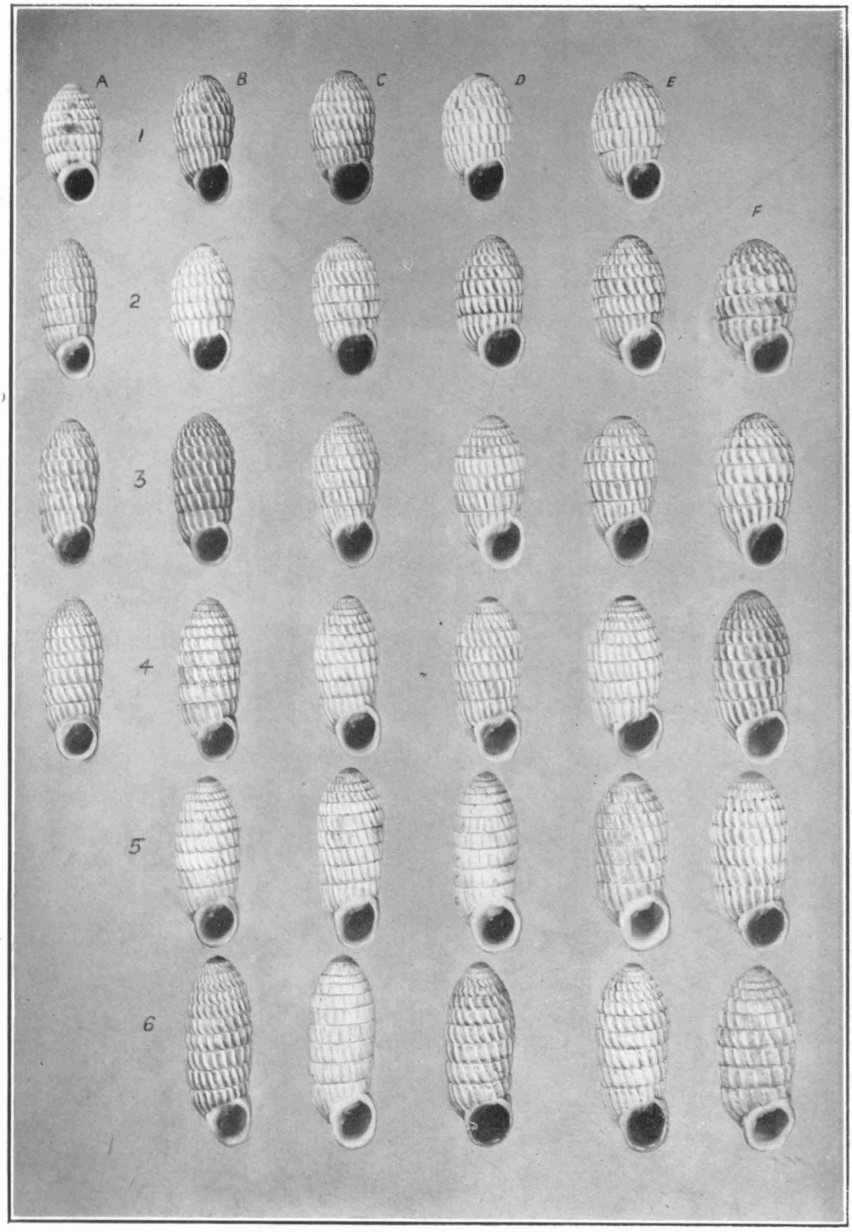

A
B
C
D
E
F
1
2
3
4
5
6

PLATE XIX

Variation in *Cerion uva knipensis*

FIG. A1. Type of form *djerimensis* (C17c).

FIGS. C3, 6, D3, 4, 6, E4–6, F3–5 from substation Cb17. F5 is the type of *knipensis*.

FIG. C5 from station C20.

FIGS. D2, E1, 2, F2 from station C18.

FIG. E3 from station Cb16.

FIG. F6 from station Cb20.

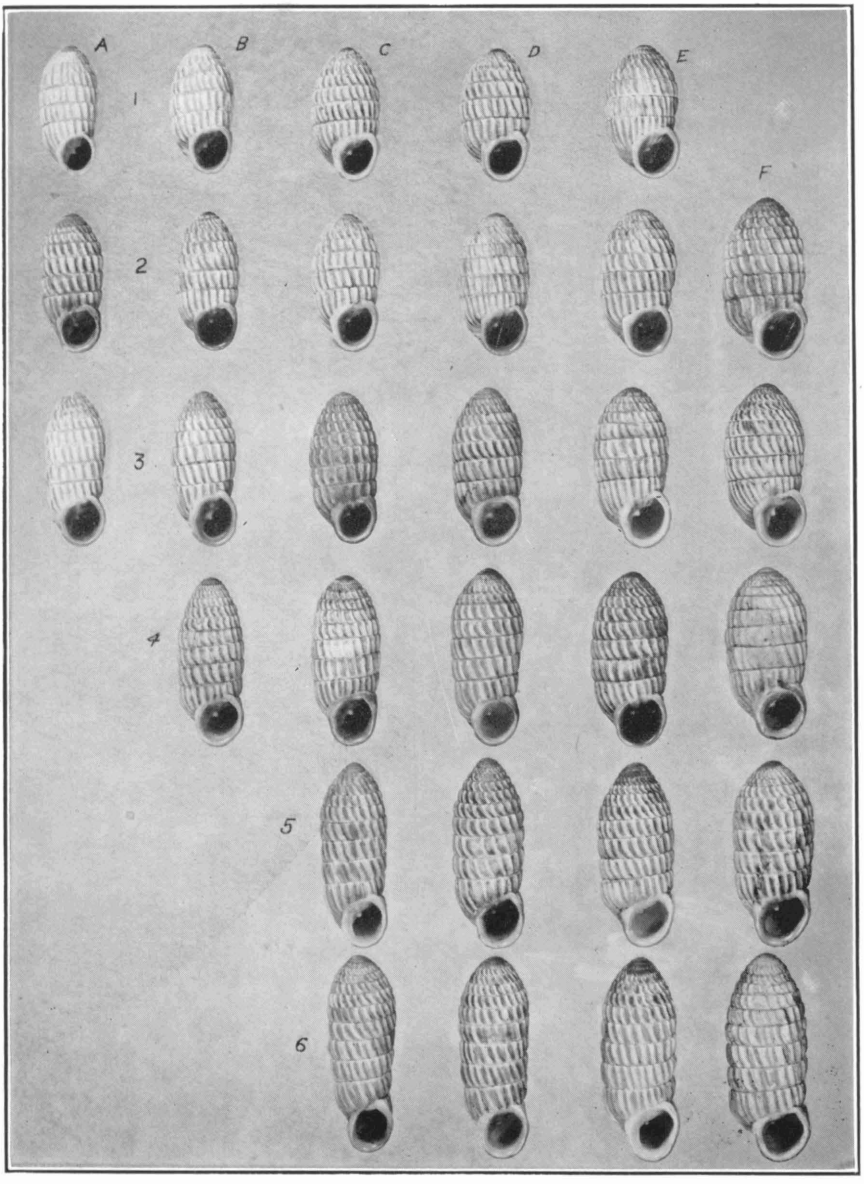

A
B
C
D
E
F
1
2
3
4
5
6

PLATE XX

Variation in *Cerion uva arubanum*

Scale and arrangement as in Plate XVIII. For extremes, see Table XIV.

FIGS. A1–3, B1–3, C1–5, D1–4, F2, 3, 6 from the colony at A2c.

FIG. C3 is the type of the subspecies.

FIGS. A4, B4, 5, D5, 6, E4, 5, F3–5 from colony at A5a.

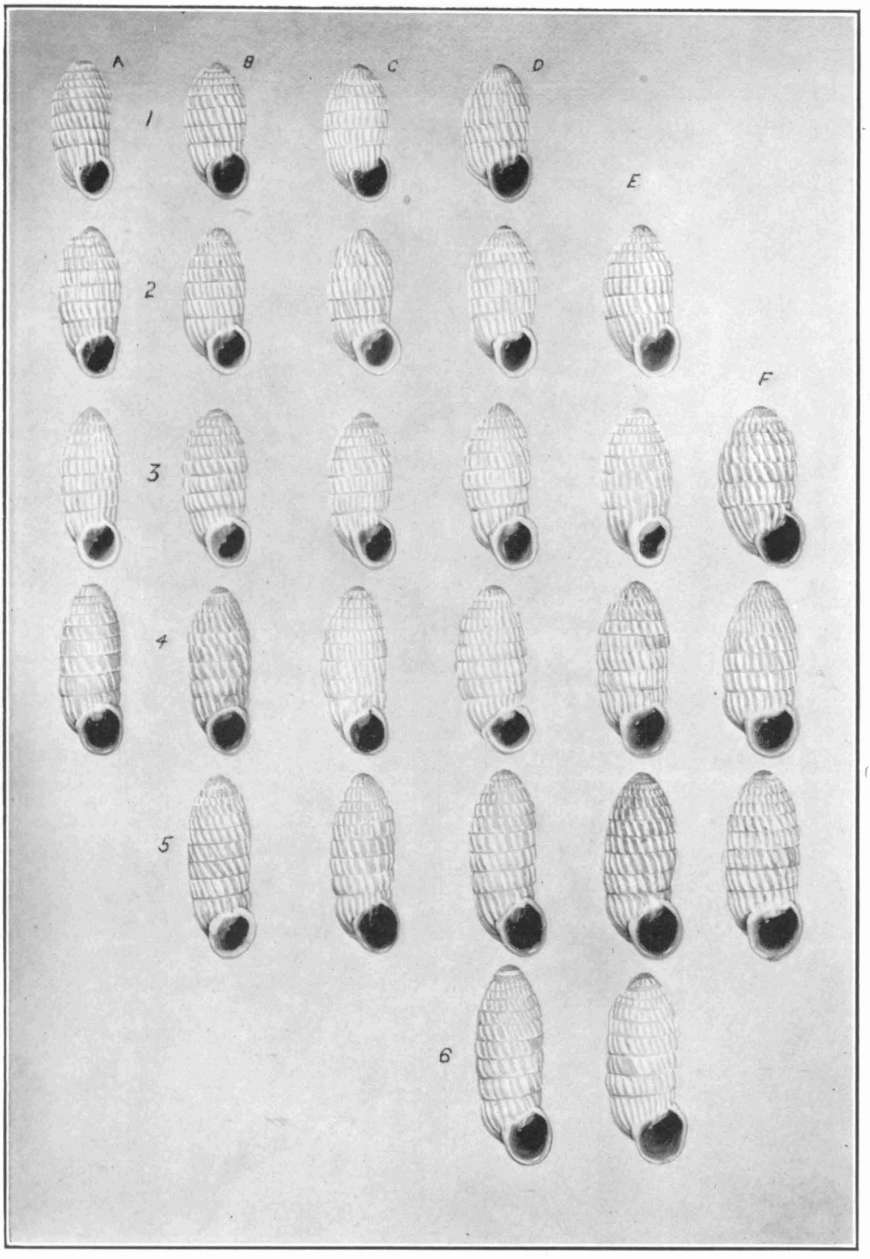

A
B
C
D
E
F
1
2
3
4
5
6

PLATE XXI

Variation in *Cerion uva bonairensis*

Scale and arrangement as in Plate XVIII. For extremes, see Table XIV.

FIGS. A1, B2, 3 from Station B9.

FIG. A2, the type of form *kralendijk*, from station B1.

FIGS. A3, B1 from station B2.

FIGS. A4, C2, D3, E3 from station B4.

FIGS. B4, C5 from station B7.

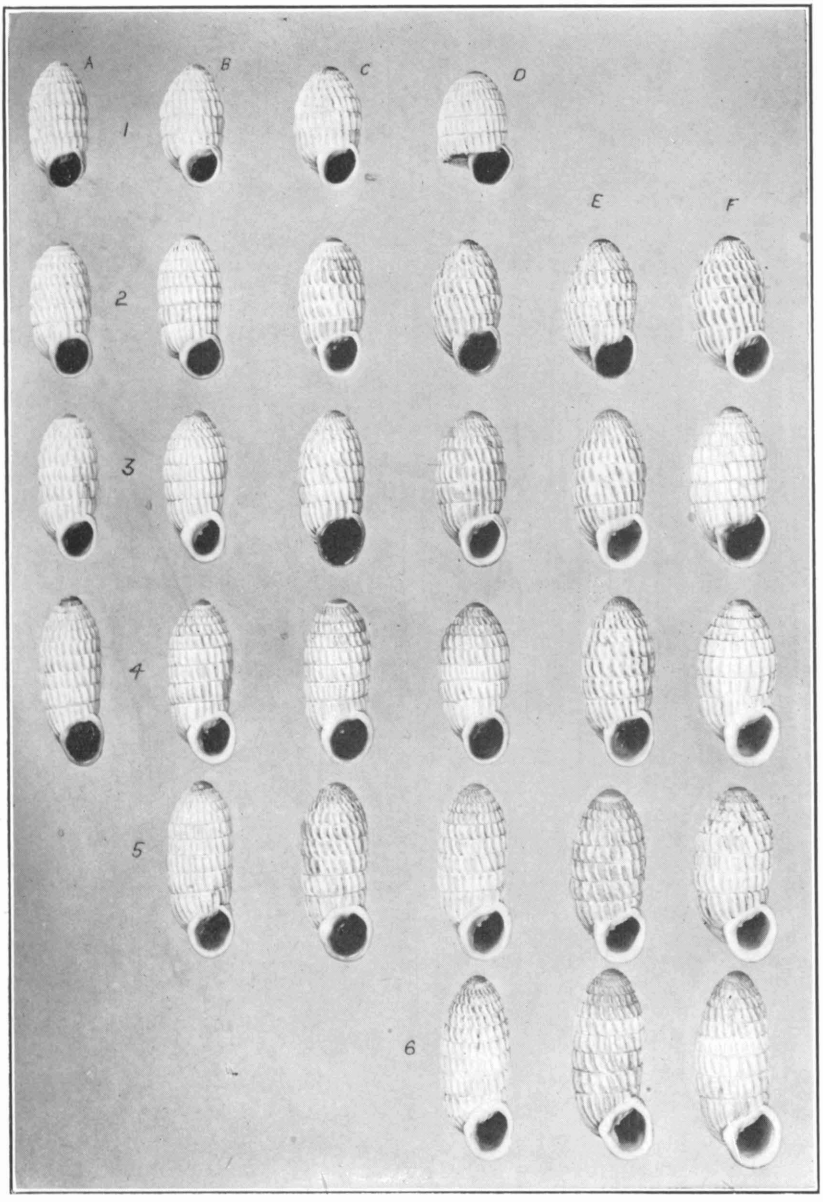
FIG. B5 from station B8.

FIGS. C1, 3, D2, F2 from substation B3a.

FIGS. C4, D5, 6 from station Bb7.

FIGS. D1, 4 from Klein-Bonaire (K1).

FIGS. E2, 4–6, F3–6 from station B5. F6 is the type of *bonairensis*.


A
B
C
D
E
F
1
2
3
4
5
6